TMDL Development Team

Bryan McFadin
John Grant
Don Song

Review Team

David Leland
Dave Parson
Ranjit Gill
Robert Klamt
Dave Hope

Document Development

Lauren Clyde
Alydda Mangelsdorf
Rebecca VanAsdlan

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CHAPTER 1
INTRODUCTION

The Gualala River Watershed Technical Support Document (TSD) for Sediment is intended to guide landowners, land managers, and resource protection agencies in the protection of water quality in the Gualala River watershed. The primary objective of the Gualala River Watershed TSD for Sediment is to identify and initially quantify sources of sediment delivery in a way that allows a relative comparison of those sources and to provide information required for non-point source implementation and planning. A secondary objective of the Gualala River Watershed TSD for Sediment is to identify sediment loading allocations that, when implemented, are expected to result in the attainment of the applicable water quality standards for sediment to protect beneficial uses. The key beneficial uses of concern are associated with cold water fisheries, particularly the coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Oncorhynchus mykiss*) fisheries.

In 1996, the National Marine Fisheries Service (NMFS) listed coho salmon in the Northern California/Southern Oregon Coasts Evolutionarily Significant Unit (ESU) as a threatened species under the federal Endangered Species Act. This ESU includes all naturally spawned populations of coho salmon in coastal streams between Cape Blanco, Oregon, and Punta Gorda, California. On June 7, 2000, NMFS also listed steelhead trout in the Northern California Evolutionarily Significant Unit (ESU) as a threatened species. The Northern California ESU includes steelhead in California coastal river basins from Redwood Creek south to the Gualala River, inclusive. These listings are results of observed or measured substantial declines in the salmonid populations over time.

1.1 Technical Source Documents and the Components of a TMDL

A Technical Support Document, or TSD, is a report developed by Regional Water Quality Control Board, North Coast Region (Regional Water Board), staff which meet federal requirements for a Total Maximum Daily Load (TMDL), but with no implementation or monitoring plan and no action on the part of the Regional Water Board or the State Water Resources Control Board (State Water Board). TSDs have not been through the State Board's or Regional Water Board's public participation and adoption process. The Gualala River watershed TSD for Sediment will be transmitted directly to U.S. EPA Region IX upon completion by Regional Water Board staff. U.S. EPA will use the TSD to develop a draft Total Maximum Daily Load (TMDL) for the Gualala River watershed that is publicly noticed for comment. The TMDLs prepared by U. S. EPA are sometimes referred to as "technical TMDLs."

The required components of a TMDL are described in 40 Code of Federal Regulation (CFR) §130.2 et seq., Section 303(d) of the Clean Water Act, and in various guidance documents (e.g., U.S. EPA 1991 "Guidance for Water Quality-based Decisions: The TMDL Process").

A TMDL is defined as the sum of the individual waste load allocations (WLAs) for point sources, load allocations (LAs) for non-point sources, and natural background (NB) loading (40 CFR §130.2). That is,

$$\text{TMDL} = \Sigma\text{WLAs} + \Sigma\text{LAs} + \text{NB}$$

where Σ = the sum, WLAs = waste load allocations, LAs = load allocations, and NB = natural background loads. A TMDL must consider seasonal variations and include a margin of safety to address uncertainty in the analysis.

This TSD includes:

- Problem Statement (section 5.0)
- Source Analysis (section 6.0)
- Loading Capacity Estimate (section 6.5)
- Load Allocation (section 6.6)
- Margin of Safety and Seasonal Variation (sections (6.7)
- Numeric Targets (section 6.8)
- Implementation and Monitoring (section 7.0)
- Public Participation (section 8.0)

A **problem statement** provides a description of the existing in-stream and upslope watershed setting and the beneficial use impairments of concern. This section also includes an introduction to salmonid life cycles. It describes the problems associated with sedimentation in the Gualala River watershed in terms of its impact on the various life cycle stages of salmonids and on the overall stability of the stream channel.

The **source analysis** provides an assessment of the relative contributions of sources to the use impairment (i.e., road, logging, bank erosion, gully erosion) and the extent of needed discharge reductions or controls. Per 40 CFR §130.2(i) and §130.7(c)(1), point, non-point, and natural background sources of pollutants of concern are described, including the magnitude and location of the sources. In short, the source analysis section provides a general assessment of the sources of sediment increases to the Gualala River watershed that are impacting beneficial uses.

The purpose of a **loading capacity** analysis is to estimate the amount of a pollutant that a waterbody can receive without violating water quality standards (40 CFR §130.2(f)). The loading capacity analysis provides the basis for the amount of upslope and other controls necessary to attain water quality standards and protect the beneficial uses.

The **load allocation** results in the assignment of sediment load reduction and/or restoration responsibility to land use activities in individual assessment areas necessary to attain water quality standards and protect beneficial uses. The allocation of responsibility section estimates source reductions to prevent human-caused releases of sediment that are likely to respond to mitigation or altered land management practices. It should be noted that the loading allocations are prescribed to meet and be protective of water quality objectives in the Gualala River watershed at the watershed scale. The attainment of water quality objectives at each site in the Gualala River watershed requires a site-specific approach, beyond the scope of the loading allocations prescribed in this document.

The discussion of the **margin of safety** summarizes the qualitative and quantitative means by which the final load allocations account for any uncertainty in the data or data analysis. The seasonal variation section summarizes the changes in the discharges of sediment, and their associated effects on beneficial uses, which may vary in different years and at different times of the year, and how the variation is addressed in this analysis.

Numeric targets are based on and implement the water quality objectives adopted in the Basin Plan. Numeric targets provide indicators of watershed health and express the desired future condition for each stressor addressed in the TMDL. The numeric targets section presents the basis for the proposed numeric targets. As additional data are developed for the Gualala River watershed, these targets can be refined to better reflect site-specific conditions within the watershed. Further, the numeric targets must be understood as goals, not requirements. They provide a guidepost to landowners, resource managers and the public by which to determine how close the TMDL is to re-creating an instream environment suitable to support sustainable populations of salmonids. They are not intended to be attained immediately, nor are they directly enforceable.

A discussion of considerations for the future development of an **implementation plan** and **monitoring plan** is included. A discussion of the public participation opportunities that have been a part of the development of the TSD is also included.

CHAPTER 2
GENERAL DESCRIPTION OF THE GUALALA RIVER WATERSHED

2.1 Location and Overview

The Gualala River watershed, located in Northern California, flows into the Pacific Ocean near the Town of Gualala approximately 114 miles north of San Francisco (U.S. Bureau of Reclamation 1974) and 17 miles south of Point Arena (see Plate 1). The Gualala River drains approximately 299 square miles, or 191,200 acres, of mostly mountainous and rugged terrain in both Sonoma and Mendocino Counties. The Mendocino-Sonoma county boundary runs down the center of the Mainstem Gualala River and through the Rockpile Creek subwatershed.

The Gualala River watershed (Calwater Number 113.8) consists of five principle tributaries (see Plate 2). These include the North Fork (113.81), Rockpile Creek (113.82), Buckeye Creek (113.83), Wheatfield Fork (113.84), and the South Fork (113.85). The Mainstem Gualala River runs for approximately three miles from the confluence of the South Fork and North Fork to the Pacific Ocean.

Subwatershed	Area (square miles)	Area (acres)	% of Watershed
North Fork	48mi^2	30,700ac.	16%
Rockpile Creek	35	22,400	12
Buckeye Creek	40	25,800	14
Wheatfield Fork	112	71,500	37
South Fork and Mainstem	64	40,800	21
	299	191,200	100

One of the most distinguishing features of the Gualala River watershed is the San Andreas Rift Zone, which underlies the path of the South Fork and Little North Fork Gualala River.

Elevations in the Gualala watershed range from sea level at the mouth to over 2650 feet along the ridges and peaks.

The primary population centers in the Gualala River watershed are the towns of Gualala, Sea Ranch, Stewarts Point, Annapolis, and Plantation.

The Gualala Watershed has few public roads crossing it. Highway 1 crosses the Mainstem Gualala River at its estuary just south of the Town of Gualala. Stewarts Point/Skaggs Springs Road is a Sonoma County road that connects Stewarts Point on the coast to Lake Sonoma, running along the Wheatfield Fork and Wolf Creek. Other public roads include the Annapolis Road, King Ridge Road in the South Fork subwatershed, and Fish Rock Road, which is a Mendocino County road that runs along the north boundary of the Gualala River watershed.

2.2 Climate

The climate in the Gualala River watershed is temperate, especially on the coast, while more extreme temperatures occur inland. According to the Fort Ross climate station (located on the coast), the average annual temperature from 1948 to 2000 is 12.1°C (53.7°F), with an annual minimum of 7.1°C (44.7°F) and an annual maximum of 17.0°C (62.6°F) (Western Regional Climate Center, 2000a). In comparison, inland temperatures range from a low of below freezing to a high of 26-32°C (80-90°F) (CDFG, 1968).

Throughout the Gualala River watershed more than ninety percent of the annual precipitation falls between October and April, with the greatest amounts falling in January (EIP, 1994). The average annual precipitation recorded at the Fort Ross climate station between 1948 to 2000 is 38.69 inches per year (WRCC, 2000b). The amount of precipitation recorded at Fort Ross has varied from 71.27 inches in 1983 to 17.98 inches in 1976 (WRCC 2000a). Inland precipitation is higher than at the coast, with an average annual amount of approximately 65 to 70 inches per year (CDFG, 1968 and EIP Associates, 1994). Plate 3 shows the estimated average rainfall distribution throughout the Gualala River watershed.

2.3 Land and Water Use

2.3.1 Logging

The Town of Gualala has always been a mill town (Mendocino County Historical Society, 1965) and the surrounding forested lands of the Gualala River watershed supported the mills. Logging has been an ongoing activity in the watershed since 1862, when harvesting of the old growth began in the lower portion of the watershed (White Parks, 1980). The Mendocino County Historical Society (1965) counted seven mills along the coast near to and including Gualala between 1862 and 1869, with many more built in 1904. A railroad was built in 1872 and 1873 to move timber to Bourne's Landing located approximately 2.5 miles north of the Town of Gualala (Mendocino County Historical Society, 1965).

Logging activity slowed after 1908 until after World War II when a second logging boom began, aided by the advent of modern machinery, and fueled by a tax on standing timber. During the intervening period, extraction of tan oak bark for use in the leather tanning industry kept workers in the woods.

Evidence of the post-war logging boom was just beginning to show up in the northern parts of the watershed when aerial photos were taken in 1952. For the most part, the photos show mature stands of trees in the forested areas of the watershed, with very few roads. By 1965, aerial photos of the watershed show large areas denuded of trees and intensively scarred by roads and skid trails. The logging practices of the time had little consideration for water quality and fisheries, as evidenced by the common practice of using stream channels as roads and landings. In 1968, major timber harvesting in the watershed had slowed with active harvesting activities confined to the selective harvest of relatively small areas of second growth Redwood and Douglas Fir (CDFG, 1968).

Forestry is still a major land use today. Approximately thirty four percent (34%) of the Gualala River watershed is owned by timber companies (Parish, 1999). Pioneer Resources owns approximately 34,000 acres (approximately 18% of the total area of the Gualala River watershed), formerly owned by Coastal Forestlands, with around 6,000 acres in the North Fork, 9,000 acres in Rockpile Creek, 10,000 acres in Buckeye Creek, and 8,000 acres in other portions of the Gualala River watershed. Gualala Redwoods owns approximately 30,000 acres (approximately 16% of the total area of the Gualala River watershed) distributed across the mainstem and tributaries of the Gualala River watershed. Mendocino Redwoods Company owns approximately 4,500 acres (approximately 2% of the total area of the Gualala River watershed), formerly owned by Louisiana-Pacific, primarily in the Wheatfield Fork.

2.3.2 Agriculture

Agriculture has also been a significant land use in the Gualala watershed (EIP, 1994). Orchards were a significant agricultural activity in the past. Today, vineyards are beginning to become more common throughout the watershed and are likely to become more widespread. In the past, sheep and cattle ranching were prominent industries. Today grazing has become less significant.

2.3.3 Gravel Mining

The Gualala River watershed also has a history of instream gravel mining. The Draft EIR prepared for Gualala Aggregates, Inc. by EIP Associates (1994) states that instream extraction of gravel in the 1950s for use on logging roads was probably between 1,000 and 5,000 cubic yards per year. In the early 1960s, commercial extraction began and rates rose to approximately 20,000 cubic yards per year. In the latter half of the 1960s, the construction of residential roads at The Sea Ranch created an increased demand for aggregate, and rates rose to approximately 40,000 cubic yards per year. From 1974 to the present, a 40,000 ton per year gravel extraction limit has been in place for commercial extraction. Table 2.1 shows annual in-stream gravel extraction weight and volumes for 1981 through 1993. Gravel extraction since 1993 has been below the 40,000 ton per year gravel extraction limit.

Gualala Aggregates, Inc. manages a mining operation at a plant located beside the Gualala River near the confluence of the Wheatfield Fork and the Upper South Fork. Gualala Aggregates, Inc., which has extracted gravel from the South Fork Gualala River and Wheatfield Fork Gualala River since 1969, has performed most of their mining on two main gravel bars totaling about 26 acres. One gravel bar is located at the confluence of the two river forks, while the other is located 2 miles downstream of the confluence.

Gravel extraction has mainly been through gravel bar skimming. In the mid-1960s, trenching was tried but discontinued due to the high amounts of organic material encountered. Currently, gravel bar skimming is the method used to mine gravel.

TABLE 2.1. GUALALA AGGREGATES INC. INSTREAM GRAVEL EXTRACTION WEIGHT AND VOLUMES (TAKEN FROM EIP ASSOCIATES, 1994)

Year	Gravel Extraction Approximate Weight (tons)	Gravel Extraction Approximate Volume (cubic yards)
1981[1]	13,000	9,286
1982[1]	20,000	14,286
1983[1]	13,613	9,724
1984[2]	30,408	21,720
1985[2]	36,314	25,939
1986[2]	43,126	30,804
1987	36,138	25,813
1988	27,414	19,581
1989	30,963	22,116
1990	30,017	21,441
1991[3]	56,489	40,349
1992[3]	29,002	20,716
1993	10,291	7,351
Average	28,983	20,702

[1] EIP unable to verify
[2] Excludes sand and gravel used for construction near the mining site.
[3] Includes a new site only in use for 1991 and 1992.

US Geological Survey (USGS) flow gages were located approximately 540 feet and 2,200 feet downstream of the confluence of the South Fork of the Gualala River and the Wheatfield Fork of the Gualala River from 1950-1961 and 1962-1971 respectively. Gage height data indicate:

- 1.5 feet of aggradation occurred from 1950 to 1960 when extraction rates were approximately 1,000 to 5,000 cubic yards/year (EIP Associates, 1994).
- 1.0 feet of degradation occurred from 1960 to 1964 when extraction rates were approximately 20,000 cubic yards/year (EIP Associates, 1994).
- 0.75 feet of degradation occurred from 1964 to 1971 when extraction rates were approximately 40,000 cubic yards/year (EIP Associates, 1994).

Given the limited gage height data available, the impact of gravel mining on channel aggradation/degradation cannot be determined.

Observations in other rivers in Sonoma County have shown that in-stream gravel bar skimming may be responsible for a change in channel cross-section towards a more flattened bar form with relatively shallower pools (EIP Associates, 1994). Cross-sectional data is available in the Gualala Aggregates Draft EIR (EIP Associates, 1994). Cross-sectional is not adequate to indicate whether a change in cross-section to a more flattened channel bar has taken place in the vicinity of Gualala Aggregates mining operation.

2.3.4 Water Rights

The appropriation of water in California falls under the jurisdiction of the State Water Board, Division of Water Rights.

Appropriative water rights exist for a total of 2,162 acre-feet/year (af/y) of water from the Gualala River watershed, at a maximum diversion rate of 7.2 cubic feet per second (cfs) (WRIMS 2000). Although municipal use is the dominant water use in the watershed, other uses of diverted water include stockwatering, irrigation, and fire protection.

Because the watershed is sparsely populated, riparian extraction in the watershed is minimal (Sommerstrom 1992). The potential peak demand from this use and additional future riparian uses in the watershed was estimated to be 2.5 cfs (EIP 1994).

The North Gualala Water Company (NGWC) received an appropriative permit to divert water from the North Fork Gualala in 1964 which allows the extraction of 2 cfs on a year round basis. The NGWC served 902 hook-ups in 1995 and was limited to a maximum of 1034 hook-ups (Higgins 1997 and WRIMS 2000).

In November 1999, the State Water Board stipulated that when the natural flow in the North Fork of the Gualala falls below the minimum requirements of 4 cfs, the NGWC would be prohibited from diverting any water from the North Fork (SWRCB, 1999). In August 2000, the State Water Board ruled that this order applied to both surface water diversions and two NGWC groundwater wells that had been previously found to fall under the State Water Board's jurisdiction (SWRCB, 2000).

The Sea Ranch once drew surface water from the South Fork Gualala by using a summer dam, but they currently draw water from the aquifer below the lower South Fork Gualala and have augmented storage with an off-site reservoir (Higgins, 1997). The Sea Ranch's water right from the State Water Board allows for a maximum extraction of 2.8 cfs, although the maximum diversion in 1994 was 0.56 cfs (EIP, 1994).

Other water users in the Gualala River watershed include agriculture and rural development. As stated in the Gualala River Watershed Literature Search and Assimilation (Higgins, 1997):

> "While agricultural water use in the Gualala River watershed has been very low in the past, wineries are now being developed in some areas. These wineries may have a direct impact on tributary flow if surface water is used. If wells are drilled in upland areas, and if the aquifer is joined to headwater springs, flows in some tributaries could be affected. EIP Associates (1994) projected that development of vacation homes or residences could result in use of up to 2.5 cfs for the entire basin."

Current low flow constraints in the Gualala River would most likely prohibit future additional appropriative water allocations; however, greater use of the rights allocated to the Sea Ranch is expected in the future (EIP, 1994).

2.4 Geology

The Gaulala River watershed is typical of watersheds in “The California Coast Ranges between San Francisco and the Oregon border [which] contain the most rapidly eroding, large-order, non-glaciated drainage basins of comparable size in the United States (Judson and Ritter, 1964). The combination of the underlying pervasively sheared and often folded Franciscan rocks (Bailey et. al., 1964), recent uplift, and a distinctive climate accounts for the large sediment yields” (Kelsey et. al. 1981).

Plate 4 illustrates the distribution of the types of geologic formations found in the Gualala River watershed.

2.4.1 Soils

Soil types within the Gualala River watershed are varied. The predominate soil is the Hugo-Josephine-Laughlin Association which occurs inland. The Hugo-Josephine-Laughlin Association is well-drained with gently sloping to very steep gravely loams (Miller 1972). Loams are soils consisting of a friable mixture of clay, silt, and sand. The soils of this association are formed in material derived from weathered, fine-grained, hard sandstone and shale (Miller 1972). Hugo and Josephine soils are the best in Sonoma County for commercial timber production. Laughlin soils are used extensively as range and pasture (Miller 1972).

According to the Soil Survey of Sonoma County (Miller 1972), the Empire-Caspar-Mendocino Association is a well-drained and moderately well-drained soil that consists of strongly sloping sandy loams and sandy clay loams. These soils are found in the coastal uplands and terraces that run parallel to the coast.

Soils of the Yorkville-Suther Association are found in patches in the upper areas of Wolf Creek, a tributary to Wheatfield Fork, and Marshall Creek, a tributary to the South Fork. These soils are moderately well drained with moderately sloping to very steep loams and clay loams (Miller 1972). The Yorkville-Suther Association is found on ultrabasic rock intrusions, other igneous rock, and on sedimentary rock. Yorkville and Suther soils are used primarily for pasture and range (Miller 1972).

2.4.2 Faults

One of the most striking geomorphic features of the landscape is the San Andreas Rift, an active fault that traverses the Gualala River watershed, running directly under the South Fork and Little North Fork of the Gualala River. “. . . The San Andreas fault zone has formed the 1 to 1.5 mile wide rift valley along which the Garcia and Gualala Rivers flow” (Williams and Bedrossian 1976). The Gualala Ridge, an elongate, forested, northwestward trending ridge, forms the drainage divide between the short streams that flow directly westward to the ocean and the rift valley containing the South Fork Gualala River (Williams and Bedrossian 1976).

According to Geology for Planning in Sonoma County (Knox and Huffman 1980), many other faults are located within the Gualala River watershed, although none besides the San Andreas Fault is known to be active. One such fault runs from the mouth of Buckeye Creek under the length of Miller Ridge. Several other smaller faults are found in the highly fractured areas of Skyline Ridge, Table Mountain, and Mohrhardt Ridge. The Mount Jackson Fault cuts through the eastern Gualala River watershed on a northwestward trend paralleling the coast approximately ten miles inland.

2.4.3 Alluvium

Alluvial Terrace Deposits (Qrt) are found along most of the watercourses of the Gualala River watershed. This surficial formation consists of poorly consolidated flat-lying deposits of silt, sand, and gravel elevated above present streams and rivers (Davenport 1984). Within the channel itself, Stream/River Channel Deposits (Qsc) are found. Consisting of silt, sand, and gravel, these deposits are characteristically unvegetated (Davenport 1984). Marine Terrace Deposits (Qmtd) are also found at the mouth of the Gualala River. These deposits are poorly to moderately consolidated deposits of marine silts, sands, and quartz-rich pea gravels (Davenport 1984).

2.4.4 Bedrock

2.4.4.1 Bedrock West of the San Andreas Fault

Bedrock west of the San Andreas Fault consists of sedimentary sandstone, mudstone, shale, and conglomerate (Williams and Bedrossian 1976). In many places, these units , are interfingered and very difficult to distinguish from each other on the basis of appearance. The German Rancho Formation (Tg) can be found on the slopes on the west side of the San Andreas Fault. This formation is composed of well-bedded sandstone, mudstone, and conglomerate and contains abundant potassium feldspar (Knox and Huffman, 1980). Also present west of the San Andreas Fault are minor amounts of the Anchor Bay Formation (Ka) and the Stewarts Point Formation (Ks and Ksb) (Knox and Huffman 1980).

2.4.4.2 Bedrock East of the San Andreas Fault

Bedrock east of the San Andreas Fault is almost entirely composed of the heterogeneous Franciscan assemblage, of Late Jurassic through Cretaceous age. One sub-unit of the Franciscan assemblage is the Coastal Belt Franciscan, the youngest and least sheared and broken sub-unit, which contains mostly sandstone. Generally, slopes are steep, as they are underlain by hard rock. Debris slides are common. The Coast Belt of the Franciscan Complex is the predominant formation east of the San Andreas Fault and is found extensively in each of the sub-watersheds (Knox and Huffman, 1980 and McKittrick 1995).

The Central Belt of the Franciscan Assemblage is the most unstable sub-unit. The Central Belt melange unit is characterized by grassy and brushy slopes and contains a huge expanse of sheared rock which forms the matrix that envelopes rock blocks of various sizes and types, including sandstone, shale, blue schist, metavolcanic, amphibolite, and sepentinite (Huffman 1972). The Central Belt of the Franciscan Assemblage is found in the Gualala River watershed in ribbons that run parallel to the coast. These ribbons can be found in the eastern portions of the North Fork, Rockpile Creek, and Buckeye Creek subwatersheds (Knox and Huffman 1980 and McKittrick 1995). Another ribbon runs from the mouth of Buckeye Creek, under Miller Ridge, and along Marshall Creek. The Central Belt of the Franciscan Assemblage becomes more prominent in the area between House and Pepperwood Creeks of the Wheatfield Fork and Marshall Creek of the South Fork subwatershed (Knox and Huffman 1980).

Scattered throughout the Gualala River watershed are patches of the Ohlson Ranch Formation, which is composed of sandstone, siltstone, and conglomerate (Knox and Huffman, 1980). These patches are most often located on ridges and upland slopes near the coast. Several of the larger patches of the Ohlson Ranch Formation are found around Annapolis and along Miller Ridge (Knox and Huffman, 1980).

2.5 Hydrology

The Mainstem Gualala River flows from the confluence of the South Fork and North Fork to the Pacific Ocean. This reach is greatly influenced by seasonal closures of the river mouth, which typically occur in early summer and last until the first heavy rains of October or November, although it may also close briefly during the winter months (CDFG 1968 and EIP 1994).

The USGS historically operated five stream flow gaging stations in the Gualala River watershed (Table 2.2). Two were located on an unnamed tributary to the Wheatfield Fork near Annapolis, Stations 11467298 and 11467300, with drainage areas of 0.33mi^2 and 0.19mi^2, respectively. Station 11467500, named "South Fork Gualala River Near Annapolis, CA" drains an area of 161 mi^2. Station 11467510 named "South Fork Gualala River Near The Sea Ranch, CA" is located in close proximity to Station 11467500, and has only recent, low flow records from June 1991 to August 1993.

The "South Fork Gualala River Near Annapolis, CA" gage (Station 11467500) installed and maintained by the USGS between 1950 to 1971 monitored a drainage area of 161mi^2 and provides the most accurate flow data available. However, the length of this hydrologic record is only twenty years, and may be somewhat wetter or drier than long-terms conditions at the site (Higgins 1997). Additional data is available for 1991 through 1994 for this station, however, flows above 1,000 cfs are not available.

TABLE 2.2. HISTORICAL STREAMFLOW GAGES OPERATED BY THE USGS

Station Number	Station Name	Period of Record	Drainage Area (sq. mi)	Data Type
11467298	Unnamed Tributary 1 to Wheatfield Fork Gualala River Near Annapolis	10/70 – 9/73	0.33	Peak flow
11467300	Unnamed Tributary 2 to Wheatfield Fork Gualala River Near Annapolis	10/61 – 9/70	0.19	Peak flow
11467500	South Fork Gualala River Near Annapolis	10/50 – 9/71 6/91 – 6/94	161	Continuous record (after 6/91 no record above 1,000 cfs)
11467510	South Fork Gualala River Near the Sea Ranch	6/91 – 12/91 5/92 – 8/93	161	Continuous record
11467300	China Gulch at Gualala, CA	10/61 – 9/73	0.54	Peak flow

A summary of the continuous discharge data was provided by EIP Associates (1994). Mean monthly streamflows are presented in Table 2.3. The maximum instantaneous peak streamflow at the gage during the period of record was measured at 55,000 cfs on December 22, 1955.

TABLE 2.3. GUALALA MEAN MONTHLY AND MAXIMUM YEARLY PEAK STREAM FLOW VALUES

Mean Monthly Flow, 1951-1971* South Fork Gualala River at USGS Gage 11467500	
Month	Mean Flow/Discharge (cfs)
January	1,471
February	1,159
March	626
April	410
May	117
June	37
July	13
August	7
September	10
October	77
November	245
December	1,026

Largest Peak Flows, 1951-1971* South Fork Gualala River at USGS Gage 11467500	
Water Year (Oct. – Sept.)	Peak Flow/Discharge (cfs)
1956	55,000
1965	47,800
1962	37,700
1954	35,900
1970	35,800
1958	35,400
1951	34,100
1953	33,900
1960	33,700
1952	29,500
1969	29,100
1967	28,900
1971	27,900

* from EIP 1994

Boccone and Rowser (1977) measured flows in the lower portions of the Gualala River during the drought period of 1976-77. Their results, as summarized by Higgins (1997), recorded a total low flow of 12.4 cfs in the Mainstem of the Gualala River. Of this flow, 3 cfs was contributed by the Wheatfield Fork and Upper South Fork, and 4.3 cfs by the North Fork, with the remaining approximately 5 cfs draining from Pepperwood, Buckeye, and Rockpile Creeks.

2.6 Vegetation

Plate 4 illustrates the distribution of the types of vegetation found in the Gualala River watershed. Generally speaking, the headwaters area of the South Fork and Wheatfield Fork subwatersheds are characterized by steep slopes forested by redwood, Douglas fir, madrone, and tan oak. Open grasslands are also interspersed throughout the headwaters of the North Fork, Rockpile Creek, Buckeye Creek, and Wheatfield Fork subwatersheds (CDFG 1968). Streamside vegetation consists primarily of red alder, California laurel, and redwood. Dense stands of redwood and some fir and hardwoods occur to within one quarter mile of the coast. A very narrow coastal prairie strip is present near the mouth and along the coast (CDFG 1968).

2.6.1 Fire History of the Gualala River watershed

The California Department of Forestry (CDF) and the United States Department of Agriculture (USDA) Forest Service have developed a comprehensive fire perimeter Graphical Information System (GIS) layer throughout the state. The data covers the period of 1950 to 1999, and includes CDF fires 300 acres and greater, and USFS fires 10 acres and greater.

Although CDF acknowledges that the database is incomplete, and the intensities of the fires listed are unknown, two general observations can be made from the fire perimeter GIS layer in the Gualala watershed:

1) Most of the documented acreage in the database burned in the period between 1950 and 1959 (Figure 2.1). This coincided with perhaps the peak rate of timber harvest in the watershed and may have exacerbated the effects of timber harvest activities on sediment loading to the streams.

2) Two areas in the headwaters of the South Fork Gualala and Wheatfield Fork tributaries burned repeatedly during the last fifty years; the habitat of these tributaries may have been severely impacted by increased sediment loading.

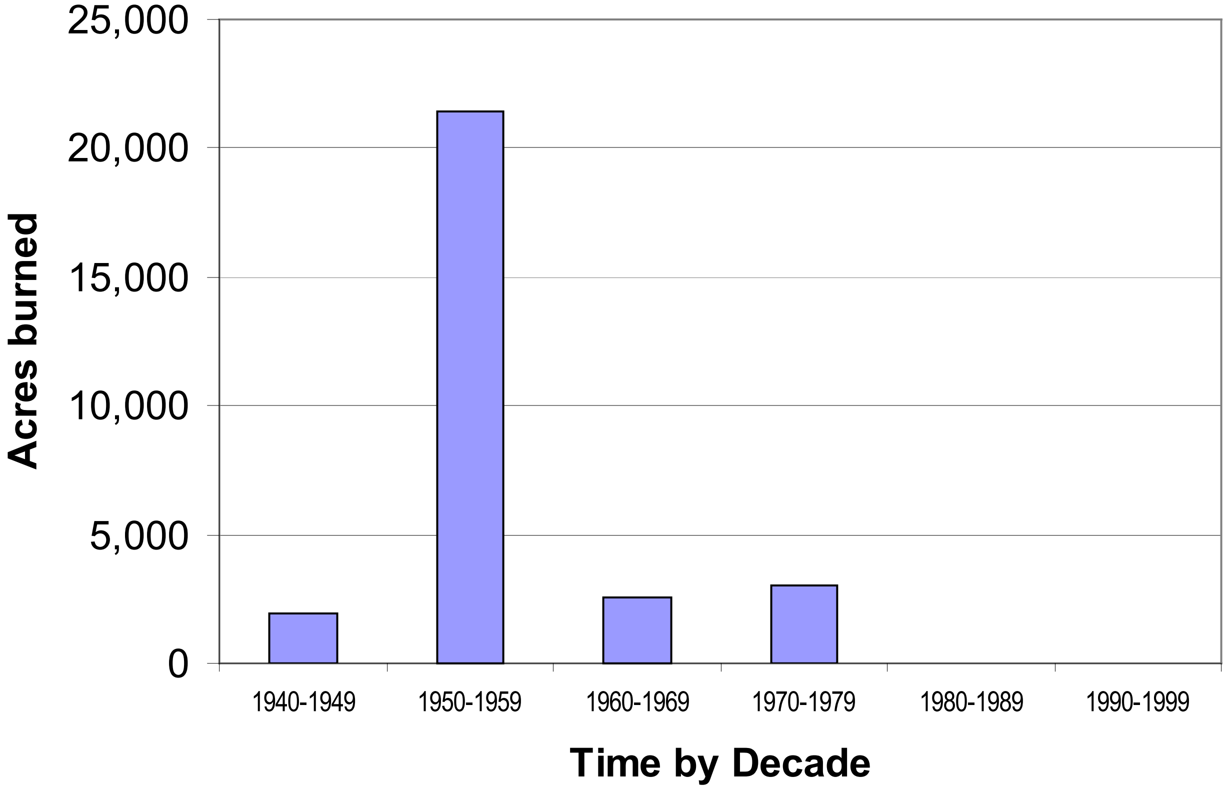

FIGURE 2.1. ACREAGE BURNED BY WILDFIRES IN THE GUALALA RIVER WATERSHED (1940-1999). (SOURCE: CALIFORNIA DEPARTMENT OF FORESTRY FIRE HISTORY DATABASE)

The relative lack of recent fire activity in the watershed may increase the possibility of catastrophic fire and associated massive sediment release in the near future. The Gualala River Watershed Council (GRWC) plans in the near future (fall 2001) to develop fuels management strategies for fire protection (Timothy Osmer, pers. communication, 2001).

CHAPTER 3
REGULATORY FRAMEWORK

The following laws and regulations can be divided into two categories. Laws such as the Clean Water Act (CWA), the Porter-Cologne Water Quality Control Act, and the Endangered Species Act are included in the first category because they lay the groundwork for TSD and TMDL development and establish legal authority. Laws such as the Z'Berg-Nejedly Forest Practice Act, the California Environmental Quality Act, and the Non-Point Source Program Strategy and Implementation Plan are included in the second category because they regulate land use management and are therefore applicable to the Gualala River watershed.

3.1 Clean Water Act

The TMDL program is required by Section 303(d)(1)(A) of the CWA that states, "Each State shall identify those waters within its boundaries for which the effluent limitations . . . are not stringent enough to implement any water quality standard applicable to such waters." The same part of the CWA also requires that the State "establish a priority ranking for such waters, taking into account the severity of the pollution and the uses to be made of such waters." In accordance with Section 303(d)(1)(A), the Regional Water Board adopted, through Resolution No. 98-45 on April 23, 1998, a priority list of waters within the North Coast Region in which water quality standards are not being met. The Gualala River is included on that list based on the finding that sedimentation is, in part, responsible for the impairment of the cold water fisheries. Section 303(d)(1)(C) of the CWA requires that "Each State shall establish for the waters identified in paragraph (1)(A) of this subsection, and in accordance with the priority ranking, the total maximum daily load . . ."

Pursuant to a Consent Decree entered in the United States District Court, Northern District of California (*Pacific Coast Federation of Fishermen's Associations, et al. v. Marcus,* No. 95-4474 MHP, March 11, 1997), the U.S. EPA committed to assuring that TMDLs would be established for eighteen rivers by December 31, 2007. Pursuant to the Consent Decree, the U.S. EPA developed a Supplemental TMDL Establishment Schedule, which set December 31, 2001, as the deadline for the establishment of a TMDL for the Gualala River.

This Gualala River watershed TSD is intended to meet federal requirements for a TMDL, but contains no implementation or monitoring plan and no action on the part of the Regional or State Board. TSDs have not been through the Regional Water Board's or State Water Board's public participation and adoption process. The Gualala River watershed TSD for sediment will be transmitted directly to U.S. EPA upon completion by Regional Water Board staff. U.S. EPA uses the TSD to develop a draft Total Maximum Daily Load (TMDL) for the Gualala River watershed that is publicly noticed for comment.

3.2 Porter-Cologne Water Quality Control Act and The Water Quality Control Plan, North Coast Region (Basin Plan)

Existing water quality requirements are described in the Basin Plan, which is the tool for comprehensive water quality planning as set forth in both California's Porter-Cologne Water Quality Control Act and the federal Clean Water Act. The North Coast Region includes all of the watersheds draining into the Pacific Ocean from the California-Oregon state line to the southern boundary of the watershed of the Estero de San Antonio and Stemple Creek in Marin and Sonoma Counties. It also includes the Lower Klamath Lake and Lost River Basins. The Basin Plan is comprehensive in scope and is regularly updated through Basin Plan amendments to ensure that new information and issues are adequately addressed.

Among other things, the Basin Plan describes the existing and potential beneficial uses of the surface and ground waters in each of the watersheds throughout the North Coast Region. It also identifies both numeric and narrative water quality objectives, the attainment of which is considered essential to protect the identified beneficial uses. The Gualala River is impaired and does not meet the Basin Plan's water quality objectives for sediment. Development and implementation of a TMDL is one means of attaining water quality objectives and protecting beneficial uses in the Gualala River.

The Basin Plan also includes implementation plans that describe the means by which specific water quality issues will be addressed by the Regional Water Board, including specific prohibitions, action plans, and policies. The implementation plans associated with TMDLs are established under the authority of the Porter-Cologne Water Quality Control Act through the Basin Plan process amendment process.

3.2.1 Beneficial Uses

The Basin Plan identifies the following existing beneficial uses of water in the Gualala River watershed:

- Municipal and Domestic Supply (MUN)
- Agricultural Supply (AGR)
- Industrial Service Supply (IND)
- Recreational Uses (REC-1 & REC-2)
- Commercial and Sport Fishing (COMM)
- Cold Freshwater Habitat (COLD)
- Migration of Aquatic Organisms (MIGR)
- Spawning, Reproduction, and/or Early Development (SPWN)
- Estuarine Habitat (EST)
- Wildlife Habitat (WILD)
- Groundwater Recharge (GWR)
- Navigation (NAV)

The beneficial uses identified above as COMM, COLD, MIGR, SPWN, and EST are all related to the Gualala River watershed's cold water fisheries. Beneficial uses associated with the cold water fisheries appear to be the most sensitive in the watershed. As such, protection of these beneficial uses is presumed to protect any of the other beneficial uses that might also be harmed by sedimentation.

The COMM beneficial use applies to water bodies in which commercial or sport fishing occurs or historically occurred for the collection of fish, shellfish, or other organisms, including, but not limited to, the collection of organisms intended either for human consumption or bait purposes. The COLD beneficial use applies to water bodies that support or historically supported cold water ecosystems, including, but not limited to, the preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates. The MIGR beneficial use applies to water bodies that support or historically supported the habitats necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish. The SPWN beneficial use applies to water bodies that support or historically supported high quality aquatic habitats suitable for the reproduction and early development of fish. The EST beneficial use applies to water bodies that support or historically supported estuarine ecosystems, including, but not limited to, the preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds).

3.2.2 Water Quality Objectives

The Porter-Cologne Water Quality Control Act, Chapter 4, Section 13241 specifies that each regional board shall establish water quality objectives which, in the regional board's judgment, are necessary for the reasonable protection of the beneficial uses and for the prevention of nuisances. The water quality objectives are considered to be necessary to protect those present and probably future beneficial uses stated above and to protect existing high quality waters of the state. As new information becomes available, the Regional Water Board will review the appropriateness of existing and proposed water quality objectives and amend the Basin Plan accordingly.

The following is a summary of water quality objectives for the Gualala River watershed according to the Basin Plan, as amended in 1996.

TABLE 3.1. NARRATIVE WATER QUALITY OBJECTIVES

Objective	Description
Color	Waters shall be free of coloration that causes nuisance or adversely affects beneficial uses.
Tastes and Odors	Waters shall not contain taste- or odor-producing substances in concentrations that impart undesirable tastes or odors to fish flesh or other edible products of aquatic origin, or that cause nuisance or adversely affect beneficial uses.

Objective	Description
Floating Material	Waters shall not contain floating material, including solids, liquids, foams, and scum, in concentrations that cause nuisance or adversely affect beneficial uses.
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.
Oil and Grease	Waters shall not contain oils, greases, waxes, or other materials in concentrations that result in a visible film or coating on the surface of the water or on objects in the water, that cause nuisance, or that otherwise adversely affect beneficial uses.
Biostimulatory Substance	Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause 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 alteration in temperature does not adversely affect beneficial uses. At no time or place shall the temperature of any COLD water be increased by more than 5°F above natural receiving water temperature.
Toxicity	All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life.
Pesticides	No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses. There shall be no bioaccumulation of pesticide concentrations found in bottom sediments or aquatic life.
Chemical Constituents	Waters designated for use as agricultural supply (AGR) shall not contain concentrations of chemical constituents in amounts which adversely affect such beneficial uses.
Radioactivity	Radionuclides shall not be present in concentrations which are deleterious to human, plant, animal or aquatic life nor which result in the accumulation of radionuclides in the food web to an extent which presents a hazard to human, plant, animal, or indigenous aquatic life.

TABLE 3.2. NUMERIC WATER QUALITY OBJECTIVES

Objective	Description
Turbidity	Turbidity shall not be increased more than 20 percent above naturally occurring background levels.
pH	The pH of waters shall always fall within the range of 6.5 to 8.5.
Dissolved Oxygen	At a minimum, waters shall contain 7.0 mg/L at all times. Ninety percent of the samples collected in any year must contain at least 7.5 mg/L. Fifty percent of the monthly means in any calendar year shall contain at least 10.0 mg/L.
Bacteria	The bacteriological quality of waters of the North Coast Region shall not be degraded beyond natural background levels. Based on a minimum of not less than five samples for any 30-day period, the median fecal coliform concentrations in waters designated for contact recreation (REC-1) shall not exceed 50/100 ml. Nor shall more than ten percent of total samples during any 30-day period exceed 400/100 ml.
Specific Conductance	Ninety percent of the samples collected in any year must not exceed 285 micromhos at 77°F. Fifty percent of the monthly means in any calendar year shall contain at least 250 micromhos at 77°F.
Total Dissolved Solids	Ninety percent of the samples collected in any year must not exceed 170 mg/L. Fifty percent of the monthly means in any calendar year shall contain at least 150 mg/L.

3.2.3 Prohibitions

In addition to water quality objectives, the Basin Plan includes two discharge prohibitions specifically applicable to logging, construction, and other associated non-point source activities. The prohibitions state:

- The discharge of soil, silt, bark, slash, 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.

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

3.3 Endangered Species Act

Originally passed in 1973, the Endangered Species Act (at 16 U.S.C. section 1531 et seq.; ESA) is a federal law that provides for the designation and protection of invertebrates, wildlife, fish, and plant species that are in danger of becoming extinct and their habitats. The ESA makes it illegal for any individual to take an endangered or threatened species without a permit from the Secretary of the Department of the Interior or the Department of Commerce. An endangered species is any species that is in danger of becoming extinct throughout all or a significant portion of its range, excluding recognized insect pests. A threatened species is one that is likely to become endangered in the foreseeable future. For a species to receive the full protection accorded by the ESA, the species must be placed on the List of Endangered and Threatened Wildlife and Plants. As resources are not available to immediately add all species that are in danger of extinction to that list, another list is maintained for candidate species. Candidate species are plants and animals native to the United States for which there is sufficient information on biological vulnerability and threats to justify proposing to add them to the threatened and endangered species list, but cannot do so immediately because other species have a higher priority for listing.

The Fish and Wildlife Service under the U.S. Department of the Interior performs most administrative and regulatory actions under the ESA. The National Marine Fisheries Service (NMFS) in the U.S. Department of Commerce deals with actions affecting marine species, including salmonids.

The listing process generally begins with a petition to the Secretary of the Interior or the Secretary of Commerce. Consultation with affected states is required prior to listing, but the Secretary makes the final decision. Whenever possible, a designation of critical habitat accompanies the listing of an endangered or threatened species. Critical habitat is the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of 16 USC §1533, on which are found those physical or biological features essential to the conservation of the species and which may require special management considerations or protection. An area may also be designated as critical habitat if the Secretary feels it is essential for conservation of the species. Critical habitat shall not include the entire geographical area which can be occupied by the threatened or endangered species except in those circumstances determined by the Secretary. The Secretary must publish and periodically update the lists and develop and implement recovery plans for the conservation and survival of endangered and threatened species.

On May 6, 1997, the NMFS listed coho salmon in the Northern California/Southern Oregon Coasts Evolutionarily Significant Unit (ESU) as a threatened species (50 CFR §227). This ESU includes all naturally spawned populations of coho salmon in coastal streams between Cape Blanco, Oregon, and Punta Gorda, California. On June 7, 2000, NMFS also listed steelhead trout in the Northern California Evolutionarily Significant Unit (ESU) as a threatened species (50 CFR §223). The Northern California ESU includes steelhead in California coastal river basins from Redwood Creek south to the Gualala River, inclusive. These listings are results of observed substantial declines in the salmonid populations over time and provide evidence that the beneficial uses as described in the Basin Plan are not being protected.

3.4 Z'Berg-Nejedly Forest Practice Act & the California Forest Practice Rules

The Z'Berg-Nejedly Forest Practice Act of 1973 (Forest Practice Act) is a state law to ". . . encourage prudent and responsible forest resource management calculated to serve the public's need for timber and other forest products, while giving consideration to the public's need for watershed protection, fisheries and wildlife, and recreational opportunities alike in this and future generations" (Pub. Res. Code §4511(c)). The California Forest Practice Rules implements the Forest Practice Act of 1973 "in a manner consistent with other laws, including but not limited to, the Timberland Productivity Act of 1982, the California Environmental Quality Act (CEQA) of 1970, the Porter Cologne Water Quality Act, and the California Endangered Species Act" (14 CCR §896(a)). Specifically, the Forest Practice Rules:

> . . . shall apply to the conduct of timber operations and shall include, but shall not be limited to, measures for fire prevention and control, for soil erosion control, for site preparation that involves disturbance of soil or burning of vegetation following timber harvesting activities conducted after January 1, 1988, for water quality and watershed control, for flood control, for stocking, for protection against timber operations which unnecessarily destroy young timber growth or timber productivity of the soil, for prevention and control of damage by forest insects, pests, and disease, for the protection of natural and scenic qualities in special treatment areas . . ., and for the preparation of timber harvesting plans (Pub. Res. Code §4551.5).

3.4.1 Timber Harvest Plans

One of the main mechanisms used by the California Department of Forestry (CDF) to implement the Forest Practice Rules is through Timber Harvesting Plan (THP) requirements. As the Forest Practice Act states, "No person shall conduct timber operations unless a timber harvesting plan prepared by a registered professional forester has been submitted for such operations . . ." (Pub. Res. Code §4581). "Timber harvesting plans shall be applicable to a specific piece of property or properties and shall be based upon such characteristics of the property as vegetation type, soil stability, topography, geology, climate, and stream characteristics" (Pub. Res. Code §4582.5). The THP approval process is a certified regulatory program (the functional equivalent of an Environmental Impact Report) under CEQA.

Both the Forest Practice Act and the Forest Practice Rules set out technical requirements for a Timber Harvesting Plan. Once CDF receives a THP, copies are made available for public review and copies are sent to the appropriate regional water board and the Department of Fish and Game for comments and recommendations per section 4582.6(a) of the Forest Practice Act. These comments ". . . shall be considered based on the comments' substance, and specificity, and in relation to the commenting agencies' area(s) of expertise and statutory mandate, as well as the level of documentation, explanation or other support provided with the comments" (14 CCR §1037.3). In addition, "the board of supervisors or planning commission of any county... may request a public hearing on any timber harvesting plan submitted for lands within the county ..." (Pub. Res. Code §4582.6(d)).

If it is determined that the THP is not in conformance with the Forest Practice Rules, the plan shall be returned to the applicant. "In addition the Director shall state any changes and reasonable conditions that in the Director's professional judgment are needed to bring the plan into conformance with the applicable rules of the Board and offer to confer with the RPF [Registered Professional Forester] in order to reach agreement on the conditions necessary to bring the plan into conformance" (14 CCR §1037.6). However, "If the plan is in conformance with the rules of the Board, then the person submitting the plan shall be notified, and timber operation thereunder may commence" (14 CCR §1037.7). The Forest Practice Rules state that "Protection of the quality and beneficial uses of water during the planning, review, and conduct of timber operations shall comply with all applicable legal requirements including those set forth in any applicable water quality control plan adopted or approved by the State Water Resources Control Board." (14 CCR §916, 936, 956)

A THP is effective for not more than three years, unless work on a THP has commenced but not completed. In that case, the THP may be extended by amendment for a one-year period in order to complete the work, up to a maximum of two one-year extensions (Pub. Res. Code §4590(a)(1), (2)). Stocking work may continue for more than this time period, ". . . but shall be completed within five years after the conclusion of other work" (Pub. Res. Code §2590(b)).

3.4.2 Sustained Yield Plans

Another mechanism used by CDF to implement the California Forest Practice Rules is through a Sustained Yield Plan, or SYP. "Consistent with the protection of soil, water, air, fish and wildlife resources, a SYP shall clearly demonstrate how the submitter will achieve maximum sustained production of high quality timber products while giving consideration to regional economic vitality and employment at planned harvest levels during the planning horizon" (14 CCR 1091.4.5(a)). Although there is no maximum size area that a SYP can apply to, a Sustained Yield Plan shall at least encompass a planning watershed (14 CCR §1091.6(a)). In addition, "The effective period of SYPs shall be no more than ten years" (14 CCR §1091.9).

While a SYP focuses on sustained timber production, watershed impacts, and fish and wildlife, the SYP is not designed to replace a Timber Harvesting Plan. "However, to the extent that sustained timber production, watershed impacts and fish and wildlife issues are addressed in the approved SYP, these issues shall be considered to be addressed in the THP; that is the THP may rely upon the SYP" (14 CCR 1091.3).

The Forest Practice Act can be found in the California Public Resources Code, Division 4, Part 2, Chapter 8. The California Forest Practice Rules can be found in Title 14 of the California Code of Regulations, Chapter 4 and 4.5. For inquires regarding the Forest Practice Act or the California Forest Practice Rules, please contact the California Department of Forestry and Fire Protection. The Gualala River watershed is a part of the Coast Forest District, which runs from the Oregon border to Santa Cruz County.

3.5 California Environmental Quality Act

CEQA (at Pub. Res. Code section 21000 et seq.) was enacted in 1970 in order to ensure that state and local agencies consider the environmental impact of their decisions when approving or carrying out a public or private project. CEQA is the broadest of California's environmental laws as it applies to all discretionary activities proposed to be carried out or approved by a public agency. CEQA is a component of the regulatory framework that influences land use regulations within the Gualala River watershed, and is therefore included in the Gualala River TSD.

The CEQA process begins with the identification of a project. Projects are activities which will potentially have a physical impact on the environment, directly or indirectly, such as an activity involving a public agency's issuance of a lease, permit, license, certificate, or other entitlement for use by a public agency (14 CCR §15378). CEQA requires a public agency approving or carrying out a project to complete an environmental review process to evaluate the environmental impacts of a project prior to approving or carrying out the project.

Once a lead agency has been established and project status is determined, the next step is to decide if a project is exempt from CEQA. Statutory exemptions from CEQA include, but are not limited to, ministerial projects or when a State of Emergency has been declared by the governor. Categorical exemptions include, but are not limited to, basic data collection, research, experimental management, and resource evaluation activities (14 CCR §15306). A third category, Certified Regulatory Programs, also fall as exempt from CEQA. Certified Regulatory Programs, however, must still contain elements of CEQA's environmental review process.
If a project is not exempt, the next step is to perform an Initial Study to identify potential environmental impacts of the project. The Initial Study may use a checklist format but must disclose the factual data or evidence used to reach conclusions regarding the significance of potential impacts. The Initial Study leads to a determination of the need for one of the following documents:

- Negative Declaration – A Negative Declaration is a written statement briefly explaining why a proposed project will not have a significant environmental effect.

- Mitigated Negative Declaration –A Mitigated Negative Declaration is a written statement describing project revisions that will mitigate potential significant impacts (14 CCR §15070(b)(1)).

- Environmental Impact Report (EIR) – An EIR is a detailed informational document prepared by a lead agency that analyzes a project's significant effects and identifies mitigation measures and reasonable alternatives (14 CCR §15121, 15362).

The California Environmental Quality Act can be found in the California Public Resources Code, Division 13, beginning at Section 21000. The Guidelines for Implementation of the California Environmental Quality Act can be found in Title 14 of the California Code of Regulations, Chapter 3, beginning with Section 15000.

3.6 Non-Point Source Program Strategy and Implementation Plan, 1998-2013

The Non-Point Source Program Strategy and Implementation Plan, 1998-2013 (Non-Point Source Plan), was adopted by the State Water Board and California Coast Commission on December 14, 1999 and January 11, 2000, respectively, and approved by the U.S. Environmental Protection Agency and the National Oceanic and Atmospheric Administration on July 17, 2000.

The purpose of the Non-Point Source Plan is to improve the State's ability to effectively manage non-point source pollution and conform to the requirements of the federal Clean Water Act and the federal Coastal Zone Act Reauthorization Amendments of 1990 (CZARA). Specifically, Section 319 of the Clean Water Act requires each state to develop a statewide non-point source plan containing specified components, including management measures to control non-point source pollution. Section 6217 of CZARA requires each coastal state to develop and implement management measures to control non-point source pollution in coastal areas.

The first Non-Point Source Plan was developed in 1988 in order to meet the requirements of Section 319 of the CWA. However, with the passage of CZARA in 1990, the state decided to propose a statewide plan that would meet both statutes.

The current Non-Point Source Plan outlines a fifteen year strategy for gradually limiting non-point source pollution throughout California. The Non-Point Source Plan outlines how federal, state, and local agencies will identify the most urgent needs for non-point source controls, and will utilize their authority under existing laws to implement non-point source controls. This includes sixty-one Management Measures (MMs) that are to be implemented by 2013. The MMs are divided into categories for agriculture, forestry, urban areas, marinas and recreational boating, hydromodification, and wetlands and riparian areas. Some examples of individual MMs are listed below:

- Under the Agriculture category, develop numeric nutrient criteria and standards for heavy metals in organic and inorganic fertilizers by 2003 (MM 1C).
- Under the Agriculture category, develop TMDLs that include rangeland load allocations for the Humboldt and Garcia River watersheds along the North Coast by 2003 (MM 1E).
- Under MM 1A, Erosion and Sediment Control, in the Agriculture category, promote interagency coordination to improve information transfer and to provide a singular agency perspective in the Russian, Gualala, Garcia, and Navarro Rivers.
- Under MM 1A, Erosion and Sediment Control, in the Agriculture category, promote hillside vineyard management practices to reduce erosion/sedimentation and improve riparian function and fish habitat in the Russian, Gualala, Garcia, and Navarro Rivers.
- Under the Forestry category, plan silvicultural activities to reduce potential delivery of pollutants to surface waters (MM 2A).
- Under the Forestry category, conduct road construction/reconstruction so as to reduce sediment generation and delivery (MM 2C).
- Under the Urban Area category, mitigate the impacts of urban runoff and associated pollutants that result from new development or redevelopment (MM 3.1).
- Under the Urban Area category, provide financial, technical, and educational assistance to help ensure that on-site disposal systems are located, designed, installed, operated, inspected,

and maintained to prevent the discharge of pollutants onto surface water and into ground water (MM 3.4)

- Under the Urban Area category, implement educational programs to provide greater understanding of watersheds (MM 3.6A).
- Under the Marina and Recreational Boating category, site and design marinas to protect against adverse impacts on fish and shellfish, aquatic vegetation, and important locally, State, or federally designated habitat areas (MM 4.1C).
- Under the Hydromodification category, by the year 2002, develop a technical assistance manual that will assist local governments and small businesses with guidelines for designing projects to avoid wetlands and riparian areas (MM 5.1).

The Non-Point Source Plan relies on a so-called "three tier" approach toward implementation. Tier One is a self-determined approach which allows property owners and others to implement Best Management Practices (BMPs) that they have determined to be appropriate for solving their non-point source problems before more stringent regulatory actions are taken. Tier Two is the regulatory-based encouragement of management practices. For example, the Regional Water Board can waive waste discharge requirements on the condition that management measures or best management practices be implemented. Tier Three is full oversight by a regulatory agency. In this case, a regional board would impose waste discharge requirements or issue a cease and desist order or a cleanup and abatement order.

CHAPTER 4
INTRODUCTION TO SALMONIDS

Salmonids are fish species in the family Salmonidae, including salmon, trout and char (Meehan, 1991). There are both anadromous and nonanadromous salmonids. Nonanadromous fish are those that mature and spawn in freshwater, such as rainbow trout. Anadromous fish are those that mature in the ocean but spawn in freshwater. Anadromous fish of interest in the Gualala River watershed include: coho salmon (*Oncorhynchus kisutch*), steelhead trout (*Oncorhynchus mykiss*), the anadromous variety of rainbow trout. Chinook salmon (*Oncorhynchus tshawytscha*) are not found in the Gualala River, although populations are established both north and south of the Gualala River watershed. The California Coastal Chinook Salmon Evolutionarily Significant Unit (ESU), as defined by NMFS and stated in 65 CFR §32, includes Humboldt Bay, Redwood Creek, and the Mad, Eel, Mattole, and Russian Rivers.

The life cycle of salmonids can be broken into seven distinct life cycle stages, each with its own specific set of environmental requirements. The life cycle requirements are well understood for some life cycle stages and not as well understood for others. Much of what is known about some life cycle stages (e.g., spawning, incubation, and emergence) is gathered from laboratory tests. Other knowledge is gathered from field studies and observations.

The typical life cycle of anadromous salmonids includes the following stages, as described by Meehan (1991):

- Adult females and males migrate to fresh water spawning grounds. The timing of migration depends on the species.
- The female builds several redds (gravel nest) and lays eggs in them over which the male ejects his milt, or sperm.
- The fertilized eggs (embryos) hatch from the eggs as alevins in 1-3 months. The alevins emerge with yolk sacs and reside in the interstices of the gravel until they are ready to feed on macroinvertebrates in the water column.
- The alevins emerge from the gravel as fry in 1-5 months, generally in the spring or summer.
- The juvenile fish remain in fresh water for a few days to 4 years, depending on the species and locality.
- The juvenile fish undergo “smoltification” then migrate to the ocean as smolts, generally in the spring or early summer. Smoltification is a process of physical change that allows a freshwater fish to survive in a saline environment.
- The smolt resides and grows in the ocean for 1-4 years before returning to its natal stream for spawning.

Steelhead trout do not always die after spawning, although Pacific salmon do.

Coho Salmon

In September 1995, the NMFS published a report entitled "Status Review of Coho Salmon from Washington, Oregon, and California" (Weitkamp et al., 1995). The following is taken from the NMFS report.

From central British Columbia south, the vast majority of coho salmon adults are 3-year-olds, having spent approximately 18 months in fresh water and 18 months in salt water (as cited in Weitkamp et al. 1995: Gilbert, 1912; Pritchard, 1940; Marr, 1943; Briggs, 1953; Shapovalov and Taft, 1954; Foerster, 1955; Milne, 1957; Salo and Bayliff, 1958; Loeffel and Wendler, 1968; and Wright, 1970). The primary exception to this pattern are "jacks," sexually mature males that return to freshwater to spawn after only five to seven months in the ocean. As cited in the NMFS report, Drucker (1972) suggested that there is a latitudinal cline in the proportion of jacks in a coho salmon population, with populations in California having more jacks and those in British Columbia having almost none. Although the production of jacks is a heritable trait in coho salmon (as cited in Weitkamp et al. 1995: Iwamoto et al., 1984), it is also strongly influenced by environmental factors (as cited in Weitkamp et al., 1995: Shapovalov and Taft, 1954; and Silverstein and Hershberger, 1992). The proportion of jacks in a given coho salmon population appears to be highly variable and may range from less than 6% to over 43% (as cited in Weitkamp et al., 1995: Shapovalov and Taft, 1954; Fraser et al., 1983; and Cramer and Cramer, 1994).

Most west coast coho salmon enter rivers in October in response to increased freshwater outflows to the ocean and spawn from November to December and occasionally into January. However, coho salmon on the Mendocino Coast, including the Gualala River watershed, generally enter freshwater much later, in late December or January, and spawn immediately afterwards, probably in response to later peak river flows of limited duration. Consequently, Mendocino Coastal fish spend little time between river entry and spawning, while northern stocks may spend one or two months in fresh water before spawning (as cited in Weitkamp et al. 1995: Flint and Zillges, 1980 and Fraser et al., 1983).

According to Weldon Jones (1994, referenced in Weitkamp et al., 1995), smolt outmigration occurs in the Navarro River watershed from late February to June. In 1964 and 1968, Graves and Burns (1970, as cited in Weitkamp et al., 1995) measured mean smolt size in Caspar Creek as 92 mm length with a range of 83-95 mm. No other smolt size measurements for watersheds in the Mendocino Coast Hydrologic Unit are reported.

Coho salmon spawning escapement in California (including the Gualala River watershed) apparently ranged between 200,000 and 500,000 adults per year in the 1940s (Brown et al. 1994, as cited in Weitkamp et al., 1995). By the mid-1960s, statewide spawning escapement was estimated to have fallen to about 100,000 fish per year (as cited in Weitkamp et al. 1995: CDFG, 1965 and California Advisory Committee on Salmon and Steelhead Trout, 1988), followed by a further decline to about 30,000 fish in the mid-1980s (Wahle and Pearson, 1987, as cited in Weitkamp et al., 1995). This is a decline from the 1940s to the 1960s of 50-80% and from the 1960s to 1980s of 70% for a total decline from the 1940s to the 1980s of 85-94%. From 1987 to 1991, spawning escapement averaged about 31,000, with hatchery populations making up 57%

of this total (as cited in Weitkamp et al., 1995: Brown et al., 1994). Without the influence of hatcheries, the total decline from the 1940s to the early 1990s would have been from 93-97%.

Specifically addressing the population abundance in the ESU that encompasses the Mendocino Coast watersheds, including the Gualala, Weitkamp (Weitkamp et al., 1995) reported that the West Coast Biological Review Team unanimously agreed that "…natural populations of coho salmon in this ESU are presently in danger of extinction. The chief reasons for this assessment were extremely low current abundance, especially compared to historical abundance, widespread local extinctions, clear downward trends in abundance, extensive habitat degradation and associated decreased carrying capacity, and a long history of artificial propagation with the use of non-native stocks. In addition, recent droughts and current ocean conditions may have further reduced run sizes."[1]

Higgins et al. (1992, referenced in Weitkamp et al.,1995) has evaluated coho salmon population trends and assesses their status as "at high risk of extinction" in the Gualala River watershed. In December 1996, NMFS listed the coho salmon in the Central California Coast Evolutionarily Significant Unit (ESU) as a threatened species, i.e., they are likely to become endangered in the foreseeable future. The Central California Coast ESU includes the coastal river basins from Santa Cruz in the south to the borders of the Eel River watershed in the north.

Steelhead Trout

In August 1996, NMFS published a report entitled "Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California" (Busby et al., 1996). The following is taken from the NMFS report.

Oncorhynchus mykiss is considered by many to have the greatest diversity of life history patterns of any Pacific salmonid species (as cited in Busby et al., 1996: Shapovalov and Taft, 1954 Barnhart, 1986), including varying degrees of anadromy, differences in reproductive biology, and plasticity of life history between generations.

Biologically, steelhead can be divided into two basic reproductive ecotypes, based on the state of sexual maturity at the time of river entry and duration of spawning migration (as cited in Busby et al., 1996: Burgner et al., 1992). The stream-maturing type (commonly known as summer steelhead in the Pacific Northwest and northern California) enters fresh water in a sexually immature condition and requires several months to mature and spawn. The ocean-maturing type (winter steelhead) enters fresh water with well-developed gonads and spawns shortly thereafter. It appears that the summer steelhead occur where habitat is not fully utilized by winter steelhead; summer steelhead usually spawn farther upstream than winter steelhead (as cited in Busby et al., 1996: Withler, 1966; Roelofs, 1983; Behnke, 1992). Where the two types co-occur, they are often separated by a seasonal hydrologic barrier, such as a waterfall. Coastal streams, such as the Gualala River watershed, are dominated by winter steelhead.

In the 1960s, a total of 65,000 steelhead trout are estimated to have existed in the Mendocino Coast Hydrologic Unit (e.g., 9,000 from the Ten Mile, 8,000 from the Noyo, 12,000 from the

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[1] Weitkamp et al. 1995, page vi.

Big, 16,000 from the Navarro, 4,000 from the Garcia and 16,000 from the Gualala). No current estimates are given.

Based in part on this data, steelhead trout in the Northern California ESU were listed by NMFS in March 1998 as a candidate species and as a proposed threatened species on February 11, 2000. The Northern California ESU includes steelhead in coastal river basins from the Gualala River north to Redwood Creek, inclusive.

4.1 Salmonid Habitat Requirements in Freshwater Streams

The abundance of juvenile salmon, trout and char in streams is a function of many factors, including abundance of newly emerged fry, quantity and quality of suitable habitat, abundance and composition of food, and interactions with other fish, birds, and mammals. Changes in spawning abundance and variation in the success of incubation and emergence affect the number of young fish entering a stream. Density-independent environmental factors (e.g., amount of suitable habitat, quality of cover, productivity of the stream, and certain types of predation) set an upper limit on the abundance of juveniles, and the population is held to that level by interactions that function in a density-dependent fashion (competition and some types of predation). Temperature, productivity, suitable space, and water quality (turbidity, dissolved oxygen, etc.) are examples of variables that regulate the general distribution and abundance of fish within a stream or drainage. All of the general factors must be within suitable ranges for salmonids during the time they use a stream segment; otherwise there will be no fish present.

Table 4.1 identifies the seven life cycle stages common to each of the salmonid species of concern. It also identifies potential impacts to salmonids at each life cycle stage. Finally, it lists some of the potential sources of the impacts named. Note that salmonids can be impacted by both natural and anthropogenic factors.

TABLE 4.1. SEDIMENT RELATED IMPACTS TO SALMONIDS

Salmonid life cycle stages and potential impacts to them		
Life Cycle Stage	Potential Impacts	Potential Sources of Impact
Migration	• Stop or impede access of adult fish to spawning grounds • Stop or impede access of fry to adequate shelter and food • Stop or impede access of juveniles to the estuary and/or ocean • Physical harm	• Low flow conditions • Sediment deltas or bars • Log or debris jams • Water supply dams • Poorly engineered or maintained road crossings (e.g., shotgun culverts) • Over-fishing • Predation
Spawning	• Absence of or reduction in appropriate substrate sizes • Substrate embedded or substantially embedded by fine sediment	• Mass wasting, including debris flows and stream bank failures • Gully erosion • Sheet and rill erosion • Drought • Loss or substantial loss of sediment storage capacity (e.g., removal or reduction in the availability of large woody debris)
Incubation	• Scouring or movement of redds • Suffocation or substantial entombment of redds	• Spring freshets • Elevated peak flows • Physical disturbance • Fine sediment delivery and/or remobilization
Emergence	• Substrate embedded or substantially embedded by fine sediment	• Fine sediment delivery and/or remobilization
Winter Rearing	• Absence of or decline in off-channel habitat • Absence of or decline in instream shelter (e.g., large woody debris) • Elevated peak flows • Increased stream flow velocities	• Disconnection of stream channel from floodplain • Removal or reduction of large woody debris and other structural elements in the stream channel • Modification of upslope hydrology (e.g., compacted soils, expanded surface drainage system, reduction in vegetation transpiration rate)
Ocean Rearing	• Physical harm • Absence of or decline in food supplies • Alteration of water temperatures	• Over fishing • Predation • Disease • Pollution • Climatic changes (e.g., greenhouse warming)

4.1.1 Sediment & Related Salmonid Requirements

Substrate

The redd construction process reduces the amount of fine sediments and organic matter in the pockets where eggs are deposited (as cited in Meehan, 1991: McNeil and Ahnell, 1964; Ringler 1970; Everest et al., 1987). If fine sediments are being transported in a stream either as bedload or in suspension, some of them are likely to be deposited in the redd. Tappel and Bjornn (1983) relate percent embryo survival to percentage of fines <6.35 mm in diameter (Table 4.2). Chinook salmon survival decreases to 75% when the percentage of fines <6.35 mm reaches about 35%. It decreases to 50% when the percentage of fines <6.35 mm reaches about 40%. Steelhead trout survival decreases to 75% when the percentage of fines <6.35 mm reaches about 30%. It decreases to 50% when the percentage of fines <6.35 mm reaches about 40%. No relationship was reported for coho salmon.

TABLE 4.2. PERCENT FINES AND SALMONID EMBRYO SURVIVAL

Relationship of Percent Fines to Embryo Survival		
Species	% Fines < 6.35mm	% Embryo Survival
Chinook	35%	75%
	40%	50%
Steelhead	30%	75%
	40%	50%

Newly emerged fry can occupy the voids of substrate made up of 2-5 cm diameter rocks, but larger fish need cobble and boulder-size (>7.5 cm diameter) substrates in order to occupy the voids. The summer or winter carrying capacity of the stream for fish declines when fine sediments fill the interstitial spaces of the substrate. In a laboratory stream experiment, Crouse et al. (1981) found that production (tissue elaboration) of juvenile coho salmon was related to the amount of fine sediments in the substrate. Density of juvenile steelhead and chinook salmon in summer and winter was found to be reduced by more than half when enough sand was added to fully embed the large cobble substrate (Bjornn et al., 1977, as cited in Meehan, 1991). The addition of fine sediments to stream substrates as a result of watershed disturbances and erosion may reduce the abundance of invertebrates, as well.

Turbidity and Suspended Sediment

The Gualala watershed is typical of North Coast watersheds that have a geology prone to storm induced erosion events. Kelsey et. al. (1981) state that watersheds in “The California Coast Ranges between San Francisco and the Oregon border contain the most rapidly eroding, large-order, non-glaciated drainage basins of comparable size in the United States (Judson and Ritter, 1964). The combination of the underlying pervasively sheared and often folded Franciscan rocks (Bailey et. al., 1964), recent uplift, and a distinctive climate accounts for the large sediment yields.” Suspended sediment and turbidity are elevated for periods of time during the high runoff, rainy season. There is inter-annual variation in the timing, duration, and levels of these constituents.

It is generally accepted that the severity of effect of suspended sediment pollution on fish increases as a function of sediment concentration and duration of exposure (Newcombe and Jensen, 1996). For temperature, appropriate statistics such as the maximum weekly average temperature have been developed to capture temperature variations and establish meaningful metrics of appropriate temperatures for salmonids. Suspended sediment data has been collected on a limited number of streams with background suspended sediment levels on the North Coast. However, rating curves for background values of suspended sediment and turbidity have not been fully developed to represent background turbidity and suspended sediment levels in North Coast watersheds. It is imperative that the needed rating curves be developed so that turbidity and suspended sediment conditions can be assessed adequately.

Salmonid smolt survival is strongly a function of smolt size (Trush, 2001). Reduced smolt growth, caused by such impacts as increased chronic turbidity or suspended sediment levels, decreases a smolt's chance of returning to a watershed as a spawning adult, cumulatively jeopardizing population sustainability (Trush, 2001). A watershed with a healthy population of salmonids is capable of producing a size class distribution and abundance of salmonid smolts that can support a sustainable returning adult population, whereas a watershed impacted by increased levels of turbidity and suspended sediment caused by anthropogenic impacts may not be able to produce a size class and distribution of salmonid smolts that can support a sustainable returning adult population (Trush, 2001). Even a small growth impairment may have highly significant implications to smolt survival and population sustainability (Trush, 2001).

Newcombe and Jensen (1996) developed measures of the severity of ill effect based on the suspended sediment concentration and the duration of exposure for juvenile and adult salmonids, adult salmonids, and eggs and larvae of salmonids and non-salmonids based on a synthesis of previously collected data. However, the cumulative impact of successive stressful events on salmonid survival has not been clearly addressed in any study to date. Research to date is suitable for assessing discrete suspended sediment or turbidity events, but unsuitable for measuring the cumulative effect of multiple events over the course of a storm season.

Elevated levels of suspended sediment may have both acute and sublethal effects on salmonids (Meehan, 1991). Migrating salmonids avoid waters with high silt loads, or cease migration when such loads are unavoidable (Cordone and Kelley, 1961). Bell (1986) cited a study in which salmonids did not move in streams where the suspended sediment concentration exceeded 4,000 mg/L (as a result of a landslide). High turbidity in rivers may delay migration, but turbidity alone generally does not seem to affect the homing of salmonids very much.

It is reported that larger juvenile and adult salmon and trout appear to be little affected by ephemerally high concentrations of suspended sediments that occur during most storms and episodes of snowmelt (Cordone and Kelley, 1961; as cited in Meehan, 1991: Sorenson et al., 1977). Bisson and Bilby (1982) reported, however, that juvenile coho salmon avoided water with turbidities that exceeded 70 NTU (nephelometric turbidity units), which may occur in certain types of watersheds and with severe erosion. (Berg and Northcote, 1985, as cited in Meehan, 1991) reported that feeding and territorial behavior of juvenile coho salmon were disrupted by short-term exposures (2.5-4.5 days) to turbid water with up to 60 NTU. Turbidities in the 25-50 NTU range (equivalent to 125-275 mg/l of bentonite clay) reduced growth and caused more newly emerged salmonids to emigrate from laboratory streams than did clear water (Sigler et al., 1984).

Barrett et. al. (1992) indicate that elevated turbidity had a consistent negative effect on reactive distance of feeding rainbow trout. As measured by Barrett et. al (1992), reactive distances of rainbow trout were 80% and 45% at turbidities of 15 and 30 NTU respectively of reactive distances observed at ambient turbidities of four to six NTU.

Newcombe and Jensen (1996) indicate reduced short term feeding rates and feeding success when exposed to a suspended sediment concentration of 20 mg/l for three hours. Newcombe and Jensen (1996) also report that juvenile and adult salmonids undergo major physiological stress and experience long-term reduction in feeding rates and feeding success when exposed to suspended sediment concentrations exceeding 148 mg/l for a duration of six days. Noggle (1978, cited in Meehan, 1991) reported that suspended sediment concentrations of 1,200 mg/L caused direct mortality of underyearling salmonids, while 300 mg/L caused reduced growth and feeding. Bozek and Young (1994) reported mortality of adult salmonids after peak suspended sediment concentrations of 9680 mg/L in a Yellowstone National Park stream.

Percent Fines <0.85 mm

As the percentage of fines increases as a proportion of the total bulk core sample, the survival to emergence decreases. Fines that impact embryo development are generally defined as particles that pass through a 0.85-mm sieve. The 0.85mm cut off is an arbitrarily established value based on the available sieve sizes at the time of the initial studies in this area.

Identifying a specific percentage of fines that can comprise the bulk core sample and still ensure adequate embryo survival is not clearly established in the literature. For example, Cederholm et al. (1981) found that coho salmon survival in a Washington stream was 30% at about 10% fines <0.85 mm in trough mixes and at 15% fines in natural redds. Koski (1966, as cited in Meehan, 1991), on the other hand, found that coho survival was about 45% on an Oregon stream when fines <0.85 mm were measured at 20%. This differs yet again from Tappel and Bjornn's (1983) work in Idaho and Washington which found that survival at 10% fines smaller than 0.85 mm varied from 20% to 80% as the amount of fines 9.5 mm or less varied from 60% to 25%. For example, Tappel and Bjornn (1983) predicted that a 70% steelhead embryo survival rate required no more than 11% fines < 0.85 mm and 23% fines < 9.50 mm. McNeil and Ahnell (1964) in their early work in Alaska found no more than 12% fines <0.85 mm in moderately to highly productive pink salmon streams.

In a broad survey of literature reporting percent fines in unmanaged streams (streams without a history of land management activities), Peterson et al. (1992, as cited in Meehan, 1991) found fines <0.85 mm ranging from 4% in the Queen Charlotte Islands to 28% on the Oregon Coast, with a median value for all the data of about 11%. Peterson et al. (1992, as cited in Meehan, 1991) recommended the use of 11% fines < 0.85 mm as a target for Washington streams because the study sites in unmanaged streams in Washington congregated around that figure. None of the data summarized by Peterson et al. (1992, as cited in Meehan, 1991) were from California.

Burns (1970) conducted three years of study in Northern California streams, including three streams he classified as unmanaged: Godwood and South Fork Yager creeks in Humboldt County and North Fork Caspar Creek in Mendocino County. He found a range of values for fines < 0.8 mm in each of these streams: 17-18% in Godwood Creek, 16-22% in South Fork Yager Creek, and 18-23% in Caspar Creek. Data collection for this study began a few years following big storms in 1964 that many conclude caused extensive hillside erosion and instream aggradation, the results of which we still observe today.

4.1.2 Temperature & Related Salmonid Requirements

In streams, temperature is not uniform in space or time. Importantly, cold water pools and cooler tributaries allow thermal refugia in water that is otherwise above the optimal temperature range. Spence et al. (1996) state that " …coldwater pockets in stratified pools ranged from 4.1 to 8.2°C cooler than ambient stream temperatures." This observation demonstrates one of the values of deep pools for salmonids. Excessive sediment can cause the infilling of pools and loss of deep pool volume available as thermal refugia for salmonids. Further, excessive sediment can cause a trend to a less complex, wider, shallower channel. Wider, shallower channels lead to increased solar radiation upon stream water increasing the likelihood of extreme warm temperature events and chronic high temperatures. The following section presents temperature and related salmonid requirements and is included as supplementary information.

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

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

It is likely that chronically elevated, sublethal temperatures cause significant stress on fish populations. Ligon et al. (1999) discuss sublethal temperature effects that "effectively block migration, reduce growth rate, create disease problems, and inhibit smoltification" (Elliott, 1981 as cited in Ligon et al., 1999) as "directly and indirectly linked with survival in natural populations of salmonids" (Ligon et al., 1999). In addition, the stressful impacts of water temperatures on salmonids are cumulative and positively correlated to the duration and severity of the exposure. Thus, the longer the salmonid is exposed to thermal stress, the less chance it has for long-term survival."

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

Literature reviews were conducted to determine temperature requirements for the various life stages of steelhead trout (*Oncorhynchus mykiss*) and coho salmon (*Oncorhynchus kisutch*). When possible, species specific requirements were summarized by four life stages: migrating adults, spawning, embryo incubation and fry emergence, and freshwater rearing. Results are summarized in Table 4.3. Some of the references reviewed covered salmonids as a general class of fish, while others were species specific.

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

- **Maximum Weekly Average Temperatures** – The Maximum Weekly Average Temperature (MWAT) is the maximum value of the mathematical mean of multiple, equally spaced, daily temperatures over a 7-day consecutive period (Brungs and Jones 1977). In different words, this is the highest value of the 7-day moving average of temperature. Brungs and Jones develop MWATs for the growth phase of fish life, as growth appears to be the life stage most sensitive to modified temperatures and it integrates many physiological functions. They also develop MWATs for spawning. Brungs and Jones calculate the MWAT metric for growth using the following equation:

MWAT metric for growth = OT + (UUILT - OT)/3

  This equation uses the physiological optimum temperature (OT) and the ultimate upper incipient lethal temperature (UUILT). The latter temperature is the "breaking point" between the highest temperature to which a fish can be acclimated and the lowest of the extreme upper temperatures that will kill the warm-acclimated fish.

  Brungs and Jones (1977) and EPA (1987) calculate a growth MWAT metric of 17.8°C (64°F) for juvenile coho salmon. This value will vary depending on the optimum and ultimate upper incipient lethal temperatures used in the calculation. An MWAT metric for steelhead is not reported, although there is an MWAT of 18.9°C (66°F) for rainbow trout.

- **Short-Term Maximum Temperatures** - Fish can withstand short-term exposure to temperatures higher than those required day in and day out without significant adverse effects. The short-term maximum temperature is intended as a measure for such conditions and is calculated using the following formula:

$$\text{Temperature } (^{o}\text{C}) = (\log \text{time (minutes)} - a)b$$

For a daily maximum the equation would use 1440 minutes (24 hours). The constants "a" and "b" are intercept and slope, respectively, derived from each acclimation temperature for each species. The results of this calculation are the temperature at which there is 50% survival of the test population. A "safety factor" of 2 ^{o}C is subtracted to calculate the temperature at which 100% of a population is expected to survive.

For juvenile coho salmon, when the acclimation temperature is 20 ^{o}C, a = 20.4022 and b = -0.6713, and the temperature at which there is 50% survival of a population is 23.7 ^{o}C (74.7 ^{o}F). With a 2°C adjustment, all fish in the test population would be expected to survive at a temperature of 21.7°C (71.1°C). Brungs and Jones (1977) do not calculate a short-term maximum temperature for steelhead, although there is a reported short-term maximum temperature value of 23.9°C (75 ^{o}F) for rainbow trout. Using the same 2°C adjustment yields a temperature of 21.9°C (71.4°F) for 100% survival.

The following paragraphs assess temperature requirements for various salmonid life stages.

Adult Migration

Salmon and trout respond to temperatures during their upstream migration (Bjornn and Reiser, 1991). Delays in migration have been observed for temperatures that were either too cold or too warm. Most salmonids have evolved with the temperature regime they historically used for migration and spawning, and deviations from the normal pattern can affect survival (Spence et. al., 1996).

Upstream migration of adult salmonids in the Gualala River occurs during a stream temperature transition period. Migration does not begin until the warmer summer period is waning, streamflows are increasing, and river temperatures are generally falling. Coho begin entering streams on the Mendocino Coast, including the Gualala River, in mid-October and may continue into February. Steelhead begin migrating in mid-November and continue through mid-March.

Bell (1986) notes migration temperatures ranging from 7.2-15.6°C (45-60°F) for coho. Several sources cite 21°C (70°F) as a temperature at which migration or movement is delayed or movement is limited for coho and steelhead (Table 4-2).

Spawning

Spawning occurs in the rainy season when flows have increased from winter rains and stream temperatures have decreased. Coho can begin spawning as soon as they reach natal spawning grounds, typically December through February. Steelhead spawning can begin in mid December and continue through mid May, with the peak in January through March. Spence et al. (1996) report that salmonid spawning has been observed at 1-20°C (33-57^{o}F). Bell (1986) cites preferred spawning temperatures of 4.4-9.4°C (40-49°F) for coho and substantially similar values for steelhead (Table 4-2).

Incubation
It is critical that the embryos during incubation, and fry before emergence, have the proper environmental conditions, including temperature, as these life stages are essentially immobile. Water temperature during incubation affects the rate of embryo development, intragravel dissolved oxygen, and survival. In general, warmer water has been found to shorten the incubation period. Incubation temperatures can also affect the size of hatching alevins (Bjornn and Reiser, 1991). Embryo incubation begins anytime after spawning has commenced. For coho, incubation peaks in December through March and can last through mid April. For steelhead, incubation peaks in January through March and can last until mid June. Bell (1986) cites a range of incubation temperatures for coho of 4.4-13.3°C (40-56°F). Others have found temperatures as low as 11°C (51.8°F) as lethal to coho during incubation (Table 4-2). There are not similar data for steelhead.

Freshwater Rearing
Temperature affects metabolism, behavior, and survival of both juvenile fish as well as other aquatic organisms that may be food sources. In streams of the Mendocino Coast, including the Gualala River, young coho and steelhead may rear in freshwater from one to four years before migrating to the ocean. Reported values of MWATs and short-term exposure maxima for juvenile rearing stages are presented in Table 4-2.

Freshwater Rearing – Coho Specific
Reported estimates of the MWAT for growth range from 16.8-18.3°C (62.2-65°F). Maximum short-term temperatures are reported by Brungs and Jones (1977) as 23.7°C (74.7°F). In an exhaustive study of both laboratory and field studies of temperature effects on salmonid and related species, McCullough (1999) concluded that upper short-term temperatures of approximately 22-24°C result in a limit to salmonid distribution, i.e., in total elimination of salmonids from a location. McCullough (1999) also notes that changes in competitive interactions between fish species can lead to a transition in dominance from salmonids to other species at temperatures 2-4°C lower than the range of total elimination.

Freshwater Rearing – Steelhead Specific
Brungs and Jones (1977) report a MWAT for growth of 19°C (66°F), and a short-term maximum temperature of 23.9°C (75°F). The conclusions in McCullough (1999) would also apply to steelhead, with respect to limitations on distributions in the field. There also is a report in the literature that addresses temperature as it relates to juvenile salmonid occurrence and behavior in the Navarro River and similar streams. Nielsen et al. (1994) studied thermally stratified pools and their use by steelhead in three North Coast rivers including Rancheria Creek, located in the Navarro River watershed. In detailed observations of steelhead behavior in and near thermally-stratified pools, they noted behavioral changes including decreased foraging and increased aggressive behavior as pool temperature reached approximately 22°C. As pool temperature increased above 22°C (71.6°F), fish left the observation pools and moved into stratified pools where temperatures were lower. These observations would seem to be generally consistent with the results reported in McCullough (1999).

TABLE 4.3. SALMONID TEMPERATURE INFORMATION

	COHO SALMON		STEELHEAD	
	Values - in °C (°F)	Reference	Values - in °C (°F)	Reference
Lower Lethal Temp.	1.7 (35) 0 (32)	Brett, 1952 Bell, 1986	0 (32)	Bell, 1986
Upper Lethal Temp.	25 (77) 23-25 (73.4-77) 24-25.8 (75.2-78.4)	Brett, 1952 Brungs and Jones, 1977 NMFS, 1997	27 (80.6) [d] 21 (69.8) [d] 23.9 (75) 24-26.7 (75.2-80)	Brungs and Jones, 1977 Brungs and Jones, 1977 Bell, 1986 McCullough, 1999
Preferred Temp.	12-14 (54-57)	Brett, 1952	13-19 (55.4-66.2) [d] 10-13 (50-55.4)	Brungs and Jones, 1977 Bell, 1986
Optimum	15 (59) 13.2 (55.8)	Brungs and Jones, 1977 NMFS, 1997	17-19 (62.6-66.2) [d] 7.2-14.4 (45-58)	Brungs and Jones, 1977 Bell, 1986
Upstream Migration	7.2-15.6 (45-60) 21.1 (70) migration delayed	Bell, 1986 Bell, 1986	21.1 (70) movement limited	Lantz, 1971 cited in ODEQ, 1995
Spawning	Prefer:4.4-9.4 (40-49) >50% Survival: 2-11 (35.6-51.8) >50% Survival: 1.4-12.1 (34.5-53.8) MWAT for spawning: 10 (50)	Bell, 1986 Murray and McPhail, 1988 Murray et al., 1990 Brungs and Jones, 1977	Prefer: 3.9-9.4 (39-49) MWAT for spawning: 9 (48) [d]	Bell, 1986 Brungs and Jones, 1977
Incubation	4.4-13.3 (40-56) >50% Survival: 2-11 (35.6-51.8) >50% Survival: 1.4-12.2 (34.5-54) >50% Survival: <13.3 (56) Max short-term temp: 13 (55)	Bell, 1986 Murray and McPhail, 1988 Murray et al., 1990 Spence, 1996 Brungs and Jones, 1977	Prefer: 10 (50) Max short-term temp.: 13 (55) [d]	Bell, 1986 Brungs and Jones, 1977
Rearing	12.2-13.9 (54-57) MWAT for growth[c]: 18 (64) [a] 17.7-18.3 (63.8-65) [b] 16.8-17.4 (62.2-63.2) [b] Max short-term temp, (50% survival) 23.7 (74.7)	Brett, 1952 Brungs and Jones, 1977 Brungs and Jones, 1977 NMFS, 1997 Brungs and Jones, 1977	MWAT for growth[c]: 19 (66) [d] Max short-term temp, (50% survival) 23.9 (75) [d]	Brungs and Jones, 1977 Brungs and Jones, 1977

a: cited in reference
b: calculated from upper lethal & optimum temperatures from references as noted above
c: MWAT for growth = OT + (UUILT-OT)/3
d: values are for rainbow trout

MWAT=Maximum Weekly Average Temperature
OT=Optimum Temperature
UUILT=Ultimate Upper Incipient Lethal Temperature

4.1.3 Other Salmonid Habitat Requirements

The following section presents other salmonid habitat requirements and is included as supplementary information.

Cover

Some of the features that may provide cover and increase the carrying capacity of streams for fish are water depth, water turbulence, large-particle substrates, overhanging or undercut banks, overhanging riparian vegetation, woody debris (brush, logs), and aquatic vegetation. Coho salmon production declined when woody debris was removed from second-order streams in southeast Alaska (as cited in Meehan, 1991: Dollof, 1983). More large woody debris and juvenile coho salmon were found in streams surrounded by mature, mixed-conifer forest than in streams lined by red alder that had grown in a 20-year-old clear-cut (as cited in Meehan, 1991: House and Boehne, 1986). When wood debris was removed from a stream, the surface area, number and size of pools decreased, water velocity increased, and the biomass of Dolly Varden decreased (Elliott, 1986 as cited in RAC, 1999). Dolly Varden is a species of char with similar life cycle requirements to salmonids. In another stream, young steelhead were more abundant in clear-cut than in wooded areas in summer but moved to areas with pools and forest canopy in winter (as cited in Meehan, 1991: Johnson et al., 1986). In addition, some anadromous fish—chinook salmon and steelhead trout, for example—enter freshwater streams and arrive at the spawning grounds weeks or even months before they spawn. Nearness of cover to spawning areas may be a factor in the selection of spawning sites by some species.

Streamflow

Bell (1986) reports the following minimum depths (m) and maximum velocities (m/s) for successful upstream migration: fall chinook salmon (0.24 m, 2.44 m/s); coho salmon (0.18 m, 2.44 m/s); and steelhead trout (0.18 m, 2.44 m/s). Streamflow also regulates the amount of spawning area available in any stream by regulating the area covered by water and the velocities and depths of water over the gravel beds.

Smoker (1955, as cited in Meehan, 1991) found a correlation between the commercial catch of coho salmon and annual runoff, summer flow, and lowest monthly flow in twenty one western Washington drainages. In the last two decades, hatchery production of coho salmon smolts has increased markedly and made such comparisons more difficult. The implication of the available studies is that the abundance of adult coho salmon is a function of the number of smolts produced, which is in turn related to streamflow and the other factors that regulate the production of smolts.

Depth, velocity, and substrate requirements can be found for fall chinook salmon, coho salmon and steelhead trout in Table 4.4.

Given flow in a stream, velocity is probably the next most important factor in determining the amount of suitable space for rearing salmonids (as cited in Meehan, 1991: Chapman, 1966; deGraaf and Bain, 1986). Newly emerged fry (20-35 mm long) of salmon, trout and char require velocities of less than 10 cm/s, based on studies of sites selected by the fish in streams (as cited in Meehan, 1991: Chapman and Bjornn, 1969; Everest and Chapman, 1972; Griffith, 1972;

Hanson, 1977; Smith and Li, 1983; Konopacky, 1984; Pratt, 1984; Bugert, 1985; Moyle and Baltz, 1985; Sheppard and Johnson, 1985). Larger fish (4-18 cm long) usually occupy sites with velocities up to about 40 cm/s.

TABLE 4.4. SALMONID STREAMFLOW REQUIREMENTS

Species	*Depth (cm)*	*Velocity for Adult Salmonids (cm/s)*	*Substrate size (cm)*
Fall chinook salmon	≥24 (Thompson, 1972*)	30-91 (Thompson, 1972*)	1.3-10.2 (Bell 1986)
Coho salmon	≥18 (Thompson, 1972*)	30-91 (Thompson, 1972*)	1.3-10.2 (Bell 1986)
Steelhead	≥24 (Smith, 1973) ≥18 (Bell, 1986)	40-91 (Smith, 1973)	0.6-10.2 (Estimated)

* Thompson, 1972 was cited in Meehan, 1991.

Young trout and salmon have been seen in water barely deep enough to cover them and in water more than a meter deep. Densities (fish/m^2) of some salmonids are often higher in pools than in other habitat types; but, that may reflect space availability rather than a preference for deep water, especially for smaller fish (<15 cm long). Everest and Chapman (1972, as cited in Meehan, 1991) found significant correlation between size of fish and total water depth at sites occupied by juvenile chinook salmon and steelhead. Most fish, regardless of size, were near the bottom.

Streamflows and velocities are at their highest in coastal streams in northern California during winter months due to rainfall. As a result, overwintering salmonids must find shelter from high winter stream velocities. For example, Mundie and Traber (1983, as cited in Meehan, 1991) found higher densities of steelhead (0.66 smolts/m^2 and 9.94 g/m^2) and coho salmon (0.85 smolts/m^2 and 12.8 g/m^2) in side-channel pools than are commonly found in the main channels of Pacific coastal streams. Peterson (1982a, 1982b, as cited in Meehan, 1991) reported coho salmon moving into side-channel pools for the winter. Salmonids will even hide in the interstitial spaces in stream substrates, particularly in winter when voids are accessible (as cited in Meehan, 1991: Chapman and Bjornn, 1969; Bjornn and Morrill, 1972; Gibson, 1978; Rimmer et al., 1984; Hillman et al., 1987). The discussion of large woody debris as cover under summer freshwater rearing, above, is relevant here, as well.

Space

During the spawning stage of the salmonid life cycle, the number of redds that can be built in a stream depends on the amount of suitable spawning habitat and the area required per spawning pair of fish (as cited in Meehan, 1991: Reiser and Ramey, 1984, 1987; IEC Beak, 1984; Reiser, 1986). Many salmonids prefer to spawn in the transitional area between pools and riffles because of the downwelling there (as cited in Meehan, 1991: Hazzard, 1932; Hobbs, 1937; Smith, 1941; Briggs, 1953; Stuart, 1953). According to Burner (1951, as cited in Meehan, 1991), the average area of a fall chinook salmon redd is 5.1m^2 while that of a coho salmon is

2.8m^2. The average area of a steelhead trout redd ranges from 4.4-5.4m^2, depending on the study (as cited in Meehan, 1991: Orcutt et al., 1968; Hunter, 1973; Reiser and White, 1981). Burner (1951, as cited in Meehan, 1991) recommends 20.1m^2 and 11.7m^2 of spawning habitat per spawning pair of fall chinook salmon and coho salmon, respectively.

As the salmonid population matures, fish densities in streams provide a measure of the spatial requirements of juvenile salmonids, but the wide variation in observed densities illustrates the diversity of habitat quantity and quality and other factors that regulate fish abundance. Based on Allen (1969, as cited in Meehan, 1991), the summer space requirements of juvenile salmonids during their first year in streams probably range from 0.25m^2 to 10m^2 of stream per fish, depending on such things as the species and age composition of fish present, stream productivity, and quality of the space. Bjornn et al. (1977, as cited in Meehan, 1991) demonstrated that by reducing pool volume by half and surface area of water deeper than 0.3m by two-thirds, fish numbers declined by two-thirds.

Dissolved Oxygen
The minimum DO recommended for spawning fish is 5.0 mg/L with at least 80% saturation. Salmonids may be able to survive when DO concentrations are relatively low (<5 mg/L), but growth, food conversion efficiency, and swimming performance will be adversely affected. High water temperature, which reduces oxygen solubility, can compound the stress on fish caused by marginal DO concentrations.

Silver et al. (1963, as cited in Meehan, 1991) reported that newly hatched steelhead and chinook salmon alevins were smaller and weaker when they had been incubated as embryos at low and intermediate DO concentrations than when they were incubated at higher concentrations. In field studies, survival of steelhead embryos (as cited in Meehan, 1991: Coble, 1961) and coho salmon embryos (as cited in Meehan, 1991: Phillips and Campbell, 1961) were positively correlated with intragravel DO in redds. Phillips and Campbell (1961, as cited in Meehan, 1991) concluded that intragravel DO must average 8 mg/L for embryos and alevins to survive well.

Barriers
In general, the success of a leap will depend on factors specific to the barrier (e.g., jump pool characteristics and stream velocity) and factors specific to the fish (e.g., species, size and condition). Stuart (1962, as cited in Meehan, 1991) observed salmon jumping over obstacles 2-3m in height. Powers and Orsborn (1985, as cited in Meehan, 1991) reported that the abilities of salmon and trout to pass over barriers depended on the swimming velocity of the fish, the horizontal and vertical distances to be jumped, and the angle to the top of the barrier. Reiser and Peacock (1985, as cited in Meehan, 1991) computed maximum jumping heights of salmonids on the basis of darting speeds: chinook salmon (2.4m), coho salmon (2.2m), and steelhead trout (3.4m). These values represent upper limits of potential, not preferred or even readily achievable heights.

Productivity of Streams & Food Sources

Streams vary in productivity due largely to the nutrients and energy available. If the findings for sockeye salmon (as cited in Meehan 1991: Brett et al. 1969) are similar for other salmonids, a yearling salmonid in a stream with daily mean temperature of 10°C would need a daily food supply equivalent to 6-7% of its body weight to attain maximum growth. Production of aquatic invertebrates that juvenile salmonids eat depends on the amount of organic material available in streams. Nearly 75% of the organic matter deposited in first-order streams is associated with debris dams, versus 58% in second-order stream and 20% in third-order streams (Bilby and Likens, 1980).

CHAPTER 5
PROBLEM STATEMENT

This chapter provides a description of the existing in-stream and upslope watershed setting and the beneficial use impairments of concern. In other words, the problem statement provides background information about the Gualala River watershed that is intended to assist readers in understanding the context for the TSD analysis. This chapter specifically focuses on the conditions associated with sedimentation in the Gualala River watershed. In addition, conditions associated with temperature are also included in this chapter. Temperature issues are related to sediment delivery by processes such as channel aggradation and pool infilling, but are also a function of processes independent of sediment delivery such as microclimates, riparian cover, and solar insolation. In summary, the beneficial uses associated with the cold water fishery are currently not being protected, as shown by the listing of Coho Salmon and Steelhead Trout as threatened species under the Endangered Species Act. The Gualala River watershed was listed under the CWA, Section 303(d) as an impaired water body due to sedimentation.

This analysis is based on those data that have been submitted to Regional Water Board staff for consideration. Due to the absence of information in some areas of the watershed and with respect to certain habitat parameters, conservative assumptions based on professional judgment have been made regarding the factors that are potentially limiting salmonid populations in the basin. The discussion in Section 6.8 (Numeric Targets) is based on the problems identified in this analysis. As additional data become available in the future (such as the North Coast Watershed Assessment Program (NCWAP) Limiting Factors Analysis), the TMDL and numeric targets can be modified.

5.1 Summary

Section 5.1 summarizes information further described and cited in sections 5.2 and 5.3.

5.1.1 Salmonid Distribution and Abundance

5.1.1.1 Steelhead

Steelhead have been observed throughout the entire watershed historically. Available information indicates that the populations show a pattern of decline. However, it does appear that steelhead continue to be present in most tributaries throughout the watershed. Data supports the hypothesis that the steelhead populations were in a declining trend as early as the 1970s. The latest estimate of the total Gualala river steelhead population was in 1977, when CDFG estimated the winter steelhead population at 4,400 (Sheahan, 1991). It is not possible to determine how the number of steelhead planted in various streams has affected the overall population.

Presence/absence surveys conducted in the South Fork Gualala River and in the Wheatfield Fork in the early 1990s indicate that the fish community is now dominated by Gualala roach and three-spine stickleback in many areas. In addition, a large percentage of the steelhead observed appear to be young of the year (YOY) that may not be surviving to mature and propagate. Additional studies would be necessary to confirm this.

One area identified that should be considered a refuge area for salmonids is the Little North Fork Gualala River.

5.1.2.1 Coho

Due to the limited data, it is impossible to estimate the population size of coho salmon in the Gualala River watershed. However, it appears that the coho that were once plentiful have all but vanished from this watershed.

Available data indicates that coho began to decline rapidly in the Gualala River watershed by the latter part of the 1960s. Few coho were observed in the stream surveys of the early 1970s and coho were last noted in CDFG stream surveys in Fuller Creek (Wheatfield Fork) and its tributaries in 1970 and in 1971. Coho were also observed in Haupt Creek, a tributary to the Wheatfield Fork, in 1970.

Coho were not observed during electrofishing surveys conducted in the basin during the 1980s and 1990s, other than the Little North Fork. Coho were not caught during any of the South Fork Gualala River and estuary studies conducted in the 1990s.

Juvenile coho that were observed during the 1997 surveys of Doty Creek and the Little North Fork Gualala River could be the result of CDFG plants in 1995 (Dennis Halligan, personal communication, as cited in Higgins, 1997). It is possible that their progeny continue to exist in this sub-watershed.

The last reported sighting of coho salmon in the Gualala River may have been the observed entry of nine adult coho into the Gualala River when the sand bar opened at the mouth during the winter of 1999-2000.

5.1.2 Stream Conditions

Available data suggest that salmonid spawning, incubation, and emergence success may be limited by the following factors:

- Impact of fine sediments on spawning and rearing habitats
- Lack of pool habitat provided by Large Woody Debris (LWD)
- Increased stream temperature possibly due to canopy removal and an oversupply of sediment

5.1.3 Substrate

As noted in Section 5.3.1, in-stream substrate samples taken by CFL (1997), GRI (1992-1999), and Knopp (1993) generally indicate that aquatic habitat throughout the watershed is impaired by excessive fine sediments. Median surface particle diameter (D_{50}) measurements were made by both CFL and GRI at numerous locations; GRI also measured percent fines data for the North Fork and some of its tributaries. V* data was provided by Knopp (1993). The data suggest that upslope disturbances have impacted stream substrates with excessive fine sediments, and impaired the ability of the aquatic habitat to support salmonid spawning, incubation, and emergence. The exception is Dry Creek where both D_{50} and percent fines data indicate good spawning habitat. Regional Water Board staff observations of conditions in the Spring of 2001 indicate that stream channels are still greatly impacted by fine sediment.

5.1.4 Large Woody Debris Abundance

Results of CFL surveys provide evidence that, with the exception of Fuller Creek, stream reaches throughout the Gualala River watershed lack essential habitat provided by LWD. As explained in Section 5.3.3, two indices measured for the survey, LWD pieces per bankfull width and LWD volume index, measured for the survey, fell short of criteria established by Peterson et al (1992). Past land management involving logging and associated practices such as splash dam log transportation, as well as previous CDFG projects that removed migration barriers throughout the watershed, have led to the dearth of salmonid habitat provided by LWD (Section 5.3.2).

5.1.5 Temperature

Temperature data from Gualala Redwoods Inc. (GRI 1993-1998) and Mendocino Redwood Company (MRC, unpublished data) suggest that stream temperatures for most of the watershed exceed preferred juvenile rearing temperature ranges for steelhead and coho. Exceedance of short-term maximum lethal temperatures for steelhead and coho occur throughout the watershed as indicated in Table 5.10 and Table 5.11.

5.2 Salmonid Distribution and Abundance

Short- and long-term trends in abundance are a primary indicator of risk in salmonid populations (Weitkamp et al., 1995). Trends may be calculated from a variety of quantitative data, including dam or weir counts, stream surveys, and catch data (Weitkamp et al., 1995). When data series are lacking, general trends may be inferred by comparing historical and current abundance estimates (Weitkamp et al., 1995).

5.2.1 Historic Salmonid Abundance and Distribution

The following information is partially extracted from the Gualala River Watershed Literature Search and Assimilation (Higgins, 1997), a compilation of Gualala River watershed data completed by Patrick Higgins under contract to the Redwood Coast Land Conservancy.
The Gualala River historically has been an important stream for its runs of steelhead, rainbow trout and coho salmon. Steelhead trout still provide a viable sport fishery. In the last decade

coho salmon have only been reported in the Little North Fork and its tributaries where coho have been planted by CDFG as recently as 1997 (CDFG, unpublished data (b)). Rainbow trout are noted to exist above impassible barriers (Cox, 1989). It is likely that chinook (king) salmon were native to the Gualala River as they were to Russian River to the south and to the Garcia River and coastal watersheds to the north.

The only known estimate of historic salmonid abundance in the Gualala River watershed was developed by the California Department of Fish and Game in the early 1960s. The CDFG reported 16,000 steelhead, 4,000 coho, and zero chinook (California Fish and Game Commission 1965).

Other fish species native to the Gualala River (Higgins, 1997) include the Gualala roach (*Lenvenia parvipinnis*), three-spined stickleback (*Gasterosteus aculeatus*), prickly sculpin (*Cottus asper*), Coast Range sculpin (*Cottus aleuticus*), and Pacific Lamprey (*Lampetra tridentata*). The Gualala roach has been designated as a "Species of Special Concern" because they are a distinct subspecies, apparently endemic to the Gualala River system, and their life history and population status are poorly understood. Moyle (1976 as cited by Higgins, 1997) states that Gualala roach prefer water temperatures less than 23 C to 24 C for long-term survival, but can survive temperatures up to 35 C (95 F).

5.2.1.1 Coho Salmon

The coho population was recently estimated for Mendocino County at 4,950 fish (Brown et al., 1994; Weitkamp et al., 1995). Adams et al. (1999) report that coho are found in 51% of the streams in which they were historically present in California and 64% of the streams in Mendocino County in which they were historically present.

While there is a paucity of data on coho salmon abundance in the Gualala River, there are the following indications that they were once numerous. Bruer (1953, as cited by Higgins, 1997) asserted that there were millions of steelhead and coho juveniles in arguing for re-opening summer "trout" fishing. The California Fish and Game Commission (1965) reported an estimated 4,000 coho in the mid-1960s in the Gualala River. The United States Bureau of Reclamation (1974, as cited in Moyle et al., 1994) estimated that 75 miles of habitat was available to coho salmon. Boydstun (1974a) reported that 831 adult coho salmon were caught in the 1972-73 angling season with 244 released. The high catch in 1972-73 may have been due (at least in part) to coho planting by CDFG (Barracco & Boccione, 1977 as cited by Higgins, 1997). In contrast, the 1976-77 creel census reported only 10 coho.

Coho are known historically to have spawned and reared in the tributaries listed below, and possibly others (Cox, 1994). In the last decade, coho have been found only in the Little North Fork (Dennis Halligan, personal communication as cited by Higgins, 1997) and Doty Creek, where they have been planted by CDFG as recently as 1997.

Gualala River Tributaries with Historic Coho Presence (Cox, 1994 and Ambrose, 2000)

- North Fork Gualala River
  - Robinson Creek
  - Dry Creek
  - Little North Fork
    - Doty Creek
- South Fork Gualala River
  - Marshall Creek
  - Sproule Creek
  - Buckeye Creek
    - Francini Creek
- Wheatfield Fork Gualala River
  - Haupt Creek
  - House Creek
  - Fuller Creek
    - North Fork Fuller Creek
    - South Fork Fuller Creek

5.2.1.2 Chinook (King) Salmon

Very little information exists on the historical presence of chinook in the Gualala River. A long-time resident of the Gualala watershed was interviewed in 1997 (Spacek, unpublished). This resident recalled catching a 34-pound salmon in 1919. Higgins (1997) explained that a fish of this size would be much too large to be a coho, and therefore was likely a chinook. Other residents who were interviewed reported that it was uncommon to catch a chinook even in the 1930s. Small runs of chinook reportedly were observed in the last decade (Coastal Forestlands (CFL) communication with Wendall (sic) Jones as cited in CFL, 1997).

5.2.1.3 Steelhead Trout

Prior to the 1940s, there appears to be little to no data on the Gualala steelhead fishery. Following World War II in 1945, there was an estimated 200-300% increase in anglers on the Gualala River (Taft, 1951), compared to pre-WWII figures. Concern about the effect of fishing on juvenile steelhead populations led CDFG to close portions of the Gualala and several other rivers for summer and winter fishing, from 1948 through 1982 (Bill Cox, personal communication 2000). The general trend during that time period was that the upper river was open for summer fishing while the lower river was open for winter steelhead fishing. With the passage of new regulations in 1982, waters of the Gualala River watershed were closed to fishing year-round, with the exception of the Mainstem and the South Fork below Valley Crossing (Bill Cox, personal communication 2000).

California Department of Fish and Game Surveys

The CDFG's files include a series of historical stream surveys in which field staff walked portions of streams noting their observations. Detailed field notes taken during these surveys, performed in various streams from the late 1950s through the late 1980s, indicate the presence of steelhead in the majority of streams surveyed. The majority of streams where steelhead were notably absent were in minor tributaries to the Wheatfield Fork. These tributaries were reported to have little to no water during the summer months.

Creel census surveys and mark-and-recapture techniques were used by CDFG in the 1950s through the 1970s to estimate populations of adult steelhead on the Gualala River. The highest catches were estimated at 1,700 steelhead in 1974-75, 1,590 in 1953-54, 1,418 in 1975-76, and 1,352 in 1954-55 (see Table 5.1).

In 1973, CDFG estimated that the steelhead population (for the entire system) was between 2,219 ("Park Hole") and 2,584 (estuary), based on recapture in two areas of the lower mainstem Gualala. The respective 95% confidence limits were 799 – 5,165 and 571 – 9,535. In 1974-75, CDFG estimated that the adult steelhead population was 7,608, with a 95% confidence interval of 6,126-10,379 (Boydstun, 1976b). In 1975-76 the population was estimated at 6,300 (Boydstun, 1976b). In 1977, CDFG estimated the winter steelhead population at 4,400 (Sheahan, 1991).

TABLE 5.1. STEELHEAD ADULT CATCH BY YEAR, INCLUDING ANGLER HOURS AND CATCH PER HOUR, CDFG CREEL CENSUS (FISHER, 1957) AND COASTAL STEELHEAD STUDIES (BOYDSTUN 1973; BOYDSTUN,1974A; BOYDSTUN, 1974B; BOYDSTUN, 1976A; BOYDSTUN, 1976B)

Years	Catch	Hours	Catch/hr	Estimated Population
1953-54	485	4,515	0.28	NR
1954-55	570	7,613	0.08	NR
1962	NR	NR(single day)	0.2	NR
1972-73	288	12,884	0.02	NR
1973-74	1,700	13,218	0.13	2,219, 2,584
1974-75	793	14,593	0.05	7,608
1975-76	1,418	27,899	0.05	6,300
1977	NR	NR	NR	4,400

NR= Information not reported

Boydstun (1974b) noted that while angler effort in 1972-73 was 60% greater than in 1953-54, the catch in the 1970s was just 25% of the 1950s catch. He attributed the decreased catch rate to decreased adult steelhead abundance. From 1970 to 1976, the CDFG supplemented Gualala River steelhead runs with hatchery fish which may have increased the escapement and catch. Higgins (1997) noted that it is also possible for external conditions to skew the catch per unit effort.

In addition to the creel censuses that were conducted by CDFG during the winters of 1953-54, 1954-55, 1972-73, 1973-74, 1974-75, and 1975-76, a single-day creel census was completed on January 24, 1962 (see Table 5.1). The 0.2 catch per angler hour that day compares favorably with the 1950s values and is higher than the 1970s values. However, the water conditions in the river on this day were noted by the CDFG biologist as "perfect for steelhead fishing."

It is possible that conditions in 1973-74 where the catch numbers were high, may have been particularly favorable for angling. In years with high flows and turbidity, such as 1972-73, catch numbers may have been adversely affected (Higgins, 1997). However, during the latter 1970s a downward trend in catch is plausible.

During the 1975-76 season, 17% of the total catch was estimated to be planted steelhead. The year prior, 23% of the total catch was estimated to be from plants (Boydstun, 1976b).
In-river harvest of steelhead in 1975-76 was estimated to be only 15% of the adult population (Boydstun, 1976b). Based on this estimate, it was concluded that sportfishing most likely had a minimal impact on the adult steelhead population. Reavis (1983, as cited by Higgins 1997), made a similar conclusion, finding that only two of the estimated 535 salmonids caught by anglers in the spring and summer of 1982 were kept.

5.2.2 Current salmonid abundance and distribution

Insufficient information exists from which to draw quantitative conclusions about the current abundance and distribution of salmonids in the Gualala River watershed. The following information, collected during the last two decades, does however offer a qualitative perspective.

Data sources considered include:
- CDFG electrofishing (summer-rearing) surveys
- Fish presence/absence surveys
- Spawning surveys
- CDFG stream inventory of McKenzie Creek watershed
- Coastal Forestland's Watershed and Aquatic Wildlife Assessment

5.2.2.1 Steelhead Trout Summer-rearing and Spawning Surveys

North Fork
The CDFG conducted electrofishing (summer-rearing) surveys in several tributaries of the Gualala River between 1983 and 1998 (Table 5.2). The density of steelhead at the various locations over this time-period in the Little North Fork, where the majority of surveys were conducted, ranged from 0.19 to 1.49 fish per square meter of stream (m^2). The average density of steelhead in the Little North Fork from 1993 to 1998 was 0.44 fish/m^2.

TABLE 5.2. STEELHEAD TROUT AND COHO SALMON POPULATION DATA COLLECTED BY CDFG REPORTED IN ITS BIOSAMPLE DATABASE (UNPUBLISHED)

Stream reach	Date	Steelhead density (fish/m^2)	Steelhead biomass (kg/ha)	Coho density (fish/m^2)*	Coho biomass (kg/ha)
Little N. Fork Gualala River	10/28/83	0.46	31.67	0	0
Robinson Creek	10/28/83	0.84	55.89	0	0
Little N. Fork Gualala River	9/23/86	NR	NR	0	0
Doty Creek	9/23/86	NR	NR	0	0
Log Cabin Creek	9/23/86	NR	NR	0	0
Dry Creek	9/24/86	NR	NR	0	0
North Fork Gualala River	9/24/86	NR	NR	0	0

Stream reach	Date	Steelhead density (fish/m^2)	Steelhead biomass (kg/ha)	Coho density (fish/m^2)*	Coho biomass (kg/ha)
Robinson Creek	9/24/86	NR	NR	0	0
Little N. Fork Gualala River (upper)	10/11/88	0.22	8.8	0.36	15.85
Little N. Fork Gualala River (lower)	10/12/88	0.64	19.65	0.92	29.85
Little N. Fork Gualala River (lower)	10/20/89	1.49	36.94	0	0
Little N. Fork Gualala River (upper)	10/20/89	0.29	12.43	0	0
Little N. Fork Gualala River (lower)	11/2/90	0.47	17.06	0	0
Little N. Fork Gualala River (upper)	11/9/91	0.54	23.18	0	0
Little N. Fork Gualala River (lower)	11/9/91	0.25	5.48	0	0
Little N. Fork Gualala River (lower)	10/28/92	0.6	18.2	0	0
Little N. Fork Gualala River (upper)	10/28/92	0.19	9.8	0	0
Little N. Fork Gualala River (upper)	9/30/93	0.55	31.97	0	0
Little N. Fork Gualala River (lower)	9/30/93	0.4	11.91	0	0
Little N. Fork Gualala River (lower)	9/19/95	0.41	12.95	0	0
Little N. Fork Gualala River (upper)	9/19/95	0.53	15.96	0	0
Soda Springs	11/8/95	NR	NR	0	0
Buckeye Creek –Unnamed Tributary	11/8/95	NR	NR	0	0
Osser Creek	11/8/95	NR	NR	0	0
Buckeye Creek- Flat Ridge	11/8/95	NR	NR	0	0
Buckeye Creek	11/8/95	NR	NR	0	0
Francini Creek	11/8/95	NR	NR	0	0
Little N. Fork Gualala River (upper)	10/30/98	0.46	17.98	0	0
Little N. Fork Gualala River (lower)	10/30/98	0.27	21.87	0	0

NR= Not Reported *all coho reported are young of year

Large numbers of juvenile steelhead were reportedly observed during the spawning surveys conducted in 1989-1990 in the Little North Fork Gualala River and its tributaries. Maahs and

Gilleard (1994) concluded that the juvenile presence and spawning of steelhead indicated the production in these streams was quite good.

Wheatfield Fork

In addition to the data in the table above, electrofishing was performed by the CDFG in August 1989 at four locations in the Fuller Creek drainage. Two of the same locations, on the mainstem and South Fork Fuller Creek, were sampled again in 1995. The resulting steelhead densities were 33.3 and 15.3 per 100 feet of stream, respectively. These densities were reported to be approximately half of the 1989 densities (Cox, 1989 and 1995).

South Fork

Juvenile steelhead were studied during the late 1980s in the lower South Fork Gualala River, below the Wheatfield Fork and in the estuary. Looking at the size of fish in the samples collected in the estuary during the spring of 1984-1986 (Brown, 1986), it appears that young-of-the-year (YOY) steelhead dominated the samples. This could indicate that the carrying capacity of the tributaries is low, as noted by Higgins (1997) or that there is a decrease in favorable living space upstream, forcing juveniles to emigrate prematurely (Graves and Burns, 1970 as cited by Mangelsdorf et al., 1997). It is also possible that the high number of YOY steelhead were the result of late season spawning just upstream in the mainstem or lower reaches of the tributaries (Higgins 1997).

Additional studies were conducted on the South Fork Gualala River in the last decade. Electrofishing surveys were conducted in July and October 1991 at 16 stations along the Lower South Fork, extending approximately from its confluence with the Wheatfield Fork downstream, to the confluence with Buckeye Creek. Seven locations upstream and nine locations downstream of the Sea Ranch wells were identified, as the purpose was to study the effects of the water diversion. Streamflows were noted to be unseasonably low during the July portion of this study. The three most abundant species at all stations were steelhead trout, Gualala roach and three-spine stickleback (see Table 5.3 and Table 5.4). Gualala roach were generally dominant, although sticklebacks were the most abundant in upstream riffle habitat in July and upstream run habitat in October. Steelhead trout were the most abundant species in upstream run habitat in July.

Nearly all of the base steelhead population was age 1^{+} with a small percentage of age 2^{+}. Conclusions of this study asserted that relatively low base populations of steelhead were present both upstream and downstream of the wells due to regional drought and seasonal low streamflow conditions.

Electrofishing surveys were performed in October 1993 for The Sea Ranch subdivision by Entrix, Inc. in the South Fork Gualala River above and below the confluence with the Wheatfield Fork, and in the Wheatfield Fork (EIP, 1994). As noted by EIP (1994), these fish counts represent an index of fish abundance, rather than an estimate of the true population number. Gualala roach were the most abundant fish at the one site (A) that was sampled downstream of the confluence of the Wheatfield and South Forks. Steelhead trout were the most prevalent at the four sites sampled on the South Fork upstream of the confluence (sites B-E), ranging from 13 to

33 fish. Two sites sampled on the Wheatfield Fork (F, G) also had a slightly higher number of steelhead than roach.

Fourteen pools on the South Fork Gualala River were surveyed by snorkel during mid-October 1993 (see Table 5.5). These pools extended from approximately 75 meters upstream of the Wheatfield Fork confluence down to the confluence with Pepperwood Creek. Gualala roach and three-spine stickleback typically congregated in large schools; therefore, their abundance was visually estimated (EIP, 1994).

TABLE 5.3. SPECIES COMPOSITION AND RELATIVE ABUNDANCE (FISH/100M) BY HABITAT TYPE UPSTREAM AND DOWNSTREAM OF SEA RANCH WELLS, 1991 (ENTRIX, 1992)

Habitat Type	Species	July		October	
Habitat	Species	Upstream	Downstream	Upstream	Downstream
Riffle	Steelhead	280	63	18	13
	Gualala roach	297	125	136	236
	Three-spine stickleback	615	69	63	68
Run	Steelhead	451	121	47	40
	Gualala roach	148	161	505	146
	Three-spine stickleback	116	52	690	63
Deep Pool	Steelhead	135	63	80	145
	Gualala roach	200	134	231	263
	Three-spine stickleback	116	110	147	115
Rootwad Pool	Steelhead	388	193	171	81
	Gualala roach	977	1,474	318	178
	Three-spine stickleback	380	30	326	0

TABLE 5.4. AVERAGE JUVENILE STEELHEAD POPULATION ESTIMATES BY HABITAT TYPE UPSTREAM AND DOWNSTREAM OF SEA RANCH WELLS, 1991 (ENTRIX, 1992)

Juveniles	July		October	
	Upstream	Downstream	Upstream	Downstream
Base population				
Riffle	8.0	3.3	0	2.5
Run	65.0	16.7	0	3.0
Deep Pool	44.5	20.0	29.0	24.0
Rootwad Pool	202.0	30.0	39.0	15.0
YOY				
Riffle	278.0	66.3	18.0	25.5
Run	386.0	105.7	47.0	34.7
Deep Pool	112.0	71.0	46.5	179.0
Rootwad Pool	210.0	178.0	132.0	67.0

TABLE 5.5. SNORKEL SURVEY OPERATIONS IN THE GUALALA RIVER, OCTOBER 1993 (EIP, 1994)

Site Number	Steelhead Trout Total	Steelhead Trout by Age			Gualala Roach Total	Three-spine Stickleback Total
		0^+	1^+	2^+		
1	95	74	19	2	900	250
2	34	16	18	0	1,500	200
3	293	246	46	1	1,400	800
4	72	30	36	6	1,350	200
5	78	49	26	3	880	126
6	47	30	17	0	400	0
7	65	51	13	1	720	60
8	68	58	10	0	30	0
9	9	9	0	0	740	0
10	6	4	2	0	350	0
11	27	23	4	0	100	1
12	8	8	0	0	1,200	200
13	135	100	35	0	750	0
14	140	100	35	5	750	150
TOTALS	1,077	798	261	18	11,070	1,987

Steelhead were observed at all sites, ranging in abundance from 6 to 283 fish. Age 0^+ steelhead accounted for 74 percent of the population overall. Age 1^+ accounted for 24 percent of the population. The remaining 2% were comprised of age 2^+ fish. The Gualala roach was the most abundant fish at the majority of sites, with population estimates of greater than 700 fish at 10 of the 14 pools surveyed. The roach and stickleback were typically common in backwater areas. Stickleback typically inhabit shallow water habitats that could not be accurately assessed by snorkeling, and therefore may have been more abundant than the survey indicated (EIP, 1994).

Halligan (2000) studied the densities of steelhead in the North Fork Gualala River under contract to the Gualala River Steelhead Project (GRSP) during the fall of 2000. The purpose of the study was to determine if the released steelhead would overwhelm the carrying capacity of the stream and have an adverse affect on the naturally reared fish.

Unfortunately, there is very little information regarding optimal densities for salmonids in Northern California. The only report that comes close to suggesting an optimal upper limit is Harvey and Nakamoto (1996, as cited by Halligan, 2000) when they observed a significant decline in juvenile steelhead survival rates when densities rose from 1.5 fish/m^2 to 3 fish/m^2 in South Fork Caspar Creek.

Four survey reaches were studied within the mainstem Gualala River and the North Fork Gualala River (Table 5.6). Underwater observations for this study were made by snorkeling. Several pool/riffle sequences were surveyed to obtain inter-reach habitat variability. The first set of dives was on September 16. On October 13, a second set of dives was made, after a rain when smolt may have migrated to the estuary.

TABLE 5.6. JUVENILE STEELHEAD OBSERVATIONS IN THE GUALALA RIVER WATERSHED BY SIZE CLASS, DENSITY, AND STREAM LENGTH (HALLIGAN, 2000).

Reach	Age Class	Number by Age Class		Density (fish/m^2)		Fish per meter of stream length	
		Sept.	Oct.	Sept.	Oct.	Sept.	Oct.
1 Mainstem- 100' downstream of N. Fork	YOY	**0**	**0**	**0**	**0**	**0**	**0**
	1+	0	3	0	0.0008	0	0.014
	2+	0	7	0	0.002	0	0.033
	3+	0	2	0	0.002	0	0.033
	Total	**0**	**12**	**0**	**0.005**	**0**	**0.08**
2 N. Fork- 100' Upstream of Little N. Fork	YOY	33	22	0.03	0.02	0.19	0.13
	1+	64	83	0.06	0.08	0.37	0.47
	2+	9	12	0.008	0.01	0.05	0.07
	3+	3	0	0.003	0	0.02	0
	Total	**109**	**117**	**0.101**	**0.11**	**0.63**	**0.67**
3 N. Fork- 2,500' down-stream of Robinson Creek	**YOY**	99	60	0.07	0.04	0.39	0.23
	1+	73	133	0.05	0.09	0.29	0.52
	2+	8	16	0.006	0.01	0.03	0.06
	3+	0	1	0	0.001	0	0.004
	Total	**180**	**210**	**0.126**	**0.14**	**0.71**	**0.81**
4 N. Fork- 3,500' upstream of Dry Creek	**YOY**	18	37	0.017	0.035	0.08	0.16
	1+	34	65	0.03	0.062	0.15	0.28
	2+	10	18	0.009	0.017	0.04	0.08
	3+	7	2	0.007	0.002	0.03	0.009
	Total	**69**	**122**	**0.063**	**0.12**	**0.3**	**0.53**

The resulting data from the Halligan (2000) study in the Gualala watershed are comparable to the fish population data collected by Entrix (1992), in the South Fork Gualala River in October

1991. The juvenile steelhead abundance in 1991 averaged 80 fish per 100 meters of stream length for all habitat types combined. The North Fork estimates averaged 30-71 fish per 100 meters (for all habitat units) in September, and 53-81 fish in October (Halligan, 2000). Previous surveys performed in the North Fork Gualala River indicated steelhead densities between 0.19 and 1.5.

Halligan (2000) concluded, that based on the low density of juvenile steelhead and the presence of underutilized habitat units, it appears that the North Fork Gualala River may not be at carrying capacity. The winter survivability of steelhead parr may be greater in the North Fork than the lower mainstem. The fish densities in the North Fork and Gualala River appear to be relatively low when compared to data from other watersheds in the region (see Table 5.7). It is important to note that these types of data are highly variable and reflect only short periods in time, not actual populations.

TABLE 5.7. JUVENILE STEELHEAD DENSITY FROM WATERSHEDS IN NORTHERN CALIFORNIA (HALLIGAN 2000)

Year	Location	Density (fish/m^2)	Source (as cited in Halligan, 2000)
1952	Lower Gualala River	0.39	Kimsey (1953)
1967-1969	N.F. Caspar Creek	0.54 – 1.39	Burns (1971)
1988-1991	L.N.F. Gualala River	0.22-1.48 (0.52)	CDFG (1991)
1993	N.F. Caspar Creek	1.5	Harvey & Nakamoto (1996)
1994-1995	Little River & Tribs. Humboldt Co.	0.3 – 0.58	Louisiana Pacific unpublished data
1998	Freshwater Creek Humboldt Co.	0.32	Pacific Lumber Co. Unpublished data
1999	Freshwater Creek Humboldt Co.	2.01	Pacific Lumber Co. Unpublished data

A stream inventory was performed by the CDFG during the summer of 1999 (CDFG, 2000) in McKenzie Creek (tributary to Marshall Creek), and its tributaries. The inventory indicated the presence of steelhead (mainly YOY), in McKenzie, Camper, and Carson Creeks; however, none were observed in Wild Hog Canyon Creek. Populations were not estimated as part of this survey. A 1964 survey of McKenzie Creek, performed by CDFG, indicated that it was an important tributary to the South Fork Gualala due to excellent steelhead and coho spawning areas (CDFG, unpublished data (a)). Coho were not observed during the 1999 survey. A 1964 stream survey of Marshall Creek noted the presence of 100 steelhead and 30 coho per 100 feet of stream.

5.2.2.2 Coho Salmon

Michael Maahs and the Salmon Troller's Marketing Association performed redd surveys in the Little North Fork and the North Fork Gualala three times during February 1991 (1st through the 15th). No live coho or carcasses were observed and only two redds were observed in the Little North Fork. Five redds were found on the North Fork just downstream from the mouth of the Little North Fork. These redds were most likely laid by fish headed for the Little North Fork which did not spawn due to low flow conditions (Maahs and Gilleard, 1994). CDFG had planted yearling coho in this stream in 1988 (see Table 5.8). However, this spawning activity was not believed to be due to returning adult coho from this release since the redds were not found until the second February survey (Maahs and Gilleard, 1994).

The CDFG conducted electrofishing (summer-rearing) surveys in several tributaries of the Gualala River between 1983 and 1998 (Table 5.2). Coho were only observed at the upper and lower Little North Fork stations during October 1988, at 0.36 and 0.92 fish/m^2, respectively. Coho were not previously observed at these locations during the October 1983 sampling, nor were they observed in subsequent sampling events during the 1989 – 93, 1995 and 1998 surveys at these same locations.

During the previous season surveys (1989-90), there were as many as 17 redds (or 2.06 redds/mile of stream) observed in the Little North Fork Gualala (Nielsen, et al., 1990), many of which were observed during the month of January (indicating that they were likely coho redds).

Coho were not observed during the snorkel, electrofishing or stream surveys conducted in the watershed during the 1990s, as described above.

5.2.3 Shifts in Fish Community Structure

Higgins (1997) described the shifts that appear to have taken place in the Gualala River community structure as the Gualala roach and the three-spine stickleback have become more prevalent in recent years. Brauer (1953, as cited in Higgins 1997) stated that although Gualala roach were present throughout the river basin, they were found only in small numbers. An electrofishing sample taken on the lower main stem Gualala River just below the North Fork by Kimsey (1952) indicated that steelhead were the most abundant species. Dive observations in July and October 1991 (EIP 1994) on the Lower South Fork below the Wheatfield Fork showed a community dominated by Gualala roach and stickleback (Tables 5.3 & 5.4). CDFG stream surveys also indicate that the density of roach and stickleback have greatly increased since the 1960s. Halligan (1997), in comments on the draft of Higgins 1997 report, suggested that steelhead might make up a higher proportion of the community after a series of wet years. The 1991 samples were taken after a sequence of drought years.

5.2.4 Hatchery Contributions

CDFG planted steelhead juveniles from the Mad River Hatchery in the Gualala River from 1972 through 1976, and then again from 1985 through 1989. A hatchery was operated by the Gualala River Steelhead Project (GRSP) in the late 1980s using native Gualala River brood fish that were caught by anglers. In 1994, the GRSP changed the emphasis of their program to rescue, rearing, and release (Bill Ackerman, personal communication). However, records indicate that steelhead were planted annually through 1997. A total of approximately 435,000 steelhead were planted during that time period.

CDFG planted coho salmon in the Gualala River and its tributaries from 1969 through 1973 and then again in 1975, 1983, 1984, and 1988, and finally from 1995-1997 (see Table 5.8). A total of approximately 348,000 coho were planted during those years (CDFG, unpublished data)**.** Coho salmon juveniles were also planted in the North Fork Gualala River in 1988 because suitable habitat was present and electrofishing surveys showed that the stream had lost its historic coho run (CDFG, unpublished data (b)). Unfortunately, the large numbers of coho planted were unable to prosper. Poor survival of coho planted in the late 1980s was ascribed to drought conditions, but the possibility of Bacterial Kidney Disease, a disease fairly common to hatchery fish, was also raised (CDF 1994). Higgins (1997) observed that although temperatures are cool enough for coho salmon introduction, spawning gravel stability and pool volume in the Gualala River may not be optimal for coho.

5.2.5 Synthesis

This assessment looks at existing data regarding the distribution and abundance of three life stages of salmonids in the Gualala River watershed as provided by spawning surveys, stream surveys, summer electroshocking and snorkel surveys (summer-rearing), and estimates of hatchery releases. Each of these data sources has the potential to provide useful information on relative population structure and abundance; however, the data are insufficient to provide a quantitative picture of salmonid abundance and distribution in the individual tributaries to the Gualala River.

5.2.5.1 Steelhead

Steelhead have been observed throughout the entire watershed historically. Available information indicates that the populations show a pattern of decline. However, it appears that steelhead continue to be present in most tributaries throughout the watershed.

Data supports the hypothesis that the steelhead populations were in a declining trend as early as the 1970s. Steelhead population estimates calculated from the CDFG 1970s creel and mark-and-recapture surveys conducted in the lower river indicate a large range in population, from a low of 571, to a high of 10,379. Nonetheless, this information does provide some perspective. If the CDFG estimate in the mid-1960s of 16,000 steelhead in the Gualala River is reasonable this range indicates that a substantial decrease in run size occurred in just a few years.

TABLE 5.8. GUALALA RIVER FISH PLANTS FROM CDFG (UNPUBLISHED DATA (C)

Year	Approximate Number of Fish		Entity responsible for planting
	Coho	Steelhead	
1969	Gualala: 90,042		CDFG
1970	Gualala: 30,000		CDFG
1971	Gualala: 30,000		CDFG
1972	Gualala: 15,003	Gualala :1,950; 10,800	CDFG
1973	Gualala: 20,007	Gualala: 20,345	CDFG
1974		Gualala: 8,532; 7102	CDFG
1975	South Fork Gualala: 10,005	Gualala: 10,036; 14,600	CDFG
1976		Gualala: 10,070	CDFG
1983	Gualala: 11,500	Walker Creek: 12,500	GRSP, GRSP
1984	Gualala: 12,000	Walker Creek: 13,400	GRSP, GRSP
1985		Gualala: 4,725; Gualala: 5,000	CDFG, GRSP
1986		Gualala: 27,450; Doty Creek: 30,000	CDFG, GRSP
1987		Gualala: 11,250; Gualala: 13,000	CDFG, GRSP
1988	Little N. Fork Gualala: 84,000	Gualala: 79,000; Gualala: 29,750	CDFG; GRSP, CDFG
1989		Gualala: 42,700; Old Bridge Hole (Son. Co. Park) 31,000	CDFG; GRSP
1990		Gualala River, Regional Park: 20,025; Gualala River, County Park 21,312	GRSP; GRSP
1991		Robinson Creek: 2,000	GRSP
1994		North Fork Gualala: 4,600	GRSP
1995	Little N. Fork Gualala: 20,000	North Fork Gualala: 3,500	CDFG; GRSP
1996	Little N. Fork Gualala: 12,480	N. Fork Gualala 3,500	CDFG; GRSP
1997	Little N. Fork Gualala: 12,880	Doty Creek: 4,200	CDFG; GRSP

GRSP= Gualala River Steelhead Project Plant
CDFG= California Dept. of Fish & Game
Location was not reported if *Gualala* is noted in location column

In only one sub-watershed were the CDFG stream surveys (unpublished data (a)) conducted frequently enough to make any observations from the data. This information was collected in the Fuller Creek sub-watershed, where surveys were conducted in many of the same areas in the 1960s, 1970s, and 1980s. These surveys indicate that significant numbers of steelhead were observed in the early part of the 1970s, but these numbers (30-50/100 feet of stream) are lower than those of the early 1960s (approximately 150/100 feet of stream). In the late 1980s surveys, the populations were noted to have decreased even further (17-53/100 feet of stream).

Presence/absence surveys conducted in the South Fork Gualala River and in the Wheatfield Fork in the early 1990s indicate that the fish community is now dominated by Gualala roach and three-spine stickleback in many areas. In addition, a large percentage of the steelhead observed appear to be YOY that may not be surviving to mature and propagate. Additional studies would be necessary to confirm this.

Halligan (2000) concluded that the fish densities in the North Fork Gualala River are low compared to data from other watersheds in the region (see Table 5.6 and 5.7). The steelhead densities from this study are also lower than densities of previous surveys conducted by the CDFG in the 1980s (see Table 5.2 and 5.6).

One area identified that should be considered a refuge area for salmonids is the Little North Fork Gualala River. As stated earlier, Maahs and Gilleard (1994) concluded that the juvenile presence and spawning of steelhead in the Little North Fork Gualala River indicated that the production in these streams was quite good. It is also possible that the planting of steelhead in this sub-watershed was more successful, possibly due to the presence of adequate habitat.

It is not possible to determine how the number of steelhead planted in various streams has affected the overall population. As stated earlier, studies during the 1975-76 season estimated that 17% of the total catch was planted steelhead. The year prior, 23% of the total catch was estimated to be from plants (Boydstun, 1976b).

In-river harvest of steelhead in 1975-76 was estimated to be only 15% of the adult population (Boydstun, 1976b). The latest estimate of the total Gualala river steelhead population was in 1977, when CDFG estimated the winter steelhead population at 4,400 (Sheahan, 1991).

5.2.5.2 Coho

Due to the limited data, it is impossible to estimate the population size of coho salmon in the Gualala River watershed. However, it appears that the coho that were once plentiful have all but vanished from this watershed.

Available data indicates that coho began to decline rapidly in the Gualala River watershed by the latter part of the 1960s. Few coho were observed in the stream surveys of the early 1970s and coho were last noted in CDFG stream surveys in Fuller Creek (Wheatfield Fork) and its tributaries in 1970 and in 1971. Coho were also observed in Haupt Creek, a tributary to the Wheatfield Fork in 1970.

Coho were not observed during electrofishing surveys conducted in the basin during the 1980s and 1990s, other than the Little North Fork, as noted earlier. Coho were not caught during any of the South Fork Gualala River and estuary studies conducted in the 1990s.

Juvenile coho that were observed during the 1997 surveys of Doty Creek and the Little North Fork Gualala River could be the result of CDFG plants in 1995 (Dennis Halligan, personal communication, as cited in Higgins, 1997). It is possible that their progeny continue to exist in this sub-watershed.

The last reported sighting of coho salmon in the Gualala River may have been the observed entry of nine adult coho into the Gualala River when the sand bar opened at the mouth during the winter of 1999-2000.

5.3 Summary of Water Quality Conditions in the Gualala Watershed

As described in Chapter 4, salmonids are anadromous fish that live part of their lives in the ocean and part in freshwater. The intent of this section is to evaluate the condition of the freshwater habitat available to salmonids migrating to the Gualala River watershed for spawning, rearing, and outmigration to the ocean. While conditions outside of the Gualala River watershed certainly have an effect on the success of the salmonid populations that return there to spawn, it is the condition of the freshwater environment, particularly the sediment conditions, that is the focus of this assessment.

5.3.1 Data Describing Sediment Conditions

The effect of excess sediment on the salmonid lifecycle and habitat is discussed in Chapter 4 and, in greater detail, in other references such as Spence et al. (1996) and Meehan (1991). Information about in-stream sediment conditions was compiled from four sources:

- Coast Forestlands, Ltd. (CFL) Watershed and Aquatic Wildlife Assessment published in 1997.
- Gualala Timber Harvest Plans submitted in 1999, 2000.
- *Testing Indices of Cold Water Fish Habitat*, Knopp (1993).
- *Gualala River watershed literature search and assimilation*, Higgins (1997).

5.3.1.1 Coastal Forestlands, Ltd. (CFL) Assessment Data

Up until the summer of 1998, Coast Forestlands, Ltd. (CFL) owned approximately 35,000 acres in the Gualala watershed. CFL collected stream data at twelve sites in the Gualala watershed. Parameters collected include particle size distribution in riffles, residual depth of pools, canopy conditions, and large woody debris (LWD) frequency and volume. Data was collected both in the field and by remote sensing techniques.

CFL measured surface particle size distributions by Wolman pebble counts in 1996 on three "prominent riffles which represented potential spawning sites" in each study reach, including reaches on the North Fork Gualala, lower Rockpile Creek, and lower Buckeye Creek. The pebble count data shows the study reaches having an overabundance of fine sediment. Median surface particle diameter (D_{50}) measurements ranged from 8 to 38 millimeters (estimated from graphically presented data). In addition, CFL reported "percent sand on riffles", which measured percentage fine sands in the samples with less than 2 millimeter diameter (which correlates with percent fines, described in the next section). CFL noted that samples from Upper Buckeye Creek exceeded 15% sand for this parameter.

Criteria for evaluating D_{50} data presented by CFL can be taken from Knopp (1993), who measured a suite of habitat variables, including median surface particle diameter of riffles, in 60 streams draining the Franciscan geologic formation in northwest California (including Grasshopper and Fuller Creeks in the Gualala Watershed). Sampled streams were divided into three categories of increasing upslope erosion potential to assess whether measured variables were affected by that condition. The results of the study showed statistically significant differences between D_{50}s of managed and unmanaged streams. The mean D_{50} of unmanaged streams was 80.6 mm, while the mean of highly disturbed watersheds was 37.6 millimeters (mm). Comparing the Knopp data and the CFL data, instream conditions measured by CFL are similar to highly disturbed watersheds as described in Knopp.

5.3.1.2 Gualala Redwoods, Inc. Stream Monitoring Data

Gualala Redwoods, Incorporated (GRI) owns approximately 30,000 acres in the Gualala watershed and has monitored sediment conditions on streams in its ownership. A portion of its data, median particle size (D_{50}) and percent fines < 0.85 mm, has been reported in timber harvest planning (THP) documents. Its results are summarized in Table 5.9. As shown in Table 5.9, D_{50} values ranged from 14 to 89 mm for sampling locations throughout the watershed between 1997 and 1999. With the exception of Dry Creek, an upland tributary to the North Fork Gualala River, the median particle sizes were found to be 40 mm or less. The data are similar to CFL data and further indicate highly disturbed watersheds and widespread impact of upslope disturbances throughout the watershed.

GRI measured percent fine sediments using a McNeil sampler from riffles in North Fork tributaries. The results are given in Table 5.9. GRI data show a range of percent fines for the five North Fork tributaries sampled (Little North Fork, Doty, Dry, McGann Gulch, and Robinson Creeks) from 11% to 28%. With the exception of Dry Creek, all of the tributaries, on average, have percent fines greater than 15%, and thus fall within the range for salmonid habitat that is less than ideal (Section 6.8). At Dry Creek, both D_{50} and percent fine data for this stream indicate that the substrate for this creek provides suitable salmonid spawning habitat with respect to these two parameters.

TABLE 5.9. PERCENT FINES (<0.85 MM DIAM.) AND D_{50} OF STREAMBED SAMPLES AT VARIOUS LOCATIONS IN THE GUALALA RIVER WATERSHED (SOURCE: GRI THP DOCUMENTS)

Stream	Station	Year	% fines (<0.85mm)	D_{50} (mm)
Little North Fork	201	92	10.9	-
		93	21.0	-
		94	20.4	-
		95	20.8	-
		96	15.4	-
		97	16.0	-
	202	93	11.4	-
		94	14.6	-
		95	18.8	-
		96	17.2	-
		97	21.5	18
	203	93	17.1	-
		94	20.4	-
		95	11.6	-
		96	19.6	-
		97	18.8	35
		98	-	34
		99	-	36
	255	93	19.4	-
		94	17.2	-
		95	11.9	-
		96	24.4	-
		97	27.8	-
Doty Creek	256	93	16.2	-
		94	11.4	-
		95	16.9	-
		96	16.9	-
		97	17.0	-

Stream	Station	Year	% fines (<0.85mm)	D_{50} (mm)
Dry Creek	211	95	16.8	-
		96	14.7	-
		97	11.5	31
		98	-	45
		99	-	62
	212	97	-	89
	405	97	-	65
McGann Gulch	209	95	19.2	-
		96	26.8	-
		97	19.9	-
Robinson Creek	207	95	15.2	-
		96	18.1	-
		97	17.9	38
		99	-	36
	208	97	-	29
Buckeye Creek	223	97	-	25
	224	97	-	26
	231	97	-	24
		98	-	24
North Fork	204	97	-	14
	406	97	-	18
Big Pepperwood	218	97	-	31
		98	-	40
		99	-	31
	219	97	-	39
Gualala	217	98	-	25
Rockpile Creek	221	97	-	27
		98	-	25
	275	97	-	26
	401	97	-	28

5.3.1.3 Knopp Report Data (1993)

As part of a study to develop indices for cold water fish habitat in coastal Northern California (referred to earlier in this section), Knopp (1993) reported the following data for Fuller and Grasshopper Creeks in the Gualala River watershed:

Stream	V*	D_{50} (mm)
Fuller Creek	0.37	43.2
Grasshopper Creek	0.59	36.8

V* is a parameter that represents the proportion of fine sediments that occupy the scoured residual volume of a pool (Lisle and Hilton, 1992). The values for the parameters listed above corresponded to watersheds that the report categorized as having moderate to high levels of disturbance.

5.3.1.4 Regional Water Board Staff Observations

Regional Board Staff were able to observe approximately 4.5 miles of streams during their random sample plot field work. An additional, approximately 1.5 miles of streams scattered throughout the watershed were also visited.

A thin to non-existent armor layer (surface layer that is more coarse than the subsurface sediments) underlain and embedded with fine sediment typified observed riffles. The absence of an armor layer is indicative of an oversupply of sediment (Dietrich et al., 1989). Sand is the dominant substrate in many of the observed reaches. Spawning size gravels are overlain and embedded with fine sediment in observed riffles of the North Fork, Rockpile Creek, Wheatfield Fork, and the South Fork while Buckeye Creek was characterized by relatively more embeddedness and fine sediment without an armoring layer. Francini Creek, a tributary to Buckeye Creek, has fine sediment almost completely burying cobble.

The pools observed in the Gualala watershed are typically shallow and contained substantial volumes of fine sediments. Pools in areas expected to be deep, such as at abrupt bends or pools formed by boulders, were observed to be shallow with a substrate of sand and fine sediment. A substantial portion of the observed reaches were runs and glides with small substrate (sand to pea-size) that presumably would contain pool habitats if the sediment load were lower. While the North Fork Gualala River contained the most substantial pools of the observed stream reaches, there is a lack of pools suitable for rearing salmonids in observed reaches throughout the Gualala watershed.

Buckeye Creek, Rockpile Creek, and the lower Wheatfield Fork appear to be aggraded, as indicated by the wide, flat channel geometry, lack of an armor layer, scarcity of pools, and exposed tree roots in the streambanks. Notable exceptions are the areas of Fuller Creek and the upper South Fork that were observed to be recovering from prior aggradation. The observed reaches of the North Fork Gualala also appear to be recovering from prior aggradation, as indicated by the presence of partially buried logs, vegetated mid-channel bars (now floodplains or terraces), and exposed bedrock sills. The channel does, however, show evidence of an over-abundance of fine sediment indicated by sand to pea-size accumulations in pools and flatwater habitats.

5.3.2 Habitat Conditions

CDFG conducted a number of stream surveys from the 1950s to the 1980s. These are summarized in Section 5.1. Few recent habitat inventories exist for streams in the Gualala watershed. CDFG conducted a fisheries inventory of McKenzie Creek and its tributaries in 1999. A moderate amount of data describing stream conditions that relate to salmonid habitat conditions is contained in the Coastal Forestlands, Ltd. (CFL) *Watershed and Aquatic Wildlife Assessment* (1997). In addition, Gualala Redwoods, Inc. (GRI) reported some habitat information in their recent timber harvest plans (THPs).

5.3.2.1 CFL Channel Assessment Data

Results of CFL's surveys indicate that the stream reaches surveyed are LWD deficient. Values of two indices, LWD pieces per bankfull width and volume index, are well below targets developed by Peterson *et al* (1992) for the State of Washington (Table 5.10). A notable exception is Fuller Creek, where indices were much higher than the Washington standards. The Washington State targets are based on values taken from unmanaged streams in western Washington, where forests are dominated by Douglas Fir. Rates of decomposition of Douglas Fir are higher than Redwood, therefore it is reasonable to assume that LWD abundance would be higher in unmanaged Redwood forest streams.

TABLE 5.10. LARGE WOODY DEBRIS CONDITIONS OF GUALALA SUB-WATERSHEDS (CFL, 1997)

Planning WS	CFL LWD Frequency (# LWD/ Bankfull Width)	Washington LWD Frequency Target	Volume Index (m^3/LWD)	Washington Volume Index Target
Fuller Creek	5.1	**2.21**	1.6	**1.45**
Buckeye Creek	1	**2.07**	0.9	**2.99**
NF Gualala	0.7	**2.04**	1.3	**3.36**
Mid Rockpile	0.5	**2.01**	2.0	**3.93**
Lower Mid Rockpile	0.3	**1.99**	1.9	**4.39**
Lower Buckeye Creek	0.7	**1.95**	1.3	**5.22**

The low volume and frequency of LWD in the Gualala Watershed may be reflective of the early beginnings of logging in the watershed. The first mill in Gualala was built in 1862 and logging continued in earnest until 1906 when the mill at Gualala burned down and logging decreased. Logging picked up once again after World War II. Second growth logging began as early as 1894, and it is likely that many stands are in their fourth or fifth cycle (White-Parks 1980). The riparian timber stands were most likely logged most extensively, given the fact that they were closest to the railroads and skid trails that were used to move the trees to the mills. In the earliest days of Gualala logging the method of transporting logs was the “splash dam”, which was breached after enough water was impounded behind the dam to float the many logs placed in the channels to the mill at the river mouth. Removal of obstructions, such as submerged logs, was a common practice in the splash dam era. Logging in the later half of the twentieth century has undoubtedly limited recruitment of LWD since.

CFL evaluated canopy conditions on Class I streams on their ownership by analysis of aerial photos (Table 5.11). Photos from 1965 and 1995 were analyzed to evaluate the degree of recovery during the 1965-1995 period. The results show recovery ranging from approximately 61-73% for four of the stream reaches (Billings, middle Rockpile, lower middle Rockpile, and lower Rockpile). The North Fork Gualala reach was anomalous in that from 1965-1995 canopy opening on the reach had increased 102 % since 1965.

CFL also reported the average residual pool depth at three “prominent” pools in each of the field sampled reaches as shown on Table 5.11. It is unclear how “prominent” was defined. It is possible that the three “prominent” pools surveyed were the three largest pools. Of the twelve reaches surveyed, three had average residual pool depths ranging from 1.25 to 1.6 feet, three ranged from 3.3 to 3.9 feet, and the other six ranged from 2.0 to 2.7 feet. Although the data is poorly defined, if one assumes that the three “prominent” pools sampled were the deepest pools in the reach, the data indicates pool depths are less than desirable.

TABLE 5.11. CANOPY CONDITIONS ON SELECT STREAM REACHES (CFL, 1997)

Planning WS	% Valley Canopy Opening (‘65 photo)	% Valley Canopy Opening (‘95 photo)	% Decrease in Valley Opening '65-'95	% Canopy Closure (field) ‘65-‘95
NF Gualala	12.9	26	-102%	33
Billings Creek	26.3	7	73%	N/A
Mid Rockpile	68.4	18	74%	40
Lower Rockpile	69.2	47.7	31%	N/A
Lower Mid Rockpile	76.7	29.7	61%	30
Fuller Creek	N/A	29.6	N/A	21
Buckeye Creek	N/A	18.2	N/A	28
Lower Buckeye Creek	N/A	9.5	N/A	29
Flat Ridge Creek	N/A	12.4	N/A	N/A
NF Buckeye	N/A	14	N/A	N/A
Wolf Creek	N/A	16.3	N/A	N/A
Tobacco Creek	N/A	35.6	N/A	N/A

5.3.2.2 EIP Data

In 1991 EIP Associates surveyed approximately 4.1 miles of the lower South Fork Gualala from the confluence of the South Fork and Wheatfield Fork at Valley Crossing to the Confluence of the North and South Forks. The most common habitat was shallow pools (Table 5.12). Higgins

(1997) suggests that a portion of the habitat reported by EIP Associates would have been better classified as run or glide, rather than shallow pool. Higgins then concluded, "the low pool frequency and high occurrence of flat water habitats clearly indicates major aggradation problems in the lower reaches of the Gualala River."

TABLE 5.12. LOWER SOUTH FORK GUALALA HABITAT TYPING DATA (EIP, 1994)

Reach	Shallow Pool	Deep Pool	Root Wad Pool	Glide	Riffle	Run
Valley Crossing - Sea Ranch Road	59.6	7.1	0.9	21.1	9.1	2.2
Sea Ranch Road – Buckeye Creek	77.2	9.1	0.3	4.6	4.9	4.1
Buckeye Creek – North Fork	72	13.2	0	5.2	4.1	5.2

5.3.2.3 Gualala Redwoods, Inc. Timber Harvest Plans

Baseline data collected by Gualala Redwoods, Inc. (GRI) on Pepperwood and Buckeye Creeks were summarized in a recent timber harvest plan (GRI Flats South THP, 1999).
Big Pepperwood Creek was found to contain "good quantities of gravels which do not appear embedded." The stream was reported to have 90 to 100 percent canopy cover in the lower reaches of the creek, with an average high stream temperature of 60.6°F (15.9°C). In Buckeye Creek, pools were found to comprise 20% of all habitat types, with pool depths of greater than 3 feet. The overall mean shelter rating for pools was 126 (of a maximum of 300). An average shelter rating of 100 is considered desirable for good salmonid habitat. Pool tailings were found generally to be moderately embedded (25 to 50%) with fine sediments. Buckeye Creek was estimated to have 65% canopy cover, and an average high temperature of 71.9°F (22.1°C), above the preferred range of coho salmon.

5.3.2.4 McKenzie Creek

The California Department of Fish and Game (CDFG) conducted a fisheries inventory of approximately 2.6 miles of McKenzie Creek and its tributaries in July and August of 1999. The surveyed tributaries included Carson Creek, Camper Creek, and Wild Hog Canyon. The objectives of the inventory were to document presence and distribution of salmonid species, as well as their available habitat (CDFG, undated).

The results of the inventory showed that habitat conditions in the surveyed streams were below desirable levels. For instance, pools were found to be shallow, averaging 1.2 feet deep, with only 15% deeper than three feet. Pool shelter ratings were also found to be low, with a mean shelter rating of 23. Embeddedness ratings, a measure of spawning substrate suitability, generally showed spawning substrates of poor quality due to excess fine sediments.

Water temperatures measured during the survey were suitable for steelhead in all streams. Camper Creek was the only stream found to have temperatures suitable for coho salmon, however. The report suggests that higher riparian canopy densities in Camper Creek are responsible for the better temperature conditions.

Two pools in McKenzie Creek and one pool in Carson Creek were electrofished. Juvenile steelhead and California roach were found in both creeks, and a three-spined stickleback was found in McKenzie Creek. No coho salmon were found.

5.3.2.5 Regional Water Board Staff Observations

A range of channel complexity conditions was noted in the watershed. In some reaches, a lack of deep pools and woody debris, and a high proportion of runs and glides diminished channel complexity. In other observed stream reaches, especially reaches of Buckeye Creek, the channel is mostly flat and shallow, with little complexity. Many areas lacked a defined thalweg and were flat from bank to bank. In general, channel complexity was noted to be poor. Stream reaches with moderate to high complexity were found in Fuller Creek and the upper South Fork.

The main subwatershed streams and their immediate tributaries that were observed had very few large woody debris (LWD) pieces in the active channel. However, smaller tributaries were observed to have substantial quantities of LWD, mostly stumps and cull logs from earlier logging activities which in certain locations have created large debris jams. In contrast to other observed tributaries where aggradation was more extreme, the North Fork Gualala River had some LWD pieces that had been buried in the past and are now partially exposed. In general, an adequate amount of LWD was noted in first and second order stream channels, while a dearth of LWD was noted in higher order streams.

5.3.2.6 Anecdotal Evidence

Higgins' 1997 "Gualala River Watershed Literature Research and Assimilation" contains an 1898 photo of sailboats near the mouth of the Gualala River, which he interpreted to indicate deeper lagoon conditions. His interpretation is supported by Ken Spacek's memories of river conditions when he was a boy, which would contrast stream conditions prior to the Forest Practice Rules and the 1964 flood to conditions of today. Spacek recalls the challenge of driving off-road vehicles up and down the river and the extreme difficulty of crossing the river due to the depth of flow, whereas now the same stretches can be driven without getting axles wet. Spacek also recalls jumping off of boulders into swimming holes where sediment has now buried both the pools and the boulders (Ken Spacek, personal communication 2001).

In 1997 Ken Spacek interviewed seven elders from the Gualala Watershed about historical stream and fishery conditions. The following list summarizes the recollections of the interviewees (Spacek, unpublished):

- Fish were abundant in the past and now are scarce,
- The Gualala has filled in with sediment, particularly on the South Fork downstream of Valley Crossing,
- Brush willow is much more common today,

- Log and driftwood accumulations are less common,
- River otters are now more common in the Gualala than in the past,
- The mouth of the river stays closed longer and takes more rain to breach
- Chinook Salmon used to be found in the Gualala.

5.3.3 Data Describing Stream Temperature Conditions

Stream temperatures may also be a factor limiting salmonid production in the Gualala River watershed. Stream temperatures may be affected by increased sedimentation. For example, thermal refugia, such as deep thermally stratified pools and cold water seeps where fish are able to escape warmer water, can be eliminated by increased sedimentation. The following section presents data describing stream temperature conditions and is included as supplementary information.

The effect of temperature on the salmonid lifecycle is complex and is discussed in Section 4.1.2. Briefly, the salmonid life cycle processes affected by temperature include: metabolism; food requirements (appetite and digestion); growth rates; development of embryos and alevin; timing of life history events (such as adult migration, fry emergence, smoltification); competitor and predator-prey interactions; disease-host and parasite-host interactions; and, the development of aquatic invertebrate food sources (Spence et al. 1996). Stream temperature also determines the amount of dissolved oxygen that can be carried by a stream, with higher temperatures resulting in lower dissolved oxygen concentrations.

Stream temperature data have been collected in the Gualala River watershed by several entities. Often the sources do not report the methods of data collection, or complete data sets or statistics that would allow further analysis.

The Gualala River Watershed Council (GRWC) installed hobo temperature data loggers on the North Fork of Fuller Creek, the South Fork of Fuller Creek, and the Wheatfield Fork in the summer of 1997 (Higgins, 1997). Data are available in graphical format showing daily minimum and maximum temperatures. The probes were placed in a shaded portion of the stream in flowing water and recorded temperature at a regular interval, numerous times a day for the period of record. Monthly temperature ranges are shown in Table 5.13. Additionally, numerous hobo temperature loggers were installed by the GRWC from 1998 to 2000, although the 1998-99 data was not available at the time this report was prepared (see Table 5.13). Maximum weekly average temperature (MWAT) values shown for GRWC data are the highest of the seven-day moving average of the daily average temperature for a single station in a single season.

Temperature data are also available from Gualala Redwoods Incorporated (GRI) timber harvest plan monitoring. Hobo temperature data loggers were placed in various streams at the inlets of pools in well mixed areas by GRI from 1993 through 1998. The period of monitoring for each station in each year is unknown, but it is likely that monitoring occurred during low flow periods (approximately May through September). Seasonal daily maximum and maximum weekly average temperature (MWAT) statistics are reported for each temperature probe on an annual basis while daily data are available for a limited number of stations (GRI, 1998; 1999a; 1999b;

1999c; 1999d; 1999e; 1999f; 1999g; 1999h; 2000). Maximum weekly average temperature (MWAT) values reported by GRI are the highest of the seven-day moving average of the daily average temperature for a single station in a single season. Summary data is given in Table 5.13. Plate 6 shows GRI sampling locations.

Mendocino Redwood Company (MRC) monitored stream temperature using Stowaway data loggers on Annapolis Falls Creek and Fuller Creek, both tributaries to the Wheatfield Fork (MRC, unpublished data). Monitoring was performed in the summer of 1995 and 1996 on Annapolis Falls Creek. Monitoring was performed in the summer of 1994 and 1995 on Fuller Creek. Temperature probes were placed in shallow pools (<1 meter in depth) directly downstream of riffles. Data is reported for each temperature probe location on a line graph showing minimum, maximum, and mean daily temperature. Summary statistics are also included. Monthly temperature ranges for MRC temperature data are given in Table 5.13.

Figure 5.1 shows MWAT values by subwatershed for temperature monitoring locations within the Gaulala River watershed. The range of MWAT values are indicated for locations where more than one year of monitoring is available. In Figure 5.1, the South Fork, Wheatfield Fork, and the North Fork subwatersheds shows MWAT bars of two colors. The bars of the left color block are mainstem locations and bars of the right color block are tributary locations.

Based on temperature data available, the following observations can be made for each subwatershed.

- MAINSTEM GUALALA RIVER: One station was monitored in the mainstem of the Gualala River. Seasonal daily maximum temperatures in excess of the upper lethal temperature (75°F) for rearing coho salmon and steelhead and MWAT values above the MWAT metric for juvenile steelhead growth (66°F) are not noted on the mainstem of the Gualala River. However, exceedance of the MWAT metric for juvenile coho salmon growth (64°F) is noted at the monitoring location.
- SOUTH FORK GUALALA RIVER SUBWATERSHED: *MAINSTEM* - Temperature ranges for continuous monitoring stations on the South Fork Gualala River indicate temperatures in excess of preferred rearing temperatures for coho salmon and steelhead. Seasonal daily maximum temperatures in excess of the upper lethal temperature (75°F) for rearing coho salmon and steelhead are noted on the mainstem South Fork Gualala River. Exceedance of the MWAT metric for juvenile coho salmon growth (64°F) and juvenile steelhead growth (66°F) are noted at five of six locations where MWAT values were calculated. No clear trend for a spatial temperature distribution is noted on the South Fork Gualala River. *TRIBUTARIES* - Exceedance of the MWAT metric for juvenile coho salmon growth (64°F) and juvenile steelhead growth (66°F) are noted at one of seven and zero of seven monitoring points respectively. No seasonal daily maximums exceeding the upper lethal temperature (75°F) for rearing coho salmon and steelhead were noted at monitoring locations on tributaries of the South Fork Gualala River.
- WHEATFIELD FORK GUALALA RIVER SUBWATERSHED: *MAINSTEM* - Exceedance of the upper lethal temperature (75°F) for rearing coho salmon and steelhead is noted at each location where the Wheatfield Fork was monitored (from just upstream of Fuller Creek to the just

upstream of the confluence with the South Fork Gualala River) excepting one location. Exceedance of the MWAT metric for juvenile coho salmon growth (64°F) and juvenile steelhead growth (66°F) is also noted at all but one monitoring point on the Wheatfield Fork. The location (GRI station 228) where upper lethal temperatures and the MWAT metric for juvenile salmonid growth are not exceeded may be located in an area where temperatures were less than average due to pool stratification, emergent groundwater, shading, and/or temperature probe placement. Temperature ranges indicate exceedance of preferred coho salmon and steelhead rearing temperatures on the Wheatfield Fork. No clear trend for a spatial temperature distribution is noted on the Wheatfield Fork.

TRIBUTARIES - Fuller Creek exhibits temperatures in excess of the upper lethal temperature (75°F) for rearing steelhead and coho salmon at two out of five locations, while temperatures on Annapolis Falls Creek are relatively lower, with no exceedance of the upper lethal temperature (75°F) for coho salmon and steelhead. MWAT values in excess of MWAT metrics for juvenile coho salmon (64°F) and steelhead growth (66°F) are noted at two and one locations respectively where this parameter is evaluated. Temperature ranges indicate exceedance of preferred coho salmon and steelhead rearing temperatures on Fuller Creek, while Annapolis Falls Creek may have temperatures within the preferred range for rearing steelhead.

- BUCKEYE CREEK SUBWATERSHED: *MAINSTEM* - Monitoring was only performed on Buckeye Creek. Monitoring indicates that temperatures are greater in upstream reaches than in downstream reaches, possibly due to cool tributary inflow, increased stream depth, coastal proximity, emergent groundwater, and/or shading in downstream reaches. Seasonal daily maximum temperatures in excess of the upper lethal temperature for rearing coho salmon and steelhead (75°F) were measured three of six monitoring locations. Reported MWAT values are in excess of the MWAT metric for juvenile steelhead growth (66°F) and juvenile coho salmon growth (64°F).
- ROCKPILE CREEK SUBWATERSHED: *MAINSTEM* - Monitoring was only performed on Rockpile Creek. No clear trend is noted for temperature increase in the downstream or upstream direction. Significant variation in maximum daily temperature is noted in the middle reach of Rockpile Creek, possibly due to cool tributary inflow, emergent groundwater, shading, and/or temperature probe placement. No exceedance of the upper lethal temperature for rearing coho salmon and steelhead (75°F) is noted on the monitored reaches of Rockpile Creek. However, MWAT values exceeding the MWAT metric for coho salmon growth (64°F) and juvenile steelhead growth (66°F) were measured at three of four locations.

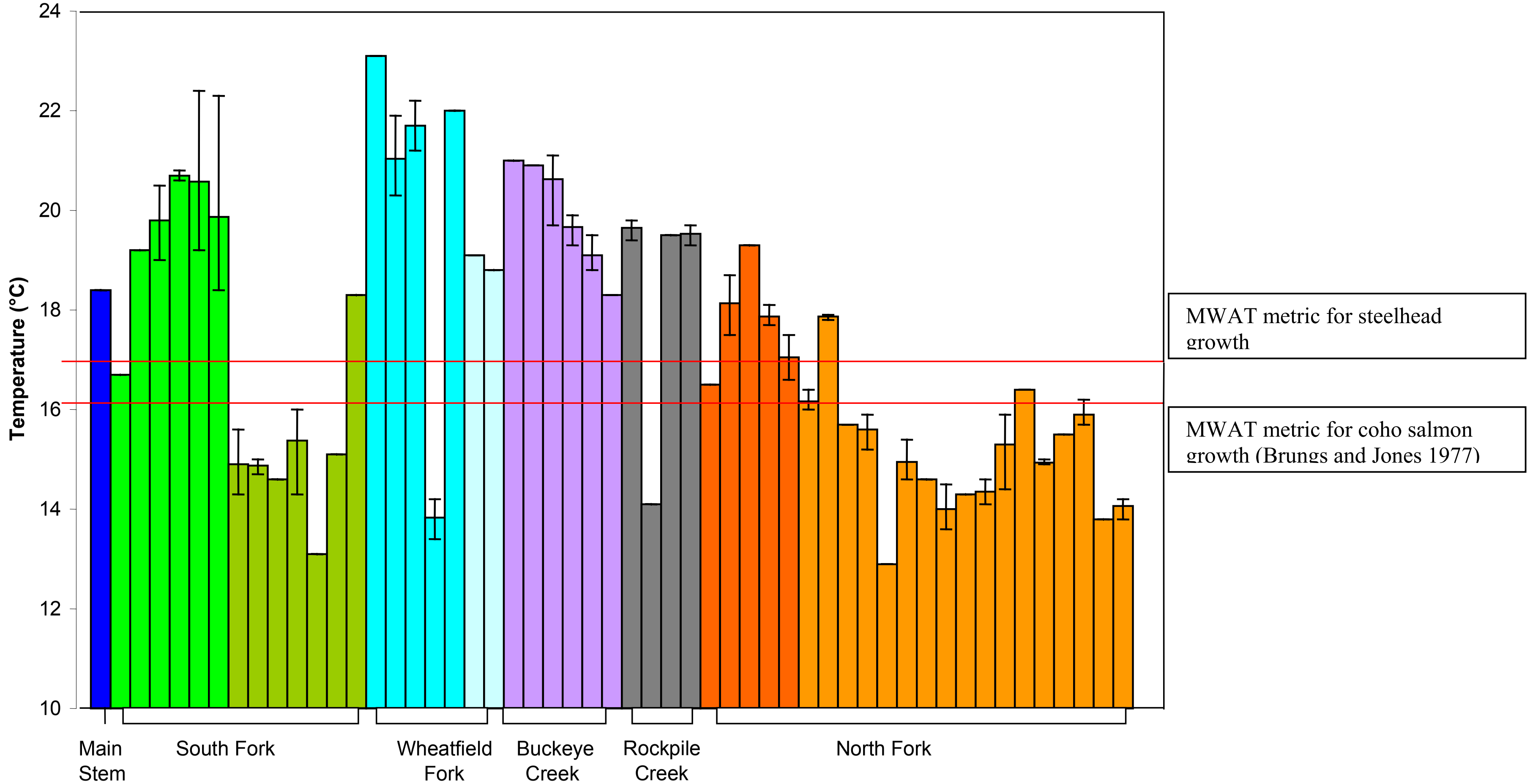

FIGURE 5.1. GUALALA RIVER WATERSHED AVERAGE MWAT VALUES BY SUBWATERSHED FROM TEMPERATURE MONITORING WITH MWAT RANGE FOR LOCATIONS WITH DATA COLLECTION FOR MORE THAN ONE SEASON

TABLE 5.13. TEMPERATURE DATA REPORTED FOR GUALALA RIVER WATERSHED STREAMS

STREAM	SAMPLING LOCATION	REFERENCE	WHEN SAMPLED	TEMPERATURE RANGE (CONTINUOUS DATA ONLY)	MAXIMUM WEEKLY AVERAGE TEMPERATURE	SEASONAL DAILY MAXIMUM
MAINSTEM						
MAIN STEM GUALALA RIVER	Just downstream of South Fork, North Fork confluence	GRWC, 2001	Jun-Oct 2000	56.7 - 73.1°F (13.7 - 22.9°C)	65.1°F (18.4°C)	73.1°F (22.9°C)
SOUTH FORK SUBWATERSHED						
SOUTH FORK GUALALA RIVER	Upper South Fork Gualala River, ~2000 feet upstream of Fort Ross Road	GRWC, 2001	July-Oct 2000	49.9 - 66.9°F (10.0 - 19.4°C)	62.1°F (16.7°C)	66.9°F (19.4°C)
	~2 miles upstream of confluence with Wheatfield Fork	GRI, 1999a	Jun-Oct 1995	53 – 73°F (12 – 23°C)		
	~0.5 miles upstream of confluence with Wheatfield Fork	GRI, 1999a	Jun-Aug 1995	57 – 74°F (14 – 23°C)		
	South Fork just downstream of Big Pepperwood	GRWC, 2001	Jun-Oct 2000	55.3 - 73.8°F (12.9 - 23.2°C)	66.6°F (19.2°C)	73.8°F (23.2°C)
	Station 229	GRI, 1999g	1995,1996,1997		68°F, 66°F, 69°F (19.9°C, 19.0°C) (20.5°C)	74°F, 72°F, 78°F (23.4°C, 22.1°C) (25.6°C)
	Station 225	GRI, 1999G	1995,1997		69°F, 69°F (20.8°C, 20.6°C)	77°F, 72°F, (24.8°C, 22.1°C)
	Station 217	GRI, 1999h	1994,1995 1996,1997		67°F, 69°F, (19.2°C, 20.6°C) 68°F, 71°F (20.1°C, 22.4°C)	73°F, 78°F, (22.7°C, 25.3°C) 76°F, 76°F (24.4°C, 24.6°C)
	Station 230	GRI, 1999g	1995,1996,1997		66°F, 65°F, 72°F (18.9°C, 18.4°C) (22.3°C)	73°F, 71°F, 76°F (22.9°C, 21.8°C) (24.4°C)

Stream	Sampling Location	Reference	When Sampled	Temperature Range (Continuous Data Only)	Maximum Weekly Average Temperature	Seasonal Daily Maximum
SOUTH FORK SUBWATERSHED (CONTINUED)						
Big Pepperwood	Station 218	GRI, 1999h	1994,1995,1996 1997,1998		58°F, 59°F, (14.4°C, 15.0°C) 58°F, 60°F, (14.3°C, 15.6°C) 60°F (15.2°C)	61°F, 62°F, (15.9°C, 16.5°C) 61°F, 63°F, (16.2°C, 17.3°C) 63°F (17.2°C)
	Station 219	GRI, 1999h	1995,1996 1997,1998		59°F, 58°F, (14.9°C, 14.7°C) 59°F, 59°F (15.0°C, 14.9°C)	63°F, 62°F, (17.0°C, 16.7°C) 64°F, 63°F (17.8°C, 17.3°C)
	Station 248	GRI, 1999h	1994		58°F (14.6°C)	63°F (17.2°C)
Little Pepperwood	Station 220	GRI, 1999h	1994,1995,1996, 1997,1998		58°F, 61°F, (14.3°C, 16.0°C) 59°F, 61°F, (15.0°C, 16.0°C) 60°F (15.6°C)	60°F, 67°F, (15.8°C, 19.4°C) 64°F, 62°F, (17.8°C, 16.7°C) 64°F (17.8°C)
Groshong Gulch	Station 250	GRI, 1999j	1996		56°F (13.1°C)	57°F (14.1°C)
McKenzie Creek	McKenzie Creek	GRWC, 2001	Aug-Oct 2000	53.2 - 60.8°F (11.8 - 16.0°C)	59.1°F (15.1°C)	61°F (16.0°C)
	McKenzie Creek 1290 ft u/s Carson Creek	GRWC, 2001	July-Oct 2000	51.9 - 69.3°F (11.1 - 20.7°C)	64.9°F (18.3°C)	69.3°F (20.7°C)
WHEATFIELD FORK SUBWATERSHED						
Wheatfield Fork	~1.5 miles upstream of Fuller Creek	GRWC, 2001	Jul-Oct 2000	58.4 – 82.0°F (14.7 – 27.8°C)	73.6°F (23.1°C)	82.0°F (27.8°C)
	~2.5 miles upstream of confluence with SF Gualala River	GRI, 1998	Jun-Oct 1995 Jun-Oct 1996 Jun-Oct 1997	57 - 79°F 57 - 75°F 55 - 78°F (14 - 26°C) (14 - 24°C) (13 - 26°C)		

Stream	Sampling Location	Reference	When Sampled	Temperature Range (Continuous Data Only)	Maximum Weekly Average Temperature	Seasonal Daily Maximum
WHEATFIELD FORK SUBWATERSHED (CONTINUED)						
Wheatfield Fork (Continued)	At Valley Crossing above confluence with SF Gualala River	GRI, 1998	Jun-Oct 1995 Jun-Oct 1996 Jun-Oct 1997	57 - 78°F 53 - 75°F 57 - 73°F (14 - 26°C) (12 - 24°C) (14 - 23°C)		
	Just upstream of Fuller Creek	Higgins, 1997	Jun-Jul 1997	62 - 82°F (17 - 28°C)		
	Station 226	GRI, 1999g	1995,1996,1997		70°F, 69°F, 71°F (20.9°C, 20.3°C) (21.9°C)	78°F, 75°F, 74°F (25.5°C, 23.8°C) (23.1°C)
	Station 227	GRI, 1999g	1996,1997		70°F, 72°F (21.2°C, 22.2°C)	75°F, 78°F, (24.0°C, 25.3°C)
	Station 228	GRI, 1999g	1995,1996,1997		57°F, 56°F, 58°F (13.9°C, 13.4°C) (14.2°C)	58°F, 57°F, 59°F (14.5°C, 14.0°C) (14.8°C)
	Station 273	GRI, 1999g	1995		72°F (22.0°C)	80°F (26.4°C)
Fuller Creek	Just upstream of confluence with Wheatfield Fork	MRC, no date	Jun-Sept 1994 Jul-Sept 1995	55 - 75°F 56 - 77°F (13 - 24°C) (13 - 25°C)		
	South Fork Fuller Creek	Higgins, 1997	Jun-Sept 1997	56 - 76°F (13 - 24°C)		
	North Fork Fuller Creek	Higgins, 1997	Jun-Sept 1997	55 - 74°F (13 - 23°C)		
	South Fork Fuller Creek ~500' upstream of North Fork Fuller Creek	GRWC, 2001	Jun-Oct 2000	54.3 – 72.5°F (12.4 – 22.5°C)	66.4°F (19.1°C)	72.5°F (22.5°C)
	North Fork Fuller Creek ~400' upstream of South Fork Fuller Creek	GRWC, 2001	Jun-Oct 2000	54.4 – 72.8°F (12.4 –22.7°C)	65.8°F (18.8°C)	72.8°F (22.7°C)

Stream	Sampling Location	Reference	When Sampled	Temperature Range (Continuous Data Only)	Maximum Weekly Average Temperature	Seasonal Daily Maximum
WHEATFIELD FORK SUBWATERSHED (CONTINUED)						
Annapolis Falls Creek	~ ¾ mile upstream of confluence with Wheatfield Fork	MRC, no date	Jun-Sept 1995 Jul-Sept 1996	53 - 67°F 52 - 64°F (12 – 19°C) (11 – 18°C)		
BUCKEYE CREEK SUBWATERSHED						
Buckeye Creek	240 feet upstream of Soda Springs Creek	GRWC, 2001	Jun-Oct 2000	56.0 – 78.7°F (13.3 - 26.0°C)	69.8°F (21.0°C)	78.7°F (26.0°C)
	Just upstream of confluence with Flat Ridge Creek	GRWC, 2001	Jun-Oct 2000	53.9 – 78.0°F (12.2 - 25.6°C)	69.7°F (20.9°C)	78.0°F (25.6°C)
	Station 231	GRI, 1999g	1994,1995 1996,1997		67°F, 70°F, (19.7°C, 20.9°C) 69°F, 70°F (20.8°C, 21.1°C)	71°F, 76°F (21.7°C, 24.4°C) 75°F, 75°F (23.7°C, 23.7°C)
	Station 224	GRI, 1999g	1995,1996,1997		68°F, 67°F, (19.9°C, 19.3°C) 68°F (19.8°C)	75°F, 72°F, (23.9°C, 22.1°C) 73°F (22.7°C)
	Station 223	GRI, 1999g	1995,1996,1997		66°F, 66°F, (19.0, 18.8) 67°F (19.5)	73°F, 71°F, (23.0°C, 21.4°C) 72°F (22.4°C)
	Station 235	GRI, 1999g	1994		65°F (18.3)	70°F (21.1°C)
ROCKPILE CREEK SUBWATERSHED						
Rockpile Creek	Station 222	GRI, 1999i	1994,1995 1996,1997		67°F, 67°F, (19.4°C, 19.7°C) 67°F ,68 (19.7°C,19.8°C)	71°F, 74°F (21.9°C, 23.5°C) 72°F, 72°F (22.1°C,22.4°C)
	Station 276	GRI, 1999i	1997		57°F (14.1°C)	59°F (15.2°C)
	Station 275	GRI, 1999i	1997		67°F (19.5°C)	68°F (20.1°C)
	Station 221	GRI, 1999i	1995,1996,1997		67°F, 67°F, (19.6°C,19.3°C) 67°F (19.7°C)	74°F, 72°F, (23.1°C,22.4°C) 72°F (22.4°C)

Stream	Sampling Location	Reference	When Sampled	Temperature Range (Continuous Data Only)	Maximum Weekly Average Temperature	Seasonal Daily Maximum
NORTH FORK GUALALA RIIVER SUBWATERSHED						
North Fork Gualala River	Just upstream of confluence with South Fork	GRWC, 2001	Jun-Oct 2000	54.6-66.3°F (12.6-19.0°C)	61.6°F (16.5°C)	66.3°F (19.0°C)
	Station 204	GRI, 1999f	1995,1996,1997		64°F, 66°F, 65°F (17.5°C,18.7°C) (18.2°C)	69°F, 68°F, 67°F (20.6°C,20.1°C) (19.4°C)
	Station 258	GRI, 1999f	1994		67°F (19.3°C)	76°F (24.5°C)
	Station 205	GRI, 1999f	1995,1996,1997		64°F, 64°F, 65°F (17.7°C,17.8°C) (18.1°C)	71°F, 69°F, 70°F (21.4°C,20.4°C) (21.1°C)
	Station 251	GRI, 1999f	1996,1997		62°F, 64°F (16.6°C, 17.5°C)	66°F, 67°F (19.0°C,19.3°C)
Dry Creek	Station 213	GRI, 1999c	1995,1996,1997		61°F, 61°F, 62°F (16.0°C,16.1°C) (16.4°C)	63°F, 63°F, 64°F (17.0°C,17.3°C) (17.8°C)
	Station 212	GRI, 1999c	1995,1996,1997		64°F, 64°F, 64°F (17.9°C,17.8°C) (17.9°C)	70°F, 69°F, 69°F (20.9°C,20.7°C) (20.5°C)
	Station 269	GRI, 1999f	1994		60°F (15.7°C)	61°F (16.2°C)
	Station 211	GRI, 1999c	1995,1996,1997		60°F, 61°F, 59°F (15.7°C,15.9°C) (15.2°C)	64°F, 64°F, 62°F (17.7°C,17.7°C) (16.9°C)
Doty Creek	Station 256	GRI, 1999f	1994		55°F (12.9°C)	57°F (14.1°C)
Little North Fork	Station 201	GRI, 1999f	1994,1995 1996,1997		58°F, 59°F, (14.7°C,15.1°C) 58°F, 60°F (14.6, °C 15.4°C)	60°F, 62°F (15.8°C,16.7°C) 61°F, 62°F (15.9°C,16.7°C)
	Station 202	GRI, 1999f	1994		58°F (14.6°C)	62°F (16.4°C)
	Station 203	GRI, 1999f	1994,1995 1996,1997		56°F, 58°F, (13.6°C,14.2°C) 57°F, 58°F (13.7°C,14.5°C)	59°F, 60°F (15.1°C,15.8°C) 60°F, 60°F (15.3°C,15.8°C)
	Station 255	GRI, 1999f	1994		58°F (14.3°C)	61°F (15.9°C)
	Station 274	GRI, 1999f	1995,1996		57°F, 58°F (14.6°C,14.1°C)	62°F, 61°F (16.4°C,16.1°C)

Stream	Sampling Location	Reference	When Sampled	Temperature Range (Continuous Data Only)	Maximum Weekly Average Temperature	Seasonal Daily Maximum
NORTH FORK GUALALA RIIVER SUBWATERSHED (CONTINUED)						
McGann Gulch	Station 209	GRI, 1999f	1995,1996,1997		61°F, 60°F, 58°F (15.9°C,15.6°C) (14.4°C)	62°F, 62°F, 60°F (16.7°C,16.4°C) (15.5°C)
	Station 210	GRI, 1999f	1995		62°F (16.4°C)	69°F (20.4°C)
Robinson Creek	Station 208	GRI, 1999f	1995,1996,1997		59°F, 59°F, 59°F (14.9°C,15.0°C) (14.9°C)	62°F, 62°F, 62°F (16.6,16.4°C) (16.7°C)
	Station 263	GRI, 1999f	1994		60°F (15.5)	64°F (17.7°C)
	Station 207	GRI, 1999f	1995,1996,1997		60°F, 60°F, 61°F (15.8°C,15.7°C) (16.2°C)	67°F, 67°F, 68°F (19.6°C,19.6°C) (20.2°C)
	Station 260	GRI, 1999f	1994		57°F (13.8°C)	58°F (14.6°C)
	Station 206	GRI, 1999f	1995,1996,1997		58°F, 58°F, 57°F (14.2°C,14.2°C) (13.8°C)	69°F, 62°F, 62°F (20.4°C,16.9°C) (16.4°C)

- NORTH FORK GUALALA RIVER SUBWATERSHED: *MAINSTEM* – Data indicates that temperatures within the North Fork Gualala River subwatershed are lower than temperatures in other subwatersheds. Further, seasonal daily maximum temperatures and MWAT values indicate that North Fork Gualala River tributaries are generally cooler than the North Fork Gualala River. Exceedance of the upper lethal temperature (75°F) for rearing coho salmon and steelhead is noted at only one location on the North Fork Gualala River. Exceedance of the MWAT metric for juvenile steelhead growth (66°F) and juvenile coho salmon growth (64°F) are noted at two of five and four of five locations respectively on the North Fork Gualala River.

  TRIBUTARIES – No exceedance of either the upper lethal temperature (75°F) for rearing coho salmon and steelhead, or of the MWAT metric for juvenile steelhead growth (66°F) are noted at any locations on monitored North Fork Gualala River tributaries. Exceedance of the MWAT metric for juvenile coho salmon growth (64°F) is noted at one location.

Table 5.14 shows summary data for upper lethal temperature and MWAT values for the Gualala River watershed.

TABLE 5.14. SUMMARY OF UPPER LETHAL TEMPERATURE AND MWAT VALUES FOR THE GUALALA WATERSHED

SUBWATERSHED		**Upper Lethal Temperature (75°F)** (locations with exceedance / total number of locations)	**MWAT metric for coho salmon growth (64°F)** (locations with exceedance / total number of locations)	**MWAT metric for steelhead growth (66°F)** (locations with exceedance / total number of locations)
GUALALA RIVER	Mainstem	0 / 1	1 / 1	0 / 1
SOUTH FORK GUALALA RIVER	Mainstem	4 / 8	5 / 6	5 / 6
	Tributaries	0 / 7	1 / 7	0 / 7
WHEATFIELD FORK	Mainstem	6 / 7	4 / 5	4 / 5
	Tributaries	2 / 6	2 / 2	1 / 2
BUCKEYE CREEK	Mainstem	3 / 6	6 / 6	5 / 6
	Tributaries	0 / 0	0 / 0	0 / 0
ROCKPILE CREEK	Mainstem	0 / 4	3 / 4	3 / 4
	Tributaries	0 / 0	0 / 0	0 / 0
NORTH FORK GUALALA RIVER	Mainstem	1 / 5	4 / 5	2 / 5
	Tributaries	0 / 17	1 / 17	0 / 17
TOTALS	Mainstem	14 / 31	23 / 27	19 / 27
	Tributaries	2 / 26	4 / 26	1 / 26

Collected data indicates that temperatures in most of the Gualala watershed exceed preferred juvenile rearing temperature ranges for steelhead and coho salmon. Limited exceedance of short-term maximum temperatures for rearing coho salmon and steelhead occur in monitored tributaries throughout the watershed while exceedance of short-term maximum temperatures occur in the mainstem of each subwatershed more frequently as indicated in Table 5.13 and 5.14. Data describing the extent of pool stratification in the watershed would help describe the extent of thermal refugia available to salmonids.

5.4 Conclusions

Available data suggest that the success of salmonid spawning, incubation, and emergence success may be limited by the following factors:

- Impact of fine sediments on spawning and rearing habitats
- Reduced channel complexity caused by elevated sediment loads
- Lack of pool habitat provided by Large Woody Debris (LWD)
- Increased stream temperature possibly due to canopy removal and an oversupply of sediment

Information regarding much of the watershed is sparse and sporadic; much of the available information is collected by timber companies who own approximately 35% of the land.

5.4.1 Salmonid Abundance

Information available is insufficient to provide a quantitative picture of salmonid abundance and distribution in individual streams; however, it suggests general trends throughout the watershed. Available data indicate that steelhead trout continue to be present in most of the watershed, although the populations show a pattern of decline starting as early as the 1970s. Historic evidence and surveys suggest that coho were once plentiful but have all but vanished in this watershed. Evidence of the historic presence of chinook salmon in the Gualala was provided from anecdotal evidence only (Spacek, unpublished interviews).

Presence/absence surveys conducted in the South Fork Gualala River and the Wheatfield Fork in the early 1990s indicate that the fish community, once plentiful with steelhead, is now dominated by Gualala roach and three-spined stickleback in many areas.

The most complete information regarding salmonid abundance was collected on Fuller Creek, a tributary of the Wheatfield Fork. CDFG surveys performed from the early 1960s to the late 1980s reveal a continuous decline in steelhead abundance. Coho began to decline rapidly in the latter part of the 1960s, and were last noted in CDFG stream surveys in 1970 and 1971.

5.4.2 Stream Conditions

As noted in Section 5.3.1, in-stream substrate samples taken by CFL (1997), GRI (1992-1999), and Knopp (1993) generally indicate that aquatic habitat throughout the watershed is impaired by excessive fine sediments. Median surface particle diameter (D_{50}) measurements were made by both CFL and GRI at numerous locations; GRI also measured percent fines data for the North Fork and some of its tributaries. V* data was provided by Knopp (1993). The data suggest that upslope disturbances have impacted stream substrates with excessive fine sediments, and impaired the ability of the aquatic habitat to support salmonid spawning, incubation, and emergence. The exception is Dry Creek where both D_{50} and percent fines data indicate good spawning habitat. Regional Water Board staff observations of conditions existing in the Spring of 2001 indicate that stream channels are still greatly impacted by fine sediment.

5.4.3 Aquatic Habitat

In a 1955 CDFG survey, Fisher stated:

> "Considerable damage has been done to Gualala River headwaters. In this respect, the stream has been damaged more than average on the north coast, percentage-wise."

Since then, CDFG surveys have reported a watershed impacted by past logging practices (Rowell et al. 1964, Klamt and Edwards 1970). Recent data indicate that current streambed habitat remains impaired for salmonid spawning, incubation, and emergence.

Results of CFL surveys provide evidence that, with the exception of Fuller Creek, stream reaches throughout the Gualala River watershed lack essential habitat provided by LWD. As explained in Section 5.3.3, two indices measured for the survey, LWD pieces per bankfull width and LWD volume index, measured for the survey, fell short of criteria established by Peterson et al (1992). Past land management involving logging and associated practices such as splash dam log transportation, as well as previous CDFG projects that removed migration barriers throughout the watershed, have led to the dearth of salmonid habitat provided by LWD (Section 5.3.2).

Temperature data from the Gualala River Watershed Council (GRWC 1997, 2000) Gualala Redwoods Inc. (GRI 1993-1998) and the Mendocino Redwoods Company (MRC, unpublished data) suggest that stream temperatures for most of the watershed exceed preferred juvenile rearing temperature ranges for steelhead and coho. Limited exceedance of short-term maximum lethal temperatures for steelhead and coho occur throughout the watershed. The causes of elevated stream temperatures (e.g., changes in channel morphology, reduced riparian canopy cover, aggradation) have not been thoroughly assessed.

5.4.4 Potential watershed improvements and additional information needs

Generally, available data indicate that aquatic habitat could be improved by reducing sediment delivery, increasing large woody debris for sediment metering and habitat, and enhancing the riparian canopy cover to reduce stream temperatures. In the Fuller Creek and McKenzie Creek watersheds, road-related erosion is believed to be a major source of sediments to the stream, and is the focus of ongoing restoration efforts.

More detailed temperature data and analysis, such as that provided by Forward Looking Infrared (FLIR) Imagery and channel surveys, will help characterize temperature dynamics and thermal refugia within the watershed.

A comprehensive monitoring program to evaluate suspended fine sediments and turbidity is required to adequately determine the impacts of fine sediment on beneficial uses including municipal and domestic supply (MUN), water contact recreation (REC-1), non-contact water recreation (REC-2), spawning reproduction, and/or early development (SPWN), and cold freshwater habitat (COLD).

CHAPTER 6
SEDIMENT SOURCE ANALYSIS

6.1 Factors Affecting Sediment Loading

The unstable geology and high precipitation rates along the North Coast of California, including the Gualala watershed, make streams in the region susceptible to elevated sediment loading from anthropogenic and natural sources. Sources of sediment delivery to aquatic habitat include natural erosion processes as well as those influenced by anthropogenic activities, such as road construction and timber harvest.

6.1.1 Natural Processes

Soil mass movements, or landslides, are a significant component of hillslope erosion and sediment transport to stream channels in mountainous regions (Meehan, 1991). Mass wasting processes such as debris slides and debris flows tend to yield sediment episodically. Other mass wasting processes such as slumping, soil creep and earthflows tend to yield sediment more gradually, although these processes may be both gradual and episodic (Selby, 1993; National Research Council, 1996).

Natural mass wasting may add substantial quantities of sediment and organic debris to the stream channel, altering aquatic habitat for many years. Effects include rapid increases in bed and suspended-sediment loads, shifts and redistribution of existing channel-bed sediments, and partial or complete blocking of the channel by debris.

Surface erosion results from the detachment of particles from the hillslope surface (Meehan, 1991). The process usually results in the delivery of fine sediment through channelized erosion from rilling and gullying, overland flow transport, or gravitational movement of dry particles (Selby, 1993). In an undisturbed watershed, surface erosion is generally low. However, effects can vary from year to year since surface erosion usually results from intense rainstorms or excess surface flows after the soil is bared by natural processes, such as landslides or wildfire.

6.1.2 Anthropogenic Activities

6.1.2.1 Road Construction

Roads are a major source of erosion and sedimentation on most managed forest and ranch lands (Weaver and Hagans, 1994). The construction of roads increases the potential for surface erosion and slope instability by increasing the area of bare soil exposed to rainfall and runoff, obstructing stream channels and by altering subsurface flow pathways. Road ditches concentrate storm runoff, and increase its erosive power to form rills and gullies, pathways of sediment delivery to streams.

Culverted stream crossings often fail during storm events causing massive fill wash outs and stream diversions. Stream crossing failures occur when the hydraulic capacity of the culvert is exceeded either because of obstruction of the inlet or inadequate culvert sizing. Stream crossing fill material is often washed into watercourses when water accumulates behind the road fill prism until it flows over and erodes the road fill, or the fill becomes saturated and catastrophically fails (Furniss et al, 1998). In some instances, stream crossing failures divert streams out of their channels and down the roadway, which often leads to gullies, landslides and other stream crossing failures (Furniss et al, 1998; Weaver, et al 1995).

Road fill prisms can act as hydraulic barriers to subsurface flow which acts to increase localized pore pressure, reducing material strength, often causing landsliding. The practice of sidecasting soils during road grading also increases the likelihood of landsliding. Cutbanks related to road construction often fail and deliver sediment and other debris to watercourses. Cutbank failures can also plug inside ditches causing erosion of the road surface. In addition, roads built on steep or unstable slopes may exacerbate soil mass movements, by increasing slope weight and decreasing slope support, as well as altering groundwater pressures. (Meehan, 1991).

6.1.2.2 Timber Harvest

Timber harvest is another anthropogenic activity that affects erosion and slope stability. The quality of management planning and implementation strongly influences sediment production from forest-harvesting activity (Meehan, 1991; Cafferata and Spittler, 1998). Timber harvest activities such as clearcutting and construction of landings and skid trails can increase erosion and sedimentation (Meehan, 1991; Lewis, 1998). These activities increase exposure of bare surfaces to rainfall and runoff, modify surface water flow pathways, and therefore increase the potential for surface erosion. Removal of vegetation associated with logging has been shown to increase peak stream flow and reduce lag between high precipitation events and high stream flow events (Ziemer, 1998), which can lead to bank erosion downstream. Vegetation removal and soil compaction associated with timber harvest can reduce the factor of safety on hillslopes and increase susceptibility to mass wasting by elevating pore pressures and decreasing root strengths (Keppler and Brown, 1998; Abe and Ziemer, 1991).

6.1.2.3 Livestock Management

Livestock grazing has the potential to increase rates of sediment delivery. Reduction of vegetative cover from intense grazing can lead to increased surface erosion by exposing soils to rainsplash, increasing runoff velocities, decreasing infiltration rates, and reducing soil strength provided by roots (Bauer and Burton, 1993; Selby, 1993). Livestock can also cause direct sediment delivery by collapsing stream banks, wearing trails at watercourse crossings, and breaking down soils where confined livestock operations (i.e. feeding areas, and corrals) are near streams. Livestock grazing can also lead to indirect sediment delivery by changing the structure and composition of riparian vegetation. Overgrazing can lead to reduction in the strength and cohesion of streambanks, which then leads to bank erosion, higher width-to-depth ratios or downcutting.

Pacific Watershed Associates conducted a sediment source investigation as part of the Van Duzen River watershed sediment TMDL. The Van Duzen River watershed is similar to the Gualala River watershed in many ways including vegetation, geology, and land use. The results of their investigation show very little direct sediment delivery attributable to cattle grazing. They concluded that current grazing activities were not a significant sediment contributor in the Van Duzen River watershed (PWA, 1999).

6.1.2.4 Vineyards

Although little information is available that documents the impacts of viticulture on soil erosion, the clearing of vegetation for viticulture may considerably increase surface erosion through exposure of bare earth to rainfall and runoff. Conversion of timberlands to vineyards could presumably have the same effects on a watershed's hydrologic response to rainfall. Observations made by Regional Water Board staff indicate that conservation practices used by vineyards (cover cropping, buffer strips, terracing, etc.) have variable effects on erosion prevention. Rills develop and soil loss becomes noticeable from vineyards when erosion rates reach 8-15 tons/acre/year (White, 1986; Laurel Marcus and Associates, 1999).

6.1.2.5 Fire History and Sediment Loading (Natural & Anthropogenic)

The burning of forests may dramatically increase sediment loading to streams (Meehan, 1991; Robichaud, 2000). The degree to which wild fires and prescribed burns affect erosion and sediment delivery varies greatly, however, depending on site characteristics and burn intensity (Robichaud, 2000). Wildfires expose bare mineral soil to increased runoff and surface erosion. In addition, fire also increases the potential for landslides after the event due to the decay of anchoring and reinforcing root systems, as well as alteration of soil and hydrologic characteristics (National Research Council, 1996).

6.2 Approach

The intent of the sediment source analysis is to characterize the loading of sediment to streams in the Gualala watershed. The analysis is meant to determine the gross level of impairment of the watershed as well as determine the relative level of impairment of each major subwatershed due to increased sediment delivery.

The approach taken in the sediment source analysis focuses on rates of sediment delivery from upslope and streamside sediment sources to waters of the state for the period of 1978 to 2000. Sediment sources identified include debris slides, debris flows, earth flows, soil creep, gullies, stream crossing washouts and diversions, road surface erosion and skid trail surface erosion. While many of the sources identified in this analysis undoubtedly contribute to chronic turbidity, the analysis is not of a suitable scale or design to assess sources of chronic turbidity.

The sediment source analysis was developed from a number of components. Those components are:

- An analysis of aerial photos taken in 1978 (Mendocino Co.), 1988 (Sonoma Co. & Mendocino Co.), 1999 (Sonoma Co), and 2000 (Mendocino Co.) which quantified mass wasting features and identified roads. Aerial photos from 1978 (Mendocino County) were also used to quanitify masswasting sources.
- Field measurement of sediment sources in stratified randomly selected 16-hectare plots
- An assessment of sediment delivery from public roads
- An analysis of selected private roads.

The sediment source analysis is meant to characterize the variety and scope of processes currently delivering sediment to the Gualala River and its tributaries. Sediment stored in channels has already been delivered to the stream system and is therefore beyond the scope of this analysis. Regional Water Board staff observed locations where large amounts of redistributed stored sediment had caused significant damage to aquatic habitat in the past. Future efforts to prioritize restoration efforts should take into account the potential for in-stream stored sediment to limit restoration effectiveness.

In contrast to direct sediment delivery in which sediment is directly discharged to a stream or is carried to a stream through a conduit such as a gully or ditch, indirect sediment delivery, which changes the rates of erosional processes over long time frames (e.g.,. loading of colluvial hollows with sediment), was not evaluated. The evaluation of indirect sediment delivery was beyond the scope of this document.

Chronic sediment delivery from bare surfaces of exposed lanslides was assumed to be a minor component of the sediment input budget, and was therefore not assessed, based on the results of the Louisiana-Pacific (L-P) Garcia River Watershed Analysis (L-P, 1998). In their study, L-P estimated delivery from this source to be 4 tons/square mile/year, less than 1% of the entire sediment inputs for the same time period. Regional Water Board staff believe this is a reasonable assumption given that the Gualala and Garcia watersheds are similar in vegetation, geology, topography, land use, and rates of sediment delivery from initial rapid landslide movement.

6.3 Methods

6.3.1 Aerial Photo Analysis

The Regional Water Board contracted with the Information Center for the Environment (Department of Environmental Science & Policy, UC Davis) to provide an aerial photo analysis of recently active mass wasting features and road systems in the Gualala watershed. For this purpose, recently active mass wasting features are defined as those that exhibit signs of movement discernible from sequential sets of aerial photos at a 1:24,000 scale. A geologist with experience in aerial photo interpretation in the Mendocino coastal area performed the aerial photo analysis. By nature, aerial photo analysis is a subjective analysis that relies on the judgment and experience of the interpreter. To improve confidence in the aerial photo results of the interpretation, 7% of the mass wasting features were visited in the field.

Active landslide features were mapped on 1988 and 1999 (Sonoma County) or 2000 (Mendocino County) vertical stereoscopic aerial photographs using a scanning stereoscope with 1.5 and 4.5 power. Use of a complete photo set from either 1999 or 2000 would have been optimal but was not available. Use of the 1999 and 2000 photos for different portions of the watershed were considered acceptable given the mild winter that occurred between the photo dates. The methodology was modified from Six Rivers National Forest protocol (Smith, 2000).

Features were initially identified on 1988 photos, then checked on 1999/2000 photos for enlargement. New features were also identified on 1999/2000 photos. The presence/absence and relative size of features present in 1988 were checked on 1978, 1965, and 1952 photos available for approximately the northern third of the watershed. The scale of 2000, 1999, 1988 and 1978 photos was 1:24,000. The 1965 scale was slightly larger (approx. 1:20,000). The 1952 photos were not in stereo pairs and had a much larger scale (approx. 1:4,000). Features were then digitized into a GIS point coverage using digital orthographic quarter quads for the Sonoma County portion, and digital raster graphs (DRG) of USGS 1:24,000 quadrangle maps for the Mendocino County portion. To avoid underestimating the contribution of smaller features difficult to identify due to photo scale, aspect and shading, those judged to be smaller than 10,000 ft^2 in plan view were not included in this inventory. Estimates of delivery from mass wasting features < 10,000 ft^2 were developed from on-the-ground measurements and extrapolated. Certainty of identification was noted as questionable, probable or definite. Questionable features were rechecked on older or overlapping photos if available, then dropped from the inventory if certainty did not improve.

Features were classified as either shallow debris slide, debris flow, deep-seated debris slide, earthflow, enlarging roadcut, or road fill/crossing failure. Only the active portions of deep-seated features were identified, usually the toe or side scarps. Similarly, large, complex earthflows were not identified in their entirety. Instead, actively eroding surfaces larger than 10,000 ft^2 were individually identified within complex earthflow features. Larger earthflows contained multiple erosion surfaces smaller than 10,000 ft^2, which were not suited to a point coverage of erosion features. Therefore, earthflow identification was not included in the aerial photo analysis (see Section 6.3.5 below for estimation techniques that were used to quantify earthflow sediment delivery). Road fill/crossing failure type was used when debris slides originated in and mobilized primarily fill material. Features classified as enlarging roadcuts were interpreted as an additional, discrete failure from a road cutbank, after cessation of road building activity. Fill and cutbank failures were distinguished from more 'natural' appearing debris slides that intersect roads by the geometry of the failure and the judgment of the interpreter.

The area of the zone of depletion of each feature was estimated using a constructed acetate overlay. Maximum length (slope distance) in delivery direction and maximum horizontal width were measured directly on photographs using a 50 per inch engineering scale. Slope position was noted as inner gorge, hillslope, no break in slope (usually within a headwall basin), or both inner gorge and hillslope with the top scarp above the inner gorge extending down to watercourse. Delivery was estimated to the nearest ten percent, based on hillslope position and visual connectivity.

The geographic relationship of each feature to management activity was also noted. Features were classified as 'natural' when there was no geographic intersection or visible connection between the feature and any apparent management activity in the region around the feature. For features intersecting roads that were improved at least to accommodate log trucks (haul roads), it was noted if the feature intersected the cut bank, fill slope, or both. It was also noted if features intersected landings, skid/tractor roads used in ground based harvesting or recent recognizable harvest units.

6.3.1.1 Mass Wasting Extrapolation Methods

1978 aerial photos were evaluated where available to extend the temporal extent of the aerial photo analysis. However, 1978 aerial photos were available only for the Mendocino portion of the Gualala watershed. The analysis of Mendocino County 1978 photos was used to aid in the estimation of sediment delivery from mass wasting features identified in Sonoma County for the period of 1978-1988. An estimate of the 1978-1988 sediment delivery for Sonoma County was made as described below.

- The delivery volume for Mendocino Co. features that appeared between 1978 and 1988 was differentiated from the delivery volume for Mendocino Co. features that enlarged between 1978 and 1988.
- The ratio of 1978-1988 sediment delivery volume for new features to total 1988 volume for Mendocino County was multiplied by the total 1988 volume for Sonoma County features to estimate Sonoma County delivery from new features.
    Assumption: The ratio of sediment delivery from new features to total feature volume for 1978 and 1988 is equal in the Gualala watershed for Mendocino and Sonoma County. This assumption was made based on the similar geology, rainfall, land use and vegetation present in Sonoma and Mendocino County portions of the Gualala River watershed.
- The ratio of 1978-1988 sediment delivery for features that enlarged to total 1988 volume for Mendocino Co. was multiplied by the total 1988 volume for Sonoma Co. features to estimate Sonoma Co. delivery from features that enlarged.
    Assumption: The ratio of sediment delivery from enlarged (1978-1988) features to total 1988 feature volume is equal in the Gualala watershed for Mendocino and Sonoma County. This assumption was made based on the similar geology, rainfall, land use and vegetation present in Sonoma and Mendocino County portions of the Gualala River watershed.
- 1978-1988 sediment delivery by subwatershed and management relation for Sonoma County features was estimated by using known 1988 volumes by subwatershed and management relation. 1988 volume ratios by subwatershed and management relation, scaled by the estimated total delivery volume for Sonoma County features were extrapolated to estimate sediment delivery volume by subwatershed and management relation for Sonoma County.
    Assumption: The sediment delivery volume by management relation and subwatershed between 1978 and 1988 is proportional to the volume by management relation and subwatershed from the 1988 photo analysis in Sonoma County. This assumption was made based on the similar geology, rainfall, land use and vegetation present in Sonoma and Mendocino County portions of the Gualala River watershed.

6.3.1.2 Field Verification Methods

45 of the 607 features identified in the aerial photo analysis and 11 additional features were field verified by the geologist who conducted the aerial photo analysis, aided by Regional Water Board staff. Measurements of slope distance, width, and slope of the surrounding hillslope were made if access was available. Estimates of average depth, delivery percent, ratio of exposed bedrock to colluvium, and age of feature were made. Average dimensions and slopes of features were estimated from measurements made using a laser rangefinder with an internal digital clinometer. A four-tiered anthropogenic hierarchy was established to estimate management activity influence. Features were classified as: 1) no apparent management relationship; 2) management activity probably did not cause feature and contributed a only minor amount of material; 3) management activity probably caused feature and has contributed a significant amount of material; and 4) management activity definitely caused feature and contributed nearly all mobilized material.

6.3.2 Field Measurement of Randomly Selected Plots

Regional Water Board staff conducted a field investigation of 17 randomly selected 16-hectare survey plots during the months of April and May 2001. The objectives of the random plot measurement effort were to quantify and categorize discrete sources of sediment delivery that have occurred since 1978, and to develop data to be used in road surface erosion and streambank erosion estimates. The year 1978 was chosen because it corresponded with aerial photo coverage available to Regional Board staff for the Mendocino County portion of the watershed where the field methods were finalized and personnel were trained.

6.3.2.1 Sample Design

A stratified random sampling approach was used to select measurement plots. Stratified random sampling is a method of sampling in which the area of interest (in this case the Gualala River watershed) is divided into subareas of relatively uniform character. For this investigation, the watershed was subdivided by geology and vegetation, attributes likely to control erosion and sediment delivery (see Plate 8). A 16-hectare grid was superimposed on the stratified areas and each grid plot assigned a random number using a spreadsheet and random number generator. Next, a randomly selected list of plots was created. If access to grid plots was denied by landowners, the grid plot in question was deleted from the list and the next grid plot was selected.

The procedure for surveying individual plots began with identification of the plot boundaries. Plot boundaries were superimposed on both orthophotos and topographic maps (Figure 6.1 and 6.2), and the coordinates of the plot corners determined for use with global positioning system (GPS) receivers. Enlarged copies of all available aerial photos were created for use in the field prior to surveying.

The process of surveying sediment sources in the field began with walking all stream channels in the plot. Stream channels were defined as watercourses exhibiting evidence of annual scour (i.e. channels that have the capacity to transport sediment through fluvial action). Stream bank height (areas susceptible to bank erosion) and composition (as percent bedrock) were measured at 100-yard intervals. Signs of active erosion and aggradation were also noted. Individual erosion features encountered while traversing stream reaches were measured and recorded as described below.

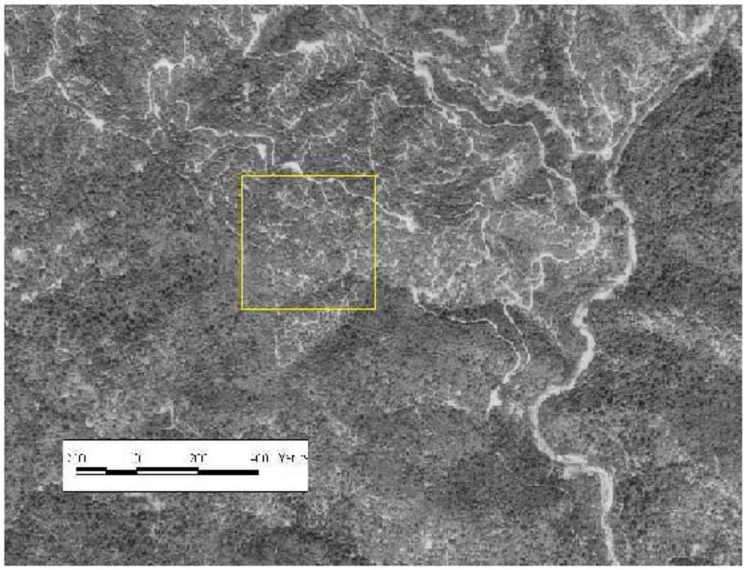

FIGURE 6.1. SMALL FEATURE SEDIMENT SOURCE EXAMPLE ORTHOPHOTO WITH SAMPLE PLOT OVERLAY

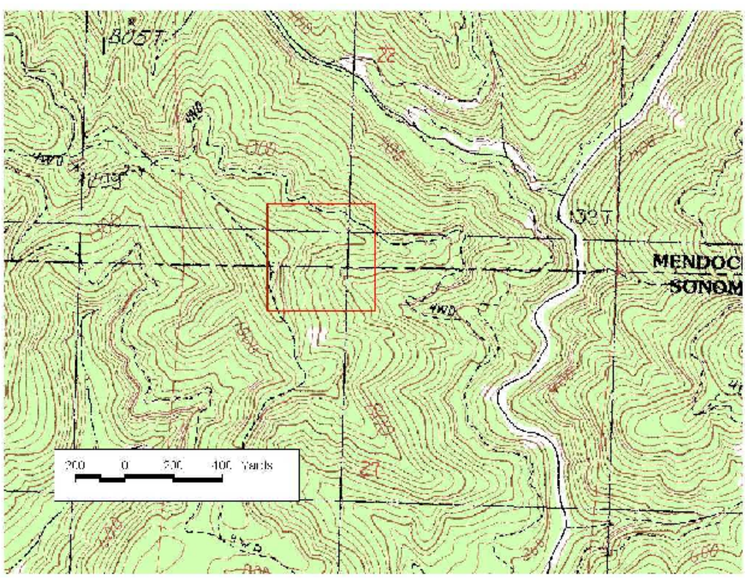

FIGURE 6.2. SMALL FEATURE SEDIMENT SOURCE EXAMPLE TOPOGRAPHICAL MAP WITH SAMPLE PLOT OVERLAY

A second component of the plot surveys measured road characteristics related to surface erosion. The total length of active roads in the plot was measured, as well as the total length of hydrologically connected roads (length that drains to stream, defined by breaks in slope and water flow paths). The height of the cutbanks, percentage of cutbanks composed of bare soil, road width, and road surface type (native, rocked, or paved) were measured at 50 yard intervals. Also, the level of use was categorized for each segment of road encountered. Roads were categorized as frequently, seasonally, or rarely used. Frequently used roads were defined as those showing signs of year-round use such as tire tracks in mud. Seasonal roads were defined as being driven often enough to prevent vegetation from growing on the entire road surface, while rarely used roads were defined as those driven frequently enough to show signs of infrequent use, but still allow vegetation to grow.

Each source of sediment delivery greater than 10 cubic yards was measured and categorized. Ten cubic yards was chosen as the minimum size based on Pacific Watershed Associates' sediment source investigation of Jordan Creek, Humboldt County, a basin with similar geology and vegetation to the Gualala River watershed. In that investigation sediment sources less than 10 cubic yards accounted for 40% of the sediment source features, but amounted to less than less than 2% of the total volume (PWA, 1999). The age of each feature was estimated from the age and type of vegetation and, when possible, aerial photos. In most instances growth of conifers on the feature enabled estimation of the feature's age.

Each feature was categorized by type (debris slide, gully, earth flow, stream crossing failure, etc.) and cause (natural, road fill, road ditch, stream crossing, skid trail, etc.). Additional information describing the hillslope location (upper, middle, low, and streamside) and geomorphic association (inner gorge, stream channel, swale, headwall, planar hillslope, break in slope, other) of each feature was collected.

6.3.2.2 Extrapolation of Results

Access to sample plots for field analysis limited data extrapolation efforts for the random plot analysis. Given an adequate number of sample plots in each geology-vegetation terrain type, sediment delivery for each geology-vegetation terrain type could have been estimated and extrapolated. However, excepting hard Franciscan conifer terrain (in which 12.4 plots were located) and hard Franciscan mixed conifer terrain (in which 3.3 plots were located), no plots, or only a fraction of a plot was surveyed for all other terrain types. In the absence of adequate sample plot data to estimate small feature delivery by geology-vegetation terrain type, delivery from non-road related features was estimated by making average delivery equal throughout the watershed. Sediment delivery associated with road cutbank, ditch, fill, and surface associated features, were extrapolated to the rest of the watershed using GIS generated road densities. For stream crossing failures, GIS generated stream crossing densities were used to extrapolate delivery volumes by watershed. Future sediment source investigations in the Gualala River watershed should combine random plot analyses with road erosion studies and allow more time for gaining landowner access and outreach.

Additional Field Data Collection

After review of the random plot field measurements, Regional Board staff determined that additional data collection was required to describe sediment delivery from main haul roads. Road-related gully volumes and hydrologic connectivity were measured on over one and a quarter miles of main haul road. The measurements were then extrapolated to all main haul roads throughout the watershed.

6.3.3 Surface Erosion Assessment

6.3.3.1 Road Surface Erosion

Road coverage of the Gualala watershed was created or improved by the Information Center for the Environment (ICE), UC Davis. 1:100,000 scale county roads from Teale Data Center and 1:24,000 roads from California Department of Forestry and Fire Protection (CDF) were used as a template to which roads were added or deleted. CDF classified roads in their coverage into the following road use/surface categories: primary (4+ lanes), secondary (2-3 lanes), improved (rocked), unimproved (seasonal), and temporary (4-wheel drive) roads. Additional roads were screen digitized to digital raster graphs from 25 Digital Orthophoto Quarter Quadrangles (DOQQs), or where DOQQs were not available 1999 or 2000 aerial photographs and a stereoscope with hand transfer.

Rates of road-related surface erosion (excluding public roads) were derived from a modified version of the Washington Forest Practice Board's (WFPB) watershed analysis methodology. In order to utilize this methodology, all roads in the database were further categorized by traffic and road surface as either hardened (paved), primary (gravel greater than 6"), seasonal (gravel less than 6") or rarely used/recently abandoned (native rock, soil). Classifications were subjective and made using limited field verification and knowledge of the road network. Hardened (paved roads) in the watershed were easily identified from local knowledge. Main haul roads on industrial timberlands, frequently-used access roads (such as Kelly Road) on private timber and range lands, as well as roads leading to residences and subdivisions were classified as primary roads (gravel>6"). Remaining roads that were identified by CDF were considered seasonal roads (gravel < 6"), and roads digitized from DOQQs were considered rarely used/recently abandoned (native rock/soil).

The following assumptions were used in applying the WFPB methodology to the Gualala River watershed:

1) parent geologic material is highly weathered sedimentary rock
2) all roads are greater than 2 years of age
3) annual precipitation in the watershed is in the range of 1200 mm – 3000 mm (47 to 118 inches)

In addition, field measurements of average vegetation coverage on cut/fillslopes (10 to 50%), average road widths (15 to 25 feet excluding ditch width), and average hydrologic connectivity (25% for rarely used roads and 50% for all others) were assumed to apply broadly to the watershed. These assumptions determine factors that are used to adjust the sediment yield from surface erosion of a reference road of 60 tons/acre of road prism/year to reflect local conditions.

The application of the model to quantify road surface erosion in the Gualala engenders moderate uncertainty. Although we believe the road coverage and use categorization is sufficiently accurate and reflective of the road densities in the watershed, the predictive model was generated more as a way of evaluating relative erosion potential for roads in Washington, rather than as a tool for accurately quantifying total sediment loads. However, the model provides a reasonable estimate for calculating average annual loadings from this process in the watershed. Regional Board staff plan to measure rates of road surface erosion at locations in the Gualala River watershed during the winter of 2001 to further refine these estimates.

6.3.3.2 Skid Trail Erosion

Sediment yields attributable to erosion of skid trails were estimated from data reported in the Garcia and Albion Watershed Analyses (Mendocino Redwood Company, 1999, Louisiana Pacific, 1998), due to the absence of data specific to the Gualala River watershed and lack of access to recent timber harvests. The average rate of skid trail erosion per square mile of area harvested by tractor yarding in the Garcia and Albion (361 ton/mi2/yr) watersheds was applied to the area harvested by tractor yarding in the Gualala River watershed. The assumption is that tractor yarding practices employed on Louisiana Pacific's Garcia and Albion properties has resulted in nearly the same rate of sediment delivery as tractor yarding practices on timberlands in the Gualala River watershed. This is a reasonable assumption given the Garcia, Albion, and Gualala River watersheds have similar geology, vegetation, topography, and climates. It was estimated that sediment delivery from skid trail surface erosion occurred for a duration of five years, based on best professional judgment. The area tractor yarded in the Gualala watershed was estimated from a GIS coverage obtained from the CDF denoting timber harvest plan (THP) areas for which the method of harvest was ground-based yarding.

6.3.4 Public Road Sediment Delivery Assessment

The US Environmental Protection Agency, with coordination from the Regional Water Board contracted with Pacific Watershed Associates (PWA, through Tetra Tech) to provide an analysis of sediment delivery caused by county road systems. The analysis provides estimates of past sediment delivery volumes from public roads, as well as information that will be useful in developing implementation strategies for public roadways. The remainder of this section is based on PWA’s draft methodology description (PWA, 2001).

A sampling strategy was utilized to characterize erosional processes and sediment delivery associated with public roads in the Gualala River watershed. Selected roads were field inventoried to identify past erosion. Sampled road information was analyzed for delivery volumes related to each hillslope position, vegetation, and bedrock association. The sample data, collected along 34.9 of 73.9 miles of road, was then extrapolated to represent all the public roads in the Gualala watershed.

All sampled roads were field inventoried for past erosion and sediment delivery, including road and turnout (historic landings) fill slope failures, stream crossing washouts, stream diversion gullies and sites of road surface and ditch erosion. Field personnel traced each erosion feature downslope as far as public access allowed to determine dimensions (length, width, depth, and volume) and past sediment delivery. In some cases topographic maps, morphologic setting, and professional judgment were employed to determine delivery. County road related erosional features that delivered sediment to a stream were recorded. Sites with more than 20yd^3 of sediment delivery in the past were given a detailed write-up, whereas sites with less than 20yd^3

of sediment delivery were mapped and given a delivery-volume range. An additional subset of past erosion data was collected describing cutbank landslides.

All erosional features with more than 20yd^3 of sediment delivery have a suite of data collected on a site form. Specific information includes: 1) unique site #; 2) age of the feature; 3) bedrock geology and dominant vegetation type; 4) type of sediment source; 5) hillslope position; 6) volume of erosion; 7) an estimate of the volume of sediment delivered to streams; 8) geomorphic association, and 9) an estimate of the potential volume of sediment that may be delivered to streams in the future.

The <20yd^3 sites were assigned to one of the following ranges based on a quick quantification of volume delivered: 1) <1yd^3; 2) 1-5yd^3; 3) 5-10yd^3, or 4) 10-20yd^3. These ranges were subsequently assigned the median value of the range to be used for sampled and extrapolated delivery volumes. In addition, the mapped location will designate (via GIS) a bedrock and vegetation type classification to be used for data extrapolation of each <20yd^3 site.

Cutbank landslides were approached somewhat similarly to <20yd^3 sites, although they were not assigned to a volume-range. Average dimensions of cutbank slides were estimated and the locations were mapped. Additionally, they were assigned a delivery percent based on observations of the nature of the slide. Delivery percent considerations included:

- Was the slide large enough to make it over the road?
- Is the road close enough to a stream, to deliver?
- Was the deposit from the slide sidecast locally (common occurrence) and delivered from there?
- And was the slide catastrophic, or gradual?

Generally, a delivery of 5 percent or less was assigned. The exception was cutbanks that failed gradually: it was assumed that slides that are oozing into an inboard ditch that is connected to a stream network will have a higher delivery percent than slides that fail onto the road bench. None of the cutbank slides were assigned a delivery greater than 10%.

The total county road delivery estimated by PWA was determined and distributed among the subwatersheds based on county road density within each subwatershed.

6.3.5 Stream Bank Erosion

The fluvial erosion of bank materials was estimated based on estimates of soil creep rate and drainage density. This method assumes that the rate of stream bank erosion is in equilibrium with the rate of soil production and delivery from hillslopes adjacent to the channels. If this assumption is false, then stream banks would be actively retreating or encroaching on the stream channel.

Regional Board staff estimated creep rates in the Gualala River watershed based on measurements of soil creep reported in literature for settings with similar climate and vegetation in the Franciscan geology of the North Coast of California. Measurements of drainage density, streambank height, and streambank composition made as part of the random plot surveys were used to estimate the extent of streambank areas susceptible to bank erosion.

Regional Board staff reviewed literature reporting measurements of soil creep in the Franciscan geologic formation (Lehre, 1987; Swanston, 1981; Swanston et al, 1995; Ziemer, 1984). Soil creep processes in the coastal belt Franciscan geology were evaluated separately from those in the central belt Franciscan geology. For the coastal belt terrain, soil creep was assumed to only act on third order and smaller streams. This assumption is based on Regional Board staff's observations that in fourth order and larger channels, most stream banks are composed of bedrock, and other mass wasting processes dominate streamside inputs. Creep rates in the central belt were modified to account for earthflow processes.

Creep rates in the coastal belt Franciscan were assumed to be 1.6 mm/year, the average of the values reported by Swanston (1981) and Lehre (1987). The rate is within the ranges suggested by the Washington Forest Practices Board (1997) (1-2 mm/year), and Selby (1993) (0.5-2 mm/year). For terrains of the central belt of the Franciscan the value above was adjusted to incorporate delivery rates associated with earthflows. The rate of earthflow creep was estimated to be 48 mm/year, based on measurements of earthflows reported by Swanston et al (1995). Regional Board staff then developed a weighted average creep rate for the central belt terrains by assuming 10% of streambanks were adjacent to earthflows (48 mm/year), with the remaining 90% creeping at the same rate as the coastal belt terrain (1.6 mm/year). This resulted in an estimated overall creep rate of 6.3 mm/year for the central belt terrain.

6.3.6 Summary of Assumptions and Confidence

Assumptions

Many assumptions were made to develop sediment delivery estimates in the sediment source analysis. These assumptions are summarized below:

<u>General</u>

- The density of delivered sediment is 1.48 tons/cubic yard (EPA, 2000).

<u>Aerial Photo Analysis</u>

- All features greater than 10,000 ft^2 in plan area were discernible on aerial photos.
- The intersection of a feature with a management relation (cut bank, fill slope, landing, etc.) is indicative of a causal mechanism (field observations and best professional judgment).
- Percent delivery was based on the proximity of the feature to a water course and best professional judgment.
- The ratio of sediment delivery from new features to total feature volume for 1978 and 1988 is equal in the Gualala watershed for Mendocino and Sonoma County (based on similar geology, vegetation, topography and climate).
- The ratio of sediment delivery from enlarged (1978-1988) features to total 1988 feature volume is equal in the Gualala watershed for Mendocino and Sonoma County (based on similar geology, vegetation, topography and climate).
- The sediment delivery volume by management relation and subwatershed between 1978 and 1988 is proportional to the volume by management relation and subwatershed from the 1988

photo analysis in Sonoma County (based on similar geology, vegetation, topography and climate).
- The average depth and slope of inner gorge features is 6.2 feet and 40 degrees respectively (field measurement of limited landslides identified in aerial photo analysis).
- The average depth and slope of mid and up-slope features is 5.4 feet and 39 degrees respectively (field measurement of limited landslides identified in aerial photo analysis).

<u>Random Sample Plots</u>
- Features less than 10 cubic yards are not a significant source of sediment in the Gualala watershed (PWA, 1999).
- Sediment delivery from non-road related features is equal throughout the watershed.
- Sediment delivery associated with road cutbank, ditch, fill, and surface associated features, was extrapolated to the rest of the watershed using GIS generated road densities (best professional judgment).
- Sediment delivery associated with stream crossing failures was extrapolated to the rest of the watershed using GIS generated stream crossing densities (best professional judgment).

<u>Road Surface Erosion</u>
- Rates of sediment delivery were estimated based on Washington Forest Practice Board's (WFPB, 1997) watershed analysis methodology (best readily available technology).
- Roads were stratified into four use classification. (limited field verification and knowledge of the road network).
- All roads are greater than 2 years of age (best professional judgment).
- Field measurements of average vegetation coverage on cut/fillslopes (10 to 50%), average road widths (15 to 25 feet excluding ditch width), and average hydrologic connectivity (25% for rarely used roads and 50% for all others) apply broadly to the watershed (best professional judgment).
- Tractor yarding practices employed on L-P's Garcia and Albion properties has resulted in nearly the same rate of sediment delivery (361 ton/mi2/yr) (MRC 1999, L-P, 1998) as tractor yarding practices on timberlands in the Gualala watershed (similar geology, vegetation, topography, and climates)

<u>Public Roads</u>
- The total county road delivery estimated by PWA was extrapolated by subwatershed based on county road density within each subwatershed (best professional judgment).

<u>Stream Bank Erosion</u>
- The rate of stream bank erosion is in equilibrium with the rate of soil production and delivery from hillslopes adjacent to the channels (best professional judgment).
- For the coastal belt Franciscan terrain, soil creep was assumed to only act on third order and smaller streams (field observations).
- Creep rates in the coastal belt Franciscan were assumed to be 1.6 mm/year, the average of the values reported by Swanston (1981) and Lehre (1987).
- The rate of earthflow creep was estimated to be 48 mm/year, based on measurements of earthflows reported by Swanston et al (1995).

- The weighted average creep rate for the central belt Franciscan terrains was developed by assuming 10% of streambanks were adjacent to earthflows (48 mm/year), with the remaining 90% creeping at the same rate as the Franciscan coastal belt terrain (1.6 mm/year). This resulted in an estimated overall creep rate of 6.3 mm/year for the Franciscan central belt terrain.

Confidence in Sediment Source Analysis

In general, confidence in an analysis was assigned as shown below.

- *High Confidence* - Data gathered in the field by Regional Water Board staff or other specified professionals (i.e. PWA).
- *Moderate Confidence* - Aerial photo interpretation and other remote sensing techniques.
- *Low Confidence* - Values reported in other watershed investigations or similar geology, topography, vegetation, and climate that are applied to the Gaulala watershed.

The aerial photo analysis portion of the sediment source analysis provides rates of sediment delivery from features greater than 10,000 ft^2 in plan area. The estimate of sediment delivery was determined by analyzing aerial photos to determine feature volumes, delivery percentages, management relations, and other attributes. Field visits to 46 of 607 features identified in the aerial photo analysis and 11 additional features were made to ground truth features and estimate average feature slope and average feature depth. In combination with feature areas and management relations determined during aerial photo interpretation, average feature slope and average feature depth were used to estimate sediment delivery. Delivery volume for the Sonoma County portion of the watershed for 1978-1988 was estimated by using extrapolation methods to relate sediment delivery determined for Mendocino County from 1978 to 1988 to Sonoma County sediment delivery from 1978 to 1988. Aerial photo analysis methods are limited by the aerial visibility of features. Features may not be visible due to photo aspect, topography, and/or vegetation. In addition, aerial photo analysis is subjective and dependent on the geologist interpreting the aerial photo. Thus, the aerial photo analysis performed by a geologist can be interpreted with moderate confidence. Extrapolation methods used to determine a temporal component of the sediment delivery for Sonoma County should be interpreted with low to moderate confidence. The overall confidence in the aerial photo analysis is moderate.

The random plot analysis portion of the sediment source analysis provides rates of sediment delivery associated with features 10,000 ft^2 in plan area and smaller. The sediment sources in each sample plot were determined in the field. These field estimates were extrapolated based on watershed characteristics as described in Section 6.3.2.2. Data collected in the field can be interpreted with high confidence. Extrapolations of field data can be interpreted with low confidence due to the relatively small amount of plots that were visited. The overall confidence in the random plot analysis is low.

The road surface portion of the sediment source analysis provides rates of sediment delivery associated with road surface erosion. The estimate of road surface erosion was estimated by applying values determined during field work and values derived from GIS coverage to a WFPB predictive model (see Section 6.3.3.1). The values for percent of road with vegetation, average vegetation coverage on cut/fillslopes, average road widths, and average hydrologic connectivity were measured during random sample plot and other field work. The confidence in the road attributes measured in the field is high, however, the confidence in these estimates applied to the entire watershed is low. The WFPB road surface erosion model applied was generated more as a way of evaluating relative erosion potential for roads in Washington, rather than as a tool for accurately quantifying total sediment loads. The confidence in the model as a tool for estimating sediment delivery is low. The overall confidence for road surface erosion sediment delivery is low.

The skid trail portion of the sediment source analysis provides rates of sediment delivery associated with skid trail surface erosion. The estimate of skid trail surface erosion was based on two values: the area harvested by ground based yarding, and the sediment delivery factor associated with ground based yarding. The estimated area harvested by ground based yarding was determined from CDF GIS coverages of timber harvest plans. The skid trail sediment delivery factor was taken from data reported in the Garcia and Albion Watershed Analyses (Mendocino Redwood Company, 1999; Louisiana Pacific, 1998). Confidence in the area harvested by ground based yarding is moderate while confidence in the sediment delivery factor is low. Overall confidence in the skid trail portion of the sediment source analysis is low.

The public roads portion of the sediment source analysis provides rates of sediment delivery associated with public roads within the Gualala River watershed. PWA (2001) measured sediment delivery from 34.9 of 73.9 miles of county roads. The rates of sediment delivery were extrapolated to the remainder of county roads by watershed as described in Section 6.3.4. The total county road delivery estimated by PWA was distributed among the subwatersheds based on county road density within each subwatershed. The confidence in the field measurements of sediment delivery is high. The confidence in PWA extrapolation methods is moderate. The confidence in the extrapolation of PWA estimates of total watershed delivery to each subwatershed is moderate. The overall confidence in the public roads portion of the sediment source analysis is moderate.

The stream bank erosion portion of the sediment source analysis provides estimates of the rate of sediment delivery associated with soil creep of stream banks and movement of earthflows. Sediment delivery was estimated using soil creep rates associated with coastal belt Franciscan geology and applying these rates to the watershed excepting the application of a weighted factor to account for earthflow in the central belt Franciscan geology. The soil creep rates were applied to stream densities derived from stream surveys in random sample plots. The stream density in random sample plots was assumed to apply broadly to the entire Gualala River watershed. The confidence in soil creep rates is low. The confidence in stream surveys within random sample plots is high. The confidence in the extrapolation of the stream surveys to the entire watershed is low. The overall confidence in the stream bank erosion portion of the sediment source analysis is low.

The confidence in the entire sediment source analysis is low to moderate. The sediment source analysis is intended to give a broad watershed-scale overview of sources of sediment delivery in the Gualala River watershed. To that end, the primary objective of the Gualala River Watershed

Technical Source Document for Sediment is to identify and quantify sources of sediment delivery in a way that allows a relative comparison of those sources and to provide information required for non-point source implementation and planning.

6.4 Sediment Source Analysis Results

This chapter and the analysis contained herein are intended to give a broad watershed-scale overview of sources of sediment delivery in the Gualala River watershed. This TSD document is intended to guide landowners, land managers, and resource protection agencies in the protection of water quality in the Gualala River watershed. The primary objective of the Gualala River Watershed TSD for Sediment is to identify and quantify sources of sediment delivery in a way that allows a relative comparison of those sources and to provide information required for non-point source planning and implementation. The sediment source analysis and load allocations should not be used for site-specific land management prescriptions or for any other purpose other than that for which they are intended.

The results of the sediment source analysis are presented in Table 6.1. Natural sediment yield accounts for approximately 1/3 of the total sediment delivery in the Gualala watershed while human-caused sediment delivery accounts for 2/3 of the sediment delivery in the watershed, or 200% of the natural load. The analysis shows that road-related processes are the dominant source of sediment delivery in the watershed.

It is important to note that although the analysis only estimates sediment delivery that has occurred since 1978, pre-1978 management activities are still causing increased sediment delivery. While conducting the field measurements of random plots, staff observed many legacy problems associated with management practices pre-dating the Z'Berg-Nejedly Forest Practices Act.

The total natural sediment delivery in the watershed is estimated to be 380 ton/mi^2/yr. Regional Water Board staff believes, based on best professional judgment, that 380 ton/mi^2/yr may actually be an underestimate of the true natural yield. In cases of uncertainty, conservative assumptions were made which incorporate a margin of safety in the loading capacity estimate. Section 303(d) of the Clean Water Act requires that TMDLs include a margin of safety to account for major uncertainties concerning the relationship between pollutant loads and instream water quality.

TABLE 6.1. SEDIMENT SOURCE ANALYSIS RESULTS

<table>
<tr><th rowspan="2">Sediment Source</th><th colspan="7">Estimated Sediment Delivery (tons/mi^2/yr)</th></tr>
<tr><th>Buckeye</th><th>North Fork</th><th>Rockpile</th><th>South Fork</th><th>Wheatfield Fork</th><th colspan="2">Entire Watershed</th></tr>
<tr><td>Natural Mass Wasting</td><td>170</td><td>170</td><td>210</td><td>190</td><td>180</td><td>180</td><td rowspan="2">Natural: 380</td></tr>
<tr><td>Stream Bank Erosion</td><td>190</td><td>200</td><td>180</td><td>220</td><td>200</td><td>200</td></tr>
<tr><td>Road Related Mass Wasting</td><td>450</td><td>580</td><td>350</td><td>290</td><td>310</td><td>370</td><td rowspan="6">Human-Caused: 840

(Roads: 710)</td></tr>
<tr><td>Road-Stream Crossing Failures</td><td>70</td><td>70</td><td>60</td><td>40</td><td>40</td><td>50</td></tr>
<tr><td>Road Related Gullying</td><td>190</td><td>80</td><td>40</td><td>130</td><td>210</td><td>150</td></tr>
<tr><td>Road Related Surface Erosion</td><td>210</td><td>160</td><td>100</td><td>150</td><td>120</td><td>140</td></tr>
<tr><td>Skid Trail Surface Erosion</td><td>40</td><td>60</td><td>20</td><td>20</td><td>20</td><td>30</td></tr>
<tr><td>Other Harvest Related Delivery</td><td>80</td><td>90</td><td>60</td><td>110</td><td>110</td><td>100</td></tr>
<tr><td>Total</td><td>1400</td><td>1410</td><td>1020</td><td>1150</td><td>1190</td><td>1220</td><td></td></tr>
</table>

The categories in Table 6.1 are defined as follows:

Natural Mass Wasting: Mass wasting (landslides, debris flows, etc.) not influenced by anthropogenic activities. Note that earthflow delivery has been incorporated into the stream bank erosion estimate.

Stream Bank Erosion: Sediment delivered to stream channels by soil creep and earthflow processes.

Road Related Mass Wasting: Mass wasting (landslides, debris flows, etc.) originating from roads. Estimate was generated from aerial photo analysis and field measurement of random plots.

Road-Stream Crossing Failures: Sediment delivery associated with erosion caused by stream crossings, including outlet erosion, stream diversions, and washouts. (This is almost certainly an underestimate due to the fact that stream crossings are often repaired after failure.)

Road Related Gullying: Sediment delivery associated with gullies caused by road runoff. Estimate was generated from field measurements of random plots and main-haul road survey.

Road Related Surface Erosion: Sediment delivery of eroded road surface materials.

Skid Trail Surface Erosion: Sediment delivery from surface erosion of skid road and trail surfaces.

Other Harvest Related Delivery: Sediment delivery associated with landings, skid roads and trails not accounted for elsewhere. This estimate was generated from the aerial photo analysis and field measurement of random plots and includes both mass wasting and fluvial erosion of skid trails and landings adjacent to streams.

Caution should be exercised when interpreting the results presented above. The numbers imply greater accuracy than is warranted, given the estimation techniques used. The source analysis and the findings presented in Chapter 5 support the following points:

1. Salmonid habitats have been significantly degraded as a result of excess sediment loads, particularly fine sediments.
2. Sediment delivery in the Gualala River watershed has been dramatically increased by human activities, especially the construction and existence of roads.
3. Most human induced processes attributed to increased sediment yields, particularly road related erosion, are easily prevented and corrected.

6.5 Loading Capacity Estimate

The purpose of a Loading Capacity Estimate is to estimate the amount of a pollutant that can be discharged to a waterbody without violating water quality standards. The water quality standards that relate to sediment-related concerns in the Gualala watershed are found in the Water Quality Control Plan for the North Coast Region (commonly referred to as the "Basin Plan"). The water quality standards state:

> The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.
>
> And
>
> Waters shall not contain substances in concentrations that result in deposition of material that causes nuisance or adversely affects beneficial uses.

The beneficial uses sensitive to sediment impacts in the Gualala River watershed are:

- Cold Freshwater Habitat (COLD)
- Rare, Threatened, or Endangered Species (RARE)
- Spawning, Reproduction, and/or Early Development (SPWN)
- Migration of Aquatic Organisms (MIGR)
- Estuarine Habitat (EST)
- Municipal and Domestic Supply (MUN)
- Water Contact Recreation (REC-1)
- Non-Contact water Recreation (REC-2), and
- Commercial and Sport Fishing (COMM)

This assessment addresses the beneficial uses most impaired by sediment, which are are those associated with the cold water fishery (COLD, SPWN, RARE, MIGR). Thus, the Loading Capacity Estimate attempts to quantify the amount of sediment, in addition to natural sources, that can be introduced to the waters of the Gualala watershed without adversely affecting the salmon and steelhead fishery.

6.5.1 Loading Capacity Methodology

Although the best available science does not yet provide for a quantitative linkage between sediment loading and instream water quality, there is a clear qualitative basis for the linkage. Sediment loading above natural rates can cause various disturbances to streams as described in Chapter 4.

Past sediment TMDLs have estimated loading capacity based on four methods:
(1) comparison of present conditions to conditions during a reference time period in which salmonid stocks were healthy,
(2) comparison of current conditions to reference watersheds (streams in good condition),
(3) relating qualitatively the desired percent change of indicators to a percent change in loading, and,
(4) Applying the percent reduction required in one watershed (based on (1), above) to another watershed.

In the case of the Gualala watershed, Method 1 is not a viable option since management activities and fisheries decline pre-date the earliest available air photo sets. Little information is available to select an appropriate reference period in the Gualala River basin to determine loading capacity. On-the-ground surveys of sediment processes that were occurring in the early 1900s are impossible due to re-vegetation and subsequent management. Thus, NCRWQCB is not determining a loading rate based on a historical period in the Gualala River basin.

Method 2 depends on data describing sediment delivery to streams that currently have properly functioning conditions. While there may be streams meeting this criterion in the Gualala watershed, NCRWQCB staff did not have access to such areas and were unable to evaluate any. Method 3 depends on the availability of in-stream indicator data from areas throughout the watershed, which was not available in the Gualala.

For the Gualala Loading Capacity Estimate, Regional Water Board staff has adopted the approach taken by USEPA for the South Fork Eel, Navarro and Ten Mile TMDLs (Method 4). This approach uses information from the Noyo watershed to relate the sediment yield regime to salmonid abundance. This method assumes that since salmonids were abundant in the Noyo during the 1930s-1950s period, the corresponding sediment yield during that period must have been sufficiently low to allow salmonid habitat of suitable quality to persist. During this era the estimated rate of sediment yield is 470 tons/mi^2/yr (EPA 1999b). Approximately 370 tons/mi^2/yr of this load is attributed to natural processes (EPA 1999b). Stated another way, the anthropogenic load during this time period is approximately 25% of the natural load. The NCRWQCB is estimating the loading capacity for the Gualala River based on the judgment that a water body can assimilate a certain proportion of load over its background rate while still meeting water quality standards. In the Noyo River, that rate is 25% over background (EPA 1999b). Given the proximity of the Noyo to the Gualala, as well as their similarities in climate, geology, vegetation, and land use history (Matthews and Associates, 1999), Regional Water Board staff, based on best professional judgment, conclude that a reasonable loading capacity estimate for the Gualala watershed is an anthropogenic load that is 25% of the natural load.

6.5.2 TMDL

Salmonids were still abundant in the Noyo and its tributaries during the 1933-1957 period, so the corresponding sediment yield during this period must have been sufficiently low to allow salmonid habitat of suitable quality to persist (EPA 1999b). The total loading capacity for the Noyo is 125% of the background load. This ratio is then applied to the background levels in the Gualala River, because the two basins are close in proximity, and have similar characteristics of geology, vegetation, and land use history. Thus, the total loading capacity for the Gualala basin is determined to be 125% of the estimated background rate. The background rate for the Gualala is 380 tons/mi^2/yr. The total loading capacity for the Gualala is determined to be 125% of background levels, or 475 tons/mi^2/yr. It should be noted that this total loading capacity is prescribed to meet and be protective of water quality objectives in the Gualala River watershed at the watershed scale. The obtainment of water quality objectives at each site in the Gualala River watershed requires a site-specific approach, beyond the scope of the loading capacity estimated in this document.

The loading capacity estimate should be re-evaluated during future revisions of the Gualala Sediment TMDL. An approach that takes into account sediment storage and long-term sediment transport capacity should be considered.

6.6 Load Allocation

The purpose of the load allocation is to identify the amount of reduction of individual sediment source categories required to meet the loading capacity. The loading capacity estimate is 125% of the natural load. This corresponds to a natural load of 380 tons/mi^2/yr (as defined in Section 6.4) and an anthropogenic load of 95 tons/mi^2/yr when applied to the estimated sediment load. The allocated anthropogenic sediment load (95 tons/mi^2/yr) is equivalent to an 89% reduction of the current estimated anthropogenic sediment load (840 tons/mi^2/yr). The load allocations shown in Table 6.2 are reflective of a total anthropogenic sediment load reduction of 89%.

The allocations in Table 6.2 were developed by Regional Water Board staff, using best professional judgment, of what is attainable. Regional Water Board staff used experience gained in the oversight of management activities including timber harvest, road construction, road repair, and road upgrade to set allocations based on the degree to which individual source processes were estimated to be controllable. Based on best professional judgement, sediment sources that were hypothesized to be more easily controlled were prescribed greater percent reductions.

TABLE 6.2. SEDIMENT SOURCE LOADING ALLOCATIONS

	Sediment Source	Current Load (tons/mi^2/yr)	Load Allocation (tons/mi^2/yr)
Natural	Natural Mass Wasting	180	180
	Streambank Erosion	200	200
Anthropogenic	Road Related Mass Wasting	370	56
	Road-Stream Crossing Failures	50	5
	Road Related Gullying	150	8
	Road Related Surface Erosion	140	7
	Skid Trail Surface Erosion	30	5
	Harvest Related Mass Wasting	100	14
	Total	1220	475

Sediment delivery associated with road surface erosion is allocated five percent of current estimated delivery. Reducing the amount of road runoff reaching watercourses (hydrologic connectivity) can effectively limit delivery of sediments generated by road surface erosion. Mitigation measures such as outsloping, installation of rolling dips and increased frequency of ditch relief culverts can greatly reduce hydrologic connectivity of roads and streams. Where the hydrologic connection of roads and streams can't be eliminated, it can be mitigated by appropriate road surfacing and limiting use of those roads during wet weather.

Road-related gullies are allocated five percent of their current estimated delivery. Most existing gullies can be easily de-watered by changes in road drainage, although some pre-existing gullies will continue to deliver.

Stream crossing failures are allocated ten percent of their current estimated delivery. Minimizing fill volumes and eliminating diversion potential can greatly reduce the volume of sediment delivered to streams. Also, many culverts currently existing at small stream crossings on seasonal roads can be eliminated by construction of armored fords. Elimination of culverts on these small crossings greatly reduces the risk of catastrophic sediment delivery.

Road-related mass wasting sources are allocated fifteen percent of their current estimated delivery. In order to attain this allocation, ownerships with high road densities may need to decommission some roads. Regional Board staff considered the controllability and predictability of these features in assigning their allocation.

Skid trail erosion is allocated seventeen percent of the estimated load for the assessment period (1978-2000). Regional Board staff believe that the most current practices are already reducing delivery rates from the planning period average. Increased use of suspension cable and helicopter yarding and a reduction in skid trail stream crossings have reduced rates of sediment delivery attributed to skid trails. Additional reductions are possible by slash packing and decommissioning skid trails in areas near watercourses.

Other harvest related delivery is allocated fourteen percent of the current estimated delivery. Much of the current estimated delivery is attributed to legacy problems associated with pre-forest practice rule management. Mass wasting associated with landings and skid trails can be significantly reduced by avoiding unstable areas and decommissioning landings.

It should be noted that these loading allocations are prescribed to meet and be protective of water quality objectives in the Gualala River watershed, at the watershed scale. The obtainment of water quality objectives at each site in the Gualala River watershed requires a site-specific approach, beyond the scope of the load allocations prescribed in this document.

6.7 Margin of Safety, Seasonal Variation and Critical Conditions

Section 303(d) of the Clean Water Act requires that TMDLs include a margin of safety to account for major uncertainties concerning the relationship between pollutant loads and instream water quality. The margin of safety can be incorporated into conservative assumptions used to develop the TMDL, or added as a separate quantitative component of the TMDL. Section 303(d) also requires that TMDLs account for seasonal variation and critical conditions.

6.7.1 Margin of Safety

This TSD incorporates an implicit margin of safety based on conservative assumptions employed in the Source Analysis. In cases of uncertainty, estimates erring towards protection of the resource were made. The following examples illustrate the conservative assumptions that led to the margin of safety.

A significant assumption made as part of the Sediment Source Analysis is that the sediment delivery from sampled plots could be extrapolated to each subwatershed. As part of the field measurement of random plots Regional Board staff visited 17 plots, 12 of which were in timberlands. Due to access limitations, Regional Board Staff were unable to sample ranchlands as extensively as timberlands. Therefore, the harvest related delivery estimates generated from the field measurements of random plots are biased towards conditions associated with timber management. Approximately 40% of lands in the watershed are timberlands. However, timber harvest has occurred in the past in nearly all areas where commercial tree species are found, including ranchlands. During the course of the Sediment Source Analysis, Regional Water Board staff were able to make observations while passing through large areas of ranchland. These observations, coupled with measurements from five random plots in ranchlands, have led Regional Board staff to believe that sediment delivery from ranchlands is likely to be less than that from timberlands. Without an adequate sample size a comparison of ranchlands to timberlands is not possible. Therefore, the results from the field measurement of random plots were extrapolated to the rest of the watershed. This constitutes a conservative assumption in regards to protection of the resource and is incorporated into the margin of safety.

Another conservative assumption incorporated in the margin of safety relates to the estimation of delivery associated with earthflows. Earthflows are common in the central belt Franciscan geology, which comprises approximately 25% of the watershed area. Without the specific locations of earthflows available, Regional Water Board staff were unable to evaluate earthflow inputs in great detail. Earthflow delivery was then incorporated into the streambank erosion estimate based on creep rates reported in the literature. This is likely to result in an underestimate of earthflow delivery. Since the loading allocations are based on the natural sediment delivery, an underestimate of natural delivery results in a lower allocation and therefore errs towards protection of the resource.

For the aerial photo, mass wasting analysis, another conservative assumption was made. For each feature, a management relation was noted. In the absence of an anthropogenic relation, a natural relation was noted. Determination of the cause of a mass wasting event is often difficult even for an experienced geologist on the ground. All features with an anthropogenic relation were assumed to be human caused, although it is likely that an anthropogenic relation may have been observed for some natural caused features (i.e. a road crossing landslide feature caused by weathering and seismic events). This is likely to result in the over estimation of anthropogenic sediment delivery and the under estimation of natural sediment delivery. As stated previously, since the loading allocations are based on the natural sediment delivery, an underestimate of natural delivery results in a lower loading capacity and therefore errs toward protection of the resource.

6.7.2 Seasonal Variation and Critical Conditions

Seasonal variations summarize the changes in the discharges of sediment and their associated effects on beneficial uses which may vary in different years and at different times of the year. Sediment delivery to streams is inherently a seasonal phenomenon. For this reason the TSD allocates sediment loads based on a ten-year rolling average. This TSD does not explicitly address critical conditions. Instream sediment conditions are a function of what has occurred upstream over a long period of time. The approach chosen then is to use indicators that are reflective of both the short-term response to mitigation, as well as its net long-term effects.

6.8 Numeric Targets

The water quality objectives that apply to sediment conditions and those activities that affect them are:

> The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.
>
> <u>and</u>
>
> Waters shall not contain substances in concentrations that result in deposition of material that causes nuisance or adversely affects beneficial uses.
>
> <u>and</u>
>
> Turbidity shall not be increased more than 20 percent over naturally occurring background levels.

The instream numeric targets proposed sections 6.8.1, 6.8.2 and 6.8.3 are based on Regional Water Board staff's interpretation of how increased sediment delivery causes nuisance and adversely affects beneficial uses. These targets reflect some of the instream sediment conditions that are required by cold water fishery species present in the Gualala watershed. The upslope targets are proposed as a means of evaluating the degree to which identified problems are addressed.

Two categories of numeric targets are proposed: targets based on indicators of instream sediment supply and stream "health", and targets based on indicators of sediment loading and risk of future delivery. These numeric targets are further categorized in terms of short, mid, and long-term processes and effects. Of course the ultimate numeric target is that of increasing returns of adult salmonids and attainment of beneficial uses. However, since other processes beyond sedimentation are significant, fish populations alone cannot be used as a gauge for determining decreasing impairment due to effects of sedimentation (i.e. desirable habitat conditions may be attained long before salmonid populations recover).

Because of the inherent variability associated with stream channel conditions, it is appropriate to evaluate the attainment of the instream numeric targets based on a weight-of-evidence approach. Also, instream targets should be evaluated based on a five-year rolling average to allow for short-term changes due to large flood events.

6.8.1 Short-Term Numeric Targets and Indicators

The short-term targets are proposed as a means of quantifying changes in the up-slope sediment supply and corresponding in-stream conditions that manifest themselves on a time-scale of a few years. For instance, decreases in hydrologic connectivity are expected to decrease the delivery of road-related surface erosion soon after implementation. Likewise, V* surveys are expected to detect changes in the supply of fine sediments soon after those changes occur. Though the targets are called short-term targets, they are meant to apply over the life of the TMDL.

V* ≤ 0.15: Lower-Order Streams

V* (pronounced "vee-star") is a measure of the fraction of a pool's volume that is filled by fine sediment and is representative of the in-channel supply of mobile bedload sediment (Lisle and Hilton 1992). Lisle and Hilton (1999) demonstrated the usefulness of the parameter by comparing annual sediment yields of select streams with their average V* values. The comparison indicated that V* was well correlated to annual sediment yield. They also demonstrated that V* values can quickly respond to changes in sediment supply. V* values in French Creek, a tributary to the Scott River, decreased to approximately one-third the initial value soon after an erosion control program focusing on roads was implemented. A study of over sixty streams in the Franciscan geology of Northern California found that mean V* values of 0.21 (21 %) or less represented good stream conditions (Knopp, 1993). Knopp's study was conducted after a period of drought that many believe had affected the results. Lisle and Hilton (1999) reported that V* values for Elder Creek, an undisturbed tributary of the South Fork Eel River in Coastal Belt Franciscan Geology, averaged only 0.09. The difference in the V* values presented by Knopp (1993) and Lisle and Hilton (1999) is indicative of the variability inherent in

V* measurements. In order to include the valuable results presented by both Knopp (1993) and Lisle and Hilton (1999), the V* target is set at the mean of both reported values based on best professional judgement. Therefore, the numeric target for V* in the Gualala watershed is 0.15, the average of 0.21 and 0.09.

In order to discern short-term changes in sediment supply, V* values from lower order ($\leq 3^{rd}$ order) streams should be analyzed. It is expected that V* values for higher order streams will not be as responsive to those changes due to high amounts of fine sediment volume currently stored as instream deposits.

Fine Sediment Volume of the Active Bed Matrix: Decreasing Trend

The fine sediment volume of the matrix material of the active bed is included as a method of tracking trends of in-stream fine sediment storage. The parameter is also intended to aid in interpretation of V* trends, and eventually as a means of describing changes in sediment supply. Volumes should be measured as described in Lisle and Hilton (1999). The target is a decreasing trend in the volume stored.

Percent Fines ≤ 0.85 mm: ≤ 14%

The percent fines ≤ 0.85 mm is defined as the percentage of subsurface fine material in pool tail-outs ≤ 0.85 mm in diameter. This parameter is chosen as one of two surrogate measurements of spawning gravel suitability. The numeric target for this parameter is 14% based on the average of values reported for unmanaged streams in the studies by Peterson et al. (1992) and Burns (1970).

Percent Fines ≤ 6.4 mm: ≤ 30%

The percent fines ≤ 6.4 mm is defined as the percentage of subsurface fine material in pool tail-outs ≤ 6.4 mm in diameter. This parameter is chosen as the second of two surrogate measurements of spawning gravel suitability. The numeric target for percent fines ≤ 6.4 mm is 30% based on Kondolf's (2000) summary of information reported in various studies.

Riffle Embeddedness: <25% or improving (decreasing) trend

Embeddedness is defined as the percent of a cobble surrounded or buried in fine sediment. A heavily embedded riffle section may be unsuitable for spawning. When constructing its redd, generally at a pool tail-out (i.e., the head of the riffle), the spawning fish uses its tail against the channel bottom to lift gravels and cover the eggs. This process results in piles of cleaner and more permeable gravel, which is more suited to nurturing of the eggs. Embedded gravels may not lift easily, which makes it difficult for fish to build their redds. Flosi et al. (1998) suggest that gravels that are less than 25% embedded are preferred for spawning.

Aquatic Insect Production

Target: improving trends in EPT Taxa, % dominant taxon and species richness indices
Benthic macroinvertebrate populations are greatly influenced by water quality and are often adversely affected by excess fine sediment. This TSD recommends calculation of several indices, following the CDFG Water Pollution Control Laboratory Stream Bioassessment Procedures (1999).

1. EPT Taxa. The EPT Taxa value 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 (EPA, 1999; Bjornn et al. 1997, in Bybee, 2000).

2. Percent Dominant Taxon. This index is calculated by dividing the number of organisms in the most abundant taxon by the total number of organisms in the sample. Collections dominated by one taxon 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.

Hydrologic Connectivity of Roads: ≤ 5%

Hydrologic connectivity of roads, defined as the proportion of road length draining to a stream, is chosen as an indicator of sediment yield. A hydrologically connected road increases the intensity, frequency, and magnitude of flood flows and suspended sediment loads in the adjacent stream, and can result in destabilization of the stream channel. Hydrologic connectivity is both an easily determined and easily correctable parameter that can result in immediate reductions in sediment yields associated with road surface erosion when corrected. Hydrologic connectivity can be reduced by outsloping roads, creating road drainage that mimics natural drainage as much as possible, and other factors (Weaver and Hagans, 1994). Hydrologic connectivity data from 20 miles of roads in the Fuller creek subwatershed collected by Pacific Watershed Associates showed hydrologic connectivity was 8%. The target value of 5% is Regional Water Board staff's best professional judgment of an achievable reduction in the proportion of road length draining to a stream, based on PWA's assessment and staff's observations in the same area of Fuller creek.

Stream Diversion Potential at Road Crossings: < 1%

Diversion potential is defined as the potential for a stream to be diverted down the road and out of its channel as a result of stream crossing capacity exceedance (Furniss et al, 1987; Weaver and Hagans, 1984). Like hydrologic connectivity, diversion potential is easily identifiable and correctable. This parameter is chosen as an indicator of sediment delivery hazard. Diversion potential in itself is not a sediment contributor, but its existence greatly elevates the consequences of stream crossing failure. The numeric target is the elimination of diversion potential at all stream crossings except those that cannot be corrected without compromising public safety, which are expected to comprise 1% or less of all stream crossings.

Stream Crossings with High Risk of Failure: ≤1%

Risk of stream crossing failure is related to the size and configuration of the crossing. The National Marine Fisheries Service stream crossing guidelines (NMFS, 2000) include a requirement that rural stream crossings have the hydraulic capacity to accommodate the 100-year flood flow. The hydraulic capacity of stream crossings is defined as the discharge corresponding to water levels at the top of the crossing inlet (HW/D=1). Flanagan et al. (1998) has described other factors that increase risk of failure such as culvert slope, width, and inlet basin configuration. The numeric target for stream crossings with high risk of failure is all stream crossings except those that cannot be corrected without compromising public safety, which are expected to comprise approximately 1% of all stream crossings.

6.8.2 Mid-Term Numeric Targets and Indicators

Mid-term targets are parameters that are not expected to be responsive until a decade or more after up-slope restoration activities have taken place. These targets address processes that are dependent on the frequency and magnitude of storm events, although it is assumed that the processes will be responsive to those events once restoration activities have been completed.

Turbidity: <20% above naturally occurring background levels

Turbidity is a measure of the ability of light to shine through water (higher turbidity indicating more material in the water that blocks 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 correlated with suspended sediment. High turbidity in the stream affects fish by reducing visibility, which may result in reduced feeding and growth. Turbidity can also reduce the primary productivity of a stream and, thus, affect the availability of food for fish. Elevated suspended sediment, particularly over a long period, may also result in direct physical harm, for example, by clogging gills.

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 storm flows, particularly during the winter, 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.

Turbidity: Decreasing trend in days of turbidity threshold exceedance

Excessive turbidity in streams can hinder the growth and rearing of young anadramous salmonids (Newcombe and Jensen, 1996; Sigler et al, 1984). 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. Therefore, the number of days per year in which a turbidity threshold is exceeded is an important indicator of the effects of turbidity on salmonids.

Sigler et al (1984) found that as little as 25 NTUs of turbidity caused a reduction in fish growth. As little turbidity monitoring has occurred in the Gualala River watershed, present turbidity levels and exceedance durations should be established before an exceedance threshold is defined.

In order to account for interannual variability in precipitation and discharge, a rolling ten-year average of exceedance days is suggested; a decreasing trend in this number will indicate the effectiveness of upslope restoration activities.

Suspended Sediment Concentration Rating Curve: Decreasing temporal trend

As described in Section 4.3.4, elevated levels of suspended sediment and turbidity in streams can be detrimental to salmonid growth and survival. Suspended sediment and turbidity levels are directly affected by 1) the amount of fine sediment that is entering a stream and 2) the storm event which causes flow such that fine sediment is mobilized. Fine sediment delivery can be caused by both natural and anthropogenic sources whose nature can be either episodic (e.g. landslides, crossing failures) or chronic (e.g. gullies, soil creep, roads). Storm events which mobilize fine sediment are episodic and will vary in intensity and duration. However, a reduction in anthropogenic sources of fine sediment delivery related to road fill failures, surface erosion, gully erosion, and stream crossing failures will lead to a decreasing trend over many years for the suspended sediment concentration and/or turbidity associated with a given exceedance probability flow. A decrease in suspended sediment concentration and/or turbidity associated with a given exceedance probability would show that fine sediment is being mobilized at decreasing levels, showing decreased stress on salmonids related to elevated suspended sediment concentration and/or turbidity.

For a stream where suspended sediment or turbidity monitoring has taken place, a rating curve that relates suspended sediment or turbidity to an exceedance probability can be developed based on the relationship between suspended sediment or turbidity to stream flowrate. This rating curve shows the likelihood of the exceedance of a given suspended sediment concentration or turbidity for a given site specific data set. Turbidity and/or suspended sediment rating curves should be developed and maintained to establish temporal trends for suspended sediment and/or turbidity concentrations. Activities likely to result in increasing turbidity over the 20% objective should be monitored and changes made through adaptive management in practices for which discharges do not comply with Basin Plan objectives.

V* ≤ 15%: Higher-Order Streams

The fraction of a pool's volume filled with fine sediment, V*, should be monitored in higher-order (> 3rd order) streams to evaluate the effectiveness of restoration efforts. This parameter is considered a mid-term target due to the amount of fine sediments currently existing in the channels of the Gualala River Watershed.

Residual Pool Depths: 2 feet for first and second order channels, 3 feet for higher order channels

Residual pool depth is defined as the maximum depth of a pool minus the maximum depth of its riffle crest (i.e. the depth of the pool at the point of zero flow). The numeric target for residual pool depth is an average of no less than two feet for first and second order channels and three feet for third order and greater channels. California Department of Fish and Game data indicates that the better Coho streams have as much as forty percent of their total length in these types of pools (Flosi et al. 1998).

Stream Crossing Failures: Decreasing Trend

The objective of this parameter is to assess to what degree stream crossing improvements are effective in reducing the delivery of sediments. Although high-risk stream crossings can be treated in a short time period, the effectiveness of those treatments will not be known until large storm events test their adequacy. Since large storm events are infrequent, it is unlikely that the effectiveness of stream crossing treatments can be assessed until at least a decade has passed.

Thalweg Variability: Increasing Trend

Variety and complexity in habitat are needed to support fish at different times in the year or at different times in their life cycles. Both pools and riffles are utilized by fish for spawning, incubation of eggs, and emergence of the fry. Once fry emerge, they rest in pools and other slower-moving water, darting into faster riffle sections to feed where insects are abundant. Deeper pools, overhanging banks, or logs provide cover from predators. Measuring the thalweg profile is an indicator of habitat complexity.

Thalweg variability is defined as the deviation of the thalweg (deepest part of the channel) from the average channel slope. It is chosen as a surrogate measure of channel complexity. More variability in the profile indicates more complexity in stream habitat. As the sediment load decreases and the frequency and depth of pools increases, the thalweg profile develops more dramatic variation around the mean profile slope. 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.

Annual Road Inspection and Correction: Increased length to 100%

Analysis by USEPA (EPA, 2000) indicates that in watersheds with road networks that have not experienced excessive 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). If not, they are potentially large sources of sediment (D. Hagans, personal comm., 1998, in EPA, 1998).

This target calls for an increase in the mileage of roads that are either one of the following: (1) inspected annually and maintained prior to winter, (2) hydrologically maintenance free, or (3) decommissioned or hydrologically closed, until all roads in the Gualala River watershed fall into one of these categories.

Road Location, Surfacing, Sidecast: Decreased road length next to stream, increased % of outsloped and hard surfaced roads

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. Other than ephemeral watercourses, 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. Road surfacing and use intensity directly influence sediment delivery from roads. Rock surfacing or paving is appropriate for frequently used roads. Sidecast 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, personal comm., 1998, in EPA, 1998).

This target calls for: (1) elimination of roads alongside inner gorge areas or in potentially unstable headwall areas, unless alternative road locations are unavailable and the road is clearly needed; (2) road surfacing, drainage methods, and maintenance appropriate to use patterns and intensities; and (3) stabilization or removal of sidecast or fill on steep (i.e., greater than 50%) or potentially unstable slopes that could deliver sediment to a watercourse.

Activity in Unstable Areas: 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 and include: steep slopes, inner gorges, headwall swales, stream banks, existing landslides, and other locations identified in the field. Because of the high risk of landsliding inherent in these features, any activity that might trigger an erosional event should be avoided, if possible. Such activities include road building, harvesting, yarding, terracing for vineyards, etc. 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 (EPA, 2000).

Disturbed Area: Decrease, or decrease in disturbance index

Studies in Caspar Creek (Lewis, 1998) indicate that there is a statistically significant relationship between disturbed areas and the corresponding suspended sediment discharge rate Lewis, 1998; J. Lewis personal comm. w/ A. Mangelsdorf, in NCRWQCB 2001). In addition, studies in Caspar Creek indicate that clearcutting causes greater increases in peak flows (and, by extension, increased suspended sediment loads) than does selective harvest Ziemer, 1998).

Available information is insufficient to identify a threshold below which effects on the Gualala River watershed would be insignificant. Accordingly, the target calls for a reduction in the amount of disturbed area or in the disturbance index. In this context, "disturbed area" is defined as the area covered by urban development or management-related facilities of any sort, including: roads, landings, skid trails, firelines, harvest areas, animal holding pens, and agricultural fields (e.g., pastures, vineyards, orchards, row crops, etc.). The definition of disturbed area is intentionally broad to include managed agricultural areas, such as pastures and harvest areas, where the management activity (e.g., logging or grazing) results in removal of vegetation sufficient to reduce significantly important rainfall interception and soil protection functions. Agricultural fields or harvest areas in which adequate vegetation is retained to perform these ecological functions can be excluded from consideration as disturbed areas. Dramatic reductions in the amount of disturbed area, then, can be made by reducing road densities, skid trail densities, clearcut areas, and other management-induced bare areas.

6.8.3 Long-Term Numeric Targets and Indicators

Long-term targets and indicators are for parameters that might not respond until decades after restoration activities have been accomplished. These parameters are dependent on infrequent hydrologic events that alter channel configurations and trigger mass wasting. As such, they are not expected to improve in the near future.

Large Woody Debris (LWD): Increasing distribution, volume and number of key pieces

California coastal streams are especially dependent on the presence of LWD to provide ecological functions, such as sediment metering and sorting, pool formation, and shelter. Large pieces of woody debris in streams influence the physical form of the channel, the movement of sediment, the retention of organic matter and the composition of the biological community (Bilby and Ward, 1989). LWD can be instrumental in forming and stabilizing gravel bars (Lisle, 1986), or in accumulating fine sediment, which keeps it from clogging spawning areas (Zimmerman et al. 1967, Megahan, 1982, in Bilby and Ward, 1989). LWD can also form pools by directing or concentrating flow in the stream in such a way that the bank or bed is scoured, or by impounding water upstream from the obstruction (Lisle and Kelsey, 1982, in Bilby and Ward, 1989). LWD plays a more significant role in routing sediment in small streams than in large ones (Bilby and Ward, 1989).

Proportion of Stream Length in Pools: 40%

Data and observations in the Gualala River watershed indicate that poor pool habitat may be a factor limiting rearing capacity. Deep and frequent pools are necessary summer rearing habitat for salmonids, particularly Coho. California Department of Fish and Game data indicates that the better Coho streams have as much as forty percent of their total length in primary pools (Flosi et al. 1998).

Road-Related Landslides: Decreasing Trend

Since road failures usually occur many years after roads are constructed and are often unpredictable, it is expected that the rate of road-related landslides is not likely to decrease until roads in problem areas are treated or decommissioned. Appropriate location, design, construction and maintenance of roads is expected to result in a reduction of the rate of road failures. However, the reduced rate of road failure is expected to lag improved practices by at least a decade or more.

CHAPTER 7
IMPLEMENTATION & MONITORING PLANS

As explained earlier in this document, the Gualala River Watershed TSD for Sediment is a technical support document , and is lacking implementation and monitoring plans. A TSD is a report developed by Regional Water Board staff which meets all federal requirements for a Total Maximum Daily Load (TMDL), but with no implementation or monitoring plan and no action on the part of the Regional or State Board. TSD is used to emphasize that the documents have not been through the Regional or State Board's public participation and adoption process. The Gualala River watershed TSD for Sediment will be transmitted directly to U.S. EPA upon completion by Regional Water Board staff.

While an implementation plan is not strictly a requirement of a TMDL, 40 CFR §130.6 requires a TMDL to be included in the State Water Quality Management Plan for the North Coast Region (Basin Plan). In order for the TMDL to be adopted into the Basin Plan, an implementation plan will be necessary. Therefore, implementation and monitoring plans must be established by the State at a later date.

Although the Regional Water Board has yet to adopt an implementation plan that applies to the Gualala River watershed, various activities to control anthropogenic sediment loading (or reduce its effects) have occurred or are underway. Some of the work described below has been funded with 319(h) grant funds administered by the Regional Water Board. The Regional Water Board also administers additional grant funds made available by proposition 13.

Recent efforts for restoration focus on watershed processes, such as stabilizing hillslopes and decreasing road-related erosion (Higgins, 1997). Pacific Watershed Associates (1996) conducted an inventory of road-related erosion sources for 25% of the Fuller Creek watershed. The study concluded that "nearly 22,000 cubic yards of eroded sediment will be delivered to the streams in the assessment area if corrective action is not undertaken, and nearly 17,000 cubic yards will come from the failure of stream crossings (PWA, 1996)." Landslides were found to be a minor source of future sediments to Fuller Creek. Erosion prevention measures associated with road improvements are currently being implemented in the Fuller Creek watershed.

Further erosion potential inventories were done on Louisiana Pacific holdings in Fuller Creek, as well as Coastal Forest Lands (now owned by Pioneer Resources, Ltd.) and will be implemented in the near future (D. Simmonds, pers. communication, 2001). Pioneer Resources, Ltd., has upgraded roads on its holdings in the Gualala River watershed in efforts to reduce road-related delivery. Ongoing road upgrades and related hillslope erosion control efforts are being carried out as part of mitigation for timber harvest plans (Higgins, 1997), but are not well documented.

As of early 2001, road assessments are also being conducted on 18 miles of Charles Ranch Road at the southern end of the Gualala River watershed. Implementation of 26 miles of road improvements for the McKenzie Creek subwatersheds are being planned for the end of 2001 or early 2002 (T. Osmer, pers. communication, 2001).

The Gualala River Watershed Council (GRWC) plans in the near future (fall 2001) to develop fuels management strategies for fire protection (T. Osmer, pers. communication, 2001). The goal of this project is to thin understory vegetation in the watershed to prevent catastrophic fire and associated massive sediment release to streams.

The Gualala Steelheaders, in cooperation with the land owner, Gualala Redwoods, Inc. (GRI), have attempted to restore large woody debris habitat in the North Fork Gualala, by installing log structures that span the stream to create pools and trap spawning gravels. GRI is currently conducting ongoing large woody debris restoration efforts throughout their lands, as well as road and upslope improvements (H. Alden, pers. communication, 2001).

CHAPTER 8
PUBLIC PARTICIPATION

Federal regulations require Total Maximum Daily Loads (TMDLs) be subject to public review (40 CFR §130.7). While the Gualala River Watershed Technical Support Document for Sediment is not, by itself, a TMDL, Regional Water Board staff provided for public participation through several mechanisms.

Meetings have been held with representatives of a number of stakeholder groups in the watershed, including the Gualala River Watershed Council (GRWC), timber companies, and vineyard interests. Staff have also made contact with local, state, and federal regulatory agency staff working in the watershed. A two-page description of the field measurement of random plots was included in a newsletter distributed by the GRWC in the spring of 2001. A more in-depth description of the random plot field measurements and a general description of how it fit into the 303(d) process was sent to over 90 landowners in the watershed. Also, staff were able to meet many landowners and discuss 303(d) issues while completing field work.

Regional Board staff plan to host a meeting in Gualala in the month of August to explain the methods used to develop the TSD and answer questions.

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GLOSSARY

Abandoned road	The designation of a road following use and completion of abandonment activities. These roads are left in a condition where no sediment sources remain and no maintenance of the road is required. These roads may be reconstructed and used for future land management activities.
Abandonment	The practice of closing a road, landing, skid trail or other facility so that regular maintenance is no longer needed and future erosion is largely prevented.
Aggradation	To fill and raise the elevation of the stream channel by deposition of sediment.
Agricultural facility	Any building, corral, pen, pasture, field, trail, or other feature on the landscape which is attributable to or associated with agricultural operations
Alevin	An alevin is a salmonid during a distinct life-cycle stage which begins from one to three months after egg fertilization. At this time, alevins emerge from eggs with yolk sacs and reside in the interstices of the gravel until they are ready to feed on macroinvertebrates in the water column. Alevins typically emerge from the gravel in one to five months as fry.
Alluvium	Clay, silt, sand, gravel, or similar material deposited by running water.
Anadromous	Refers to aquatic species which migrate up rivers from the sea to breed in fresh water.
Areas of instability	Locations on the landscape where land forms are present which have the ability to discharge sediment to a watercourse.
Baseline data	Data derived from field based monitoring or inventories used to characterize existing conditions and used to establish a database for planning or future comparisons.
Beneficial Use	Uses of waters of the state that may be protected against quality degradation including, but not limited to, domestic, municipal, agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and the preservation and enhancement of fish, wildlife and other aquatic resources or preserves.
Channel roughness	A numerical value used to describe the relative roughness of a stream channel in relationship to the size of particles on the stream bed. Roughness effects the turbulence of the stream flow.

Char	Small-scaled trout of the genus Salvelinus.
Class I	Watercourses which contain domestic water supplies, including springs, on site and/or within 100 feet downstream of the operation area and/or have fish always or seasonally present onsite, including habitat to sustain fish migration and spawning. Class I streams include historically fish-bearing streams.
Class II	Watercourses which have fish always or seasonally present offsite within 1000 feet downstream; and/or contain aquatic habitat for non-fish aquatic species. Class II waters do not include Class III waters that are directly tributary to Class I waters.
Class III	Watercourses which do not have aquatic life present, but show evidence of being capable of sediment transport to Class I and II waters under normal high flow conditions during and after completion of land management activities.
Class IV	Man-made watercourses, which usually supply downstream established domestic, agricultural, hydroelectric supply or other beneficial uses.
Colluvium	Loose rock material and soil accumulated at the foot of a slope.
Controllable source	Any source of sediment with the potential to enter a water of the State which is caused by human activity and will respond to mitigation, restoration, or altered land management.
Debris torrents	Long stretches of bare, generally unstable stream channel banks scoured and eroded by the extremely rapid movement of water-ladened debris, commonly caused by debris sliding or road stream crossing failure in the upper part of a drainage during a high intensity storm.
Decommission	See obliteration.
Deep seated landslide	Landslides involving deep regolith, weathered rock, and/or bedrock, as well as surficial soil. Deep seated landslides commonly include large (acres to hundreds of acres) slope features and are associated with geologic materials and structures.
Ditch relief	A drainage structure which will move water from an inside road ditch to an outside area, beyond the outer edge of the road fill. Ditch relief structures can include culverts, rolling dips, and/or water bars. Ditches are adequately relieved when there is no downcutting of the inside ditch or gully erosion at the outlet of the relief structure.
Drainage structure	A structure or facility constructed to control road runoff. These structures include but are not limited to fords, inside ditches, water bars, outsloping, rolling dips, culverts, or ditch drains.
Flooding	The overflowing of water onto land that is normally dry.

Fry	A young juvenile salmon after it has absorbed its egg sac and emerged from the redd.
Headwater swale	The swale or dip in the natural topography that is upslope from a stream, at its headwater. There may or may not be evidence of overland or surface flow of water in the headwater swale.
Interstices	The space between particles (e.g. space between sand grains).
Inner gorge	A geomorphic feature formed by coalescing scars originating from mass wasting and erosional process caused by active stream erosion. The feature is identified as that area of stream bank situated immediately adjacent to the stream, having a slope generally over 65% and being situated below the first break in slope above the channel.
Inside ditch	The ditch on the inside of the road, usually at the foot of the cutbank.
Landslide	Any mass movement process characterized by downslope transport of soil and rock, under gravitational stress by sliding over a discrete failure surface, or the resultant landform.
Large woody debris	A piece of woody material having a diameter greater than 30 cm (12 inches) and a length greater than 2 m (6 feet) that is located in a position where it may enter the watercourse channel.
Mass wasting	Downslope movement of soil mass under the force of gravity - often used synonymously with "landslide." Common types of mass soil movement include rock falls, soil creep, slumps, earthflows, debris avalanches, debris slides and debris torrents.
Maximum Weekly Average Temperature (MWAT)	The maximum value of the mathematical mean of multiple, equally spaced, daily temperatures over a seven day consecutive period. In other words, this is the highest value of the seven day moving average of temperature. Brungs and Jones (1977) calculate MWAT for the growth phase of fish life using the following equation: $\text{MWAT for growth} = \text{OT} + (\text{UUILT} - \text{OT}) / 3$ where OT is the physiological optimum temperature and UUILT is the ultimate upper incipient lethal temperature.
Numeric targets	A numerical expression of the desired instream environment. A numeric target is developed based on the numeric or narrative State water quality standards which are needed to recovered the impaired beneficial use.
Obliterated road	The designation of a road following use and completion of decommission activities. These roads are left in a condition where hillslope drainage is returned to its natural drainage pattern and no slope stability hazards remain. These roads will not be reconstructed and used for future land management activities.

Obliteration	To remove those elements of a road, landing, skid trail, or other facilities that unnaturally reroute hillslope drainage or present slope stability hazards.
Permanent drainage structure	A road drainage structure designed and constructed to remain in place following active land management activities while allowing year round access on a road.
Permanent road	A road which is planned and constructed to be part of a permanent all-season transportation system. These roads have a surface which is suitable for hauling forest and ranch products throughout the entire winter period and have drainage structures, if any, at watercourse crossings which will accommodate the fifty-year flood flow, including debris. Permanent roads receive regular and storm period inspection and maintenance.
Primary Pools	In first and second order streams, a primary pool is defined to have a maximum depth of at least two feet, occupy at least half the width of the low-flow channel, and be as long as the low-flow channel width. In third and forth order streams, the criteria is the same, except maximum depth must be at least three feet. DFG habitat typing data indicate the better coastal coho streams may have as much as forty percent of their total habitat length in primary pools.
Redd	A gravel nest or depression in the stream substrate formed by a female salmonid in which eggs are laid, fertilized and incubated.
Riparian Management Zone (RMZ)	The strip of land along both sides of a watercourse where conservation measures are required for the protection of water quality and beneficial uses of water, fish and riparian habitat and for controlling erosion.
Rolling dip	A shallow, rounded dip in the road where the road grade reverses for a short distance and the surface runoff is directed in the dip or trough to the outside or inside of the road. Rolling dips are drainage facilities constructed to remain effective while allowing passage of motor vehicles at reduced road speed.
Seasonal road	A road which is planned and constructed as part of the permanent transportation system where most hauling and heavy use may be discontinued during the winter period and whose use is restricted to periods when the surface is dry. Most seasonal roads are not surfaced for winter use, but have a surface adequate for hauling of forest and ranch products in the non-winter period, and in the extended dry periods or hard frozen conditions occurring during the winter period. Seasonal roads have drainage structures at watercourse crossings which will accommodate the fifty-year flood flow and associated debris.

Sediment	Fragmented material that originates from weathering of rocks and decomposed organic material that is transported by, suspended in, and eventually deposited by water or air.
Sediment budget	An accounting of the sources, movement, storage and deposition of sediment produced by a variety of erosional processes, from its origin to its exit from a basin.
Sediment delivery	Process by which material (usually referring to sediment) is delivered to a watercourse channel by wind, water or direct placement. It is a function of the soils, slope, rainfall, soil disturbance, amount of water flowing across the site from upslope, and the filtering effect of soils and vegetation as sediment travels downslope.
Sediment discharge	The mass or volume of sediment (usually mass) passing a watercourse transect in a unit of time.
Sediment erosion	The group of processes whereby sediment (earthen or rock material) is loosened, dissolved and removed from the landscape surface. It includes weathering, solubilization and transportation.
Sediment source	The physical location on the landscape where earthen material resides which has or may have the ability to discharge into a watercourse.
Sediment yield	The sediment yield consists of dissolved, suspended, and bed loads of a watercouse channel through a given cross-section in a given period of time.
Sensitive areas	Any area, particularly in the riparian zone, which when altered by land management activities results in a loss or reduction in ecological functioning.
Shallow seated landslide	A landslide produced by the failure of the soil mantle (typically to a depth of one or two meters, sometimes includes some weathered bedrock), on a steep slope. It includes debris slides, soil slips and failure of road cut-slopes and sidecast. The debris moves quickly (commonly breaking up and developing into a debris flow) leaving an elongated, concave scar.
Sidecast	The excess earthen material pushed or dumped over the side of roads and landings.
Skid trail	Constructed trails or established paths used by tractors or other vehicles for skidding logs. Also known as tractor roads.
Smolt	A young salmon at the stage at which it migrates from fresh water to the sea.

Steep slope	A hillslope, generally greater than 50% that leads without a significant break in slope to a watercourse. A significant break in slope is one that is wide enough to allow the deposition of sediment carried by runoff prior to reaching the downslope watercourse.
Stocking	A measure of the degree to which space is occupied by well-distributed countable trees.
Stream	See watercourse.
Stream class	The classification of waters of the state, based on beneficial uses, as required by the Department of Forestry in Timber Harvest Plan development. See definitions for Class I, Class II, Class III, and Class IV for more specific definitions.
Stream order	The designation (1,2,3, etc.) of the relative position of stream segments in the drainage basin network. For example, a first order stream is the smallest, unbranched, perennial tributary which terminates at the upper point. A second order stream is formed when two first order streams join. Etc.
Subwatershed	A subset or division of a watershed into smaller hydrologically meaningful Watersheds. For example, the North Fork Navarro River is a subwatershed of the larger Navarro River watershed.
Swale	A channel-like linear depression or low spot on a hillslope which rarely carries runoff except during extreme rainfall events. Some swales may no longer carry surface flow under the present climatic conditions.
Temporary drainage structure	A road drainage structure designed and constructed to allow access during active land management activities. The temporary structure will be removed following active land management.
Thalweg	The deepest part of a stream channel at any given cross section.
Thalweg profile	Change in elevation of the thalweg as surveyed in an upstream-downstream direction against a fixed elevation.
Timber Harvest Plan	A plan, prepared by a registered professional forester and submitted to the California Department of Forestry for approval, which provides specific information regarding commercial timber operations to be undertaken by a landowner.

Unstable areas	Characterized by slide areas, gullies, eroding stream banks, or unstable soils. Slide areas include shallow and deep seated landslides, debris flows, debris slides, debris torrents, earthflows and inner gorges and hummocky ground. Unstable soils include unconsolidated, non-cohesive soils and colluvial debris.
V*	A numerical value which represents the proportion of fine sediment that occupies the scoured residual volume of a pool.
Watercourse	Any well-defined channel with a distinguishable bed and bank showing evidence of having contained flowing water indicated by deposit of rock, sand, gravel, or soil.
Watercourse & lake protection zone	As used in the Forest Practice Rules, the strip of land, along both sides of a watercourse or around the circumference of a lake or spring, where additional practices may be required for the protection of the quality and beneficial uses of water, fish and riparian wildlife habitat, other forest resources and for controlling sediment.
Waters of the state	Any surface water or groundwater, including saline water, within the boundaries of the state.
Watershed	Total land area draining to any point in a watercourse, as measured on a map, aerial photo or other horizontal plane. Also called a basin, drainage area, or catchment area.
Water quality objective	Limits or level of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area.
Water quality standard	Consist of the beneficial uses of water and the water quality objectives as described in the Water Quality Control Plan for the North Coast Region.
Yarding	The movement of forest products from the point of felling to a landing

PLATES