California Regional Water Quality Control Board
North Coast Region

Noyo River Watershed
Total Maximum Daily Load
for Sediment

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Submitted by:

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EXECUTIVE SUMMARY

The Noyo River watershed is a forested, coastal watershed in Mendocino County, California that encompasses approximately 113 square miles (72,323 acres). Its logging history dates back to 1853 when the first water-powered mill was built in the lower Noyo River. Old growth logging continued into the early part of the 20th century. Second growth logging began in the 1960s, primarily in the lower main drainage area, and continues today. Removal of residual old-growth stands began in the 1960s and continued into the mid-1980s (Marc Jameson, CDF, 1999, pers. comm.). The California Western Railroad operates the Skunk Train that traverses the Noyo River watershed along the mainstem channel. Other minor land uses found in the basin include ranching and recreation.

The purpose of the Noyo River Watershed Total Maximum Daily Load for sediment (TMDL) is to identify sediment loading allocations that, when implemented, are expected to result in the attainment of the applicable water quality standards for sediment, including the protection of beneficial uses. The primary beneficial use of concern in the Noyo River watershed is the salmonid fishery, particularly the coho salmon (*Oncorhynchus kisutch*) fishery.

A. Section 303(d) of the Clean Water Act and the Noyo River watershed

The Noyo River watershed has been placed on the 303(d) list as required by Section 303(d) of the Clean Water Act (CWA). This list describes water bodies that do not fully support all beneficial uses or are not meeting water quality objectives. It also describes the pollutant(s) for each water body that limit(s) its use or prevent(s) attainment of its water quality objectives. As required by CWA Section 303(d), pollutant loading allocations must be developed for water bodies on the 303(d) list. For the Noyo River watershed, the listing was the result of water quality problems related to sedimentation throughout the watershed. Sedimentation was determined to be impacting the cold water fishery, a beneficial use of the Noyo River watershed, including the migration, spawning, reproduction, and early development of cold water fish such as coho salmon and steelhead trout. Cold freshwater and estuarine habitats are also designated beneficial uses of the Noyo River watershed.

B. Components of the TMDL

The TMDL includes, among other things:

- Problem statement
- Source analysis
- Linkage analysis
- Numeric targets
- Load allocation(s)

Problem Statement

The problem statement includes an assessment of existing in-stream conditions. The watershed is divided into four assessment areas, including: the Headwaters Assessment Area, North Fork Noyo River Assessment Area, South Fork Noyo River Assessment Area, and Mainstem Noyo River Assessment Area. Historically, salmonids have been found in each of the assessment areas. Salmonid populations appear to have declined in recent years, quantitatively demonstrated by data from the egg-taking station in the South Fork Noyo River Assessment Area. Pool frequency, pool depth, the quantity of large woody debris and the availability of other forms of shelter (particularly from high winter flows) appear to be factors currently limiting the success of salmonids (especially coho salmon) throughout the watershed. In addition, the data indicate that cobble may be too embedded and the substrate composed of too many fines for successful spawning and fry emergence in each of the assessment areas.

Source Analysis

The source analysis includes an assessment of sources of sediment historically and/or presently impacting water quality. Several factors have contributed to the increase of sediment delivery above background delivery rates throughout the watershed. They include: high rates of timber harvest, a strong reliance on ground-based yarding methods (particularly in the Headwaters and North Fork Noyo River Assessment Areas), and high road densities. These factors have led to an increase in the rates of sediment delivery due to management-related landsliding, fluvial erosion, and surface erosion. For the purpose of this assessment, background rates of sediment are those rates estimated for the period prior to 1958 and the advent of large-scale tractor yarding. Background rates of sediment delivery are thus influenced by historic land management practices (e.g., turn-of-the-century old growth logging) and are not considered to be entirely "natural."

Linkage Analysis

The linkage analysis provides the basis for the magnitude of upslope controls necessary to attain water quality standards and protect the beneficial uses. The linkage analysis compares the estimate of sediment delivery in the 1933-1957 ("background") period to that of the 1979-1999 (Forest Practice Rules) period. Upslope sediment delivery reduction requirements are developed based on the qualitative information that the 1933-1957 period represents a period of relative salmonid abundance.

Numeric Targets

The numeric targets interpret water quality standards and provide indicators of watershed health. In particular, they reflect in-stream conditions presumed to be suitable for the successful migration, spawning, rearing, and over-wintering of salmonids in the fresh water environment. Other targets are included which indicate successful upslope management. The indicators and targets identified in Table 1.

Table 1: Summary of numeric and other targets

Indicator	Target	References
Turbidity	≤ 20% above background	Basin Plan, 1994; Reid, 1999
% fines <0.85 mm	≤14% (mean) as wet volume	Burns, 1970; CDF, 1994
Embeddedness	Increasing percentage of riffle habitat units that are less than 25% embedded	Flosi, et al., 1993; DFG 1995 (a) and (b)
Pool frequency/depth	≥40% of habitat length in pools greater than 3 feet in depth	Flosi, et al., 1993; Flosi, personal communication
V*	≤0.27 (mean)	Knopp, 1993
Backwater pools	Increasing percentage of backwater pools per habitat length	Deitrich, 1998
Large woody debris	Increase in the number and volume of key pieces of large woody debris per stream length	Bilby, et al., 1989; Beechie, et al., 1997; USDA, 1994
Thalweg profile	Increasing variation in thalweg elevation around the mean thalweg slope	Trush, 1999; Madej, 1999
Stream crossings with diversion potential	≤ 1% of all stream crossings, as a result of a storm with a 100-year recurrence interval or less	Weaver, et al., 1994; Danny Hagans, PWA, 1997, pers. comm.
Stream crossings with significant crossing failure potential	≤ 1% of all stream crossings, as a result of a storm with a 100-year recurrence interval or less	Flanagan, et al., 1998
Hydrologic connectivity	Decrease in the miles of road hydrologically connected to a watercourse	Ziemer, 1998; Furniss, 1999
Disturbed area	Decrease in the area disturbed by facilities [+]	Lewis, 1998
Activity in unstable areas	No activities (e.g., roads, harvest, yarding, etc.) in unstable areas (e.g., steep slopes, headwall swales, inner gorges, streambanks, etc.) unless a detailed geological assessment is performed that shows there is no potential for increased sediment delivery to a watercourse as a result.	Dietrich, et al., 1998; Weaver, et al., 1994; Pitlick, 1982; Pacific Watershed Associates, 1998

[+]A facility is defined as any management-related structure such as a road, railroad roadbed, skid trail, landing, harvest unit, animal holding pen, or agricultural field (e.g., pasture, vineyard, orchard, row crops). For the purpose of this target, a harvest unit or agricultural field that retains its natural characteristics with respect to rainfall interception, rainfall infiltration, and soil protection, is not considered a "facility."

Load Allocations

The load allocation(s) are the assignment of sediment loads to individual land use activities necessary to attain water quality standards and protect beneficial uses. The load allocations are assigned not as rates of sediment delivery, but as percent reductions in existing rates of management-related sediment delivery. Existing rates of management-related sediment delivery should be determined via a baseline survey conducted by landowners or their representatives, in the field. Specific load allocations are developed for each of the four assessment areas. The load allocations include consideration of the differences in management practices among the assessment areas and through time. Aggregated, the load allocations will result in an overall reduction in sediment delivery of management-related sediment delivery of 68% (including a 14% margin of safety). This is based on reductions in management-related sediment delivery from each of the assessment areas, as follows:

Headwaters Assessment Area:
- 82% reduction in sediment delivery due to mass wasting from roads
- 90% reduction in sediment delivery due to fluvial erosion from roads (including the railroad)
- 73% reduction in sediment delivery due to surface erosion from roads

North Fork Noyo River Assessment Area:
- 82% reduction in sediment delivery due to mass wasting from roads
- 90% reduction in sediment delivery due to fluvial erosion from roads
- 76% reduction in sediment delivery due to surface erosion from roads

South Fork Noyo River Assessment Area:
- 90% reduction in sediment delivery due to fluvial erosion from roads (including the railroad)
- 70% reduction in sediment delivery due to surface erosion from roads

Mainstem Noyo River Assessment Area:
- 75% reduction in sediment delivery due to mass wasting from roads
- 90% reduction in sediment delivery due to fluvial erosion from roads (including the railroad)
- 78% reduction in sediment delivery due to surface erosion from roads
- 25% reduction in sediment delivery due to mass wasting from the railroad
- 53% reduction in sediment delivery due to mass wasting from harvest areas

C. Data Sources

Regional Water Board staff conducted an assessment of existing data with contract assistance from Graham Matthews and John Coyle and Associates through a subcontract with Tetra Tech, Inc. and the U.S. Environmental Protection Agency. Data were supplied by many sources. The primary sources were: the Department of Fish and Game, the Department of Forestry and Fire Protection, Mendocino Redwoods Company, and the U.S. Geologic Survey.

CHAPTER I
INTRODUCTION

The Noyo River watershed is a forested, coastal watershed in Mendocino County, California which encompasses approximately 113 square miles (i.e., 72,323 acres) immediately west of Willits flowing through the coastal range and out to the Pacific Ocean at Fort Bragg. Its logging history dates back to 1853 when the first water-powered mill was built in the lower Noyo River. Old growth logging continued into the early part of the 20th century. Second growth logging began in the 1960s, primarily in the lower main drainage area, and continues today. Removal of residual old-growth stands began in the 1960s and continued into the mid-1980s (Marc Jameson, CDF, 1999, pers. comm.). The California Western Railroad operates the Skunk Train that traverses the Noyo River watershed along the mainstem channel. Other minor land uses found in the basin include ranching and recreation.

The primary purpose of the Noyo River Watershed Total Maximum Daily Load for Sediment (TMDL) is to identify sediment loading allocations that, when implemented, are expected to result in the attainment of the applicable water quality standards for sediment, including the protection of beneficial uses. The primary beneficial use of concern is the salmonid fishery, particularly the coho salmon (*Oncorhynchus kisutch*) fishery.

I.A Location of the Noyo River watershed

The Noyo River watershed is a moderately-sized coastal watershed with a logging history dating back to the 1850s. Approximately 19% of the basin is owned and managed by the California Department of Forestry and Fire Protection as a demonstration forest. The Noyo River watershed is unique to Mendocino County with respect to the large percent of it in public ownership (see Figure 3). Other major owners in the basin include the Mendocino Redwood Company (primarily in the upper watershed) and The Timber Company (primarily along the mainstem). There are numerous other small and moderately-sized timber operations in the basin, as well as a cattle ranch, summer camp, seasonal and year-round homes, the railroad, and other miscellaneous activities. (See Figure 1).

I.B Application of Section 303(d) of the Clean Water Act to the Noyo River watershed

The Noyo River watershed has been placed on the 303(d) list as required by Section 303(d) of the Clean Water Act (CWA). This list describes water bodies that do not fully support all beneficial uses or are not meeting water quality objectives and describes the pollutants for each water body that limit its use or prevent attainment of its water quality objectives. Water quality objectives and beneficial uses are identified for all of the water bodies in the North Coast Region in the *Water Quality Control Plan for the North Coast Region* (the Basin Plan). As required by CWA Section 303(d), pollutant loading allocations must be prepared for waterbodies on the 303(d) list. As stated above, the Noyo River watershed was listed due to water quality problems related to sedimentation. Sedimentation was presumed, upon listing, to be associated, in part, with management-related activities. Sedimentation was determined to be impacting the cold water fishery, a beneficial use of the Noyo River watershed, including the migration, spawning, reproduction, and early development of cold water fish such as coho salmon and steelhead trout. Cold freshwater and estuarine habitats are also designated uses of the Noyo River watershed.

This analysis demonstrates that management-related activities have contributed to an increase in sediment delivery to the Noyo River watershed. It also demonstrates that existing salmonid habitat is limited by various erosion-influenced factors, including infrequent and shallow pools, few backwater pools and other overwintering habitat, embedded cobble, and elevated fines in potential spawning gravels. The analysis also concludes that the limited availability of large woody debris in the channels of Noyo River watershed contribute to the noted problems associated with sedimentation.

I.C Data sources

Regional Water Board staff conducted an assessment of existing data with contractor support from Graham Matthews and associates through a subcontract with Tetra Tech, Inc. and the U.S. Environmental Protection Agency. Data were provide by many sources. The primary sources of data were: the Department of Fish and Game (DFG), the Department of Forestry and Fire Protection (CDF), and Mendocino Redwood Company (MRC), and the U.S. Geological Survey (USGS). DFG provided historic aquatic surveys. CDF provided Timber Harvest Plan (THP) data. MRC provided fish distribution and aquatic habitat data. USGS provided stream flow and topographic data.

I.D Components of a TMDL

The requirements of a TMDL are described in 40 CFR 130.2 and 130.7 and Section 303(d) of the CWA, as well as in various guidance documents (e.g., U.S. EPA, 1991). A TMDL is defined as “the sum of the individual waste load allocations for point sources and load allocations for non-point sources and natural background” (40 CFR 130.2) such that the capacity of the water body to assimilate pollutant loadings (the loading capacity) is not exceeded. That is,

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

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

This TMDL includes:

- Problem statement
- Source analysis
- Linkage analysis
- Numeric Targets
- Load allocation
- Discussion of the margin of safety and annual and seasonal variation
- Discussion of implementation, monitoring, and the time frame associated with implementation of the TMDL
- Discussion of public participation

The problem statement includes an assessment of existing in-stream and upslope conditions. The source analysis includes an assessment of sources of sediment historically and/or presently impacting water quality. The linkage analysis provides the basis for the magnitude of upslope controls necessary to attain water quality standards and protect the beneficial uses. The numeric targets interpret water quality standards and provide indicators of watershed health. The load allocation(s) are the assignment of sediment loads to land use activities in individual assessment areas necessary to attain water quality standards and protect beneficial uses. 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. Seasonal variation in erosion and sediment delivery requires consideration of seasonal affects in the implementation of the load allocation(s). A discussion of considerations for the future development of an implementation plan and monitoring plan is included, as well as a discussion of the schedule for implementing the TMDL. And, a discussion of public participation is included.

CHAPTER II
EXISTING WATER QUALITY REQUIREMENTS

Existing water quality requirements are described in *the Water Quality Control Plan, North Coast Region-- Region 1* (Basin Plan). The North Coast Region includes all of the watersheds draining into the Pacific Ocean from the California-Oregon state line southerly to the southerly 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 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 water 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 intended to protect the identified beneficial uses. Further, the Basin Plan includes implementation plans that describe the means by which specific water quality issues will be addressed by the Regional Water Board.

II. A Beneficial uses

In addition to municipal, industrial, and recreational uses of the Noyo River, the Basin Plan identifies the following other existing beneficial uses of water for the watershed:

- Commercial and sport fishing (COMM)
- Cold freshwater habitat (COLD)
- Migration of aquatic organisms (MIGR)
- Spawning, reproduction, and early development (SPWN)
- Estuarine habitat (EST)

The beneficial uses identified above (e.g., COMM, COLD, MIGR, SPWN, and EST) are all related to the Noyo River watershed’s cold water fishery. The cold water fishery appears to be the most sensitive series of beneficial uses 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).

II. B Water quality objectives

The sediment-related water quality objectives included in the Basin Plan to protect the beneficial uses of the Noyo River watershed include:

- Suspended material
- Settleable material
- Sediment
- Turbidity

The water quality objectives (WQO) for these four constituents are narrative. For suspended material, the WQO states: "Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses." For settleable material, the WQO states: "Waters shall not contain substances in concentrations that result in deposition of material that causes nuisance or adversely affect beneficial uses." For sediment, the WQO states: "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." The WQO for turbidity states: "Turbidity shall not be increased more than 20 percent above naturally occurring background levels. Allowable zones of dilution within which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof."

In addition to the water quality objectives, the Basin Plan includes two discharge prohibitions specifically applicable to logging, construction and other associated activities. These are included in the action plan for these activities. They 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."

II. C Summary

Existing data generally support the conclusion that the habitat necessary to support coho salmon in the Noyo River watershed is degraded, in part due to the increase in sediment delivery above background rates which is attributable to management activities, including: logging, road building, the railroad, and in-stream woody debris removal. The data set does not include, in sufficient quantity, measurements of suspended materials, settleable materials, suspended sediment discharge rates, and turbidity from which to directly assess water quality conditions with respect to the water quality objectives. However, the data set does include data for other, related parameters in sufficient quantity to infer "adverse effect" and the causes of those effects. The available data are presented in Chapter III (Problem Statement).

CHAPTER III
PROBLEM STATEMENT

This chapter summarizes the life cycle of the coho salmon (*Oncorhynchus kisutch*), outlines the freshwater habitat factors that influence the success of coho salmon, and discusses the data that exist for the Noyo River watershed from which certain inferences can be made with respect to the problems currently facing coho salmon. The data currently available for the Noyo River watershed may not be all of the data collected in the basin; it is all of the 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 have been made regarding the factors that are potentially limiting coho salmon in the basin. The discussion in Chapter V (Numeric and Other Targets) is based on the problems identified in this analysis. Should additional data be made available in the future that improves upon this analysis, the TMDL can be modified, including modifications to the numeric targets.

III.A General background

<u>Coho salmon life cycle</u>
Salmonids are anadromous fish that live part of their lives in freshwater and part in the ocean. The species of focus in this TMDL is the coho salmon (*Oncorhynchus kisutch*) which has been listed by the National Marine Fisheries Service as a threatened species along much of the California coast, including that in Mendocino County. Coho salmon generally return from the ocean to spawn in freshwater at the age of 3 years. In California, this typically occurs during the months of December and January. Once eggs are laid and fertilized, the incubation period usually lasts from 35 to 50 days. Coho fry emerge from their gravel nests from early March to mid-May. The fry first congregate along stream margins, in shallow pools and in backwaters and eddies. They develop into parr (juveniles), eventually seek out deeper pools, and become aggressive and territorial. California coho generally remain in freshwater for 1 to 2 years before migrating to the ocean (CDF, 1994).

Sometime in April or May, when temperatures are rapidly warming, one- to two-year old coho salmon parr begin their migration downstream to the estuary where they under go "smoltification." Smoltification is the process in which parr undergo certain physiological transformations that will allow them to survive in the saline environment of the ocean. The coho feed and grow in the ocean until they return to their natal stream for spawning (CDF, 1994).

<u>Potentially limiting factors</u>
As described by CDF (1994), the success of salmonids depends on many factors, including:

- Unimpeded access to spawning gravels

- Cool stream temperatures (i.e., 4.4 to 9.4 °C for spawning and 4.4 to 13.3 °C for embryo incubation)
- Adequate dissolved oxygen levels in the water column (>6.3 mg/l for spawning)
- Availability of appropriately sized spawning gravels with few fines (i.e., < 5% fines for high fry emergence, <15% fines to avoid a sharp drop off in emergence success).
- Adequate dissolved oxygen levels in the redds[1] (≥ 8 mg/l for high embryo survival and fry emergence)
- Adequate food (Young fish feed on drifting terrestrial and aquatic insects. Older fish also feed on other salmonid fry. Insect production is a function of substrate composition, riffles, and riparian vegetation).
- Adequate cover as protection from predators
- Protection from winter and spring freshets, including adequate availability of deep pools, backwater pools, and in-stream and bank cover

The Department of Fish and Game suggests that shelter ratings (described by Flosi, et al., 1993) should be at least 100 to provide adequate shelter for coho. Further, they suggest that good coho streams in California have 40% of their habitat length[2] in primary pools. Primary pools are defined for 3rd and 4th order[3] streams as those that are at least 3 feet deep.

Limitations in any of these factors can potentially limit the success of coho salmon. It should be clear, however, that in addition to freshwater habitat conditions, coho success also depends on ocean conditions, climate, disease cycles, and other controllable and uncontrollable factors.

III. B Description of the Noyo River Watershed

The Noyo River watershed is a forested, coastal watershed in Mendocino County that encompasses approximately 113 square miles (i.e., 72,323 acres) immediately west of Willits flowing through the coastal range and out to the Pacific Ocean at Fort Bragg. It has been divided into four assessment areas for the purpose of reviewing and assessing in-stream and upslope data. Those assessment areas are: Headwaters Assessment Area (HAA), North Fork Noyo River Assessment Area (NFAA), South Fork Noyo River Assessment Area (SFAA) and Mainstem Noyo River Assessment Area (MAA). The Mainstem Noyo River Assessment Area as defined in the TMDL combines the Middle

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[1] A redd is a gravel nest or depression in the stream substrate formed by a female salmonid in which eggs are laid, fertilized and incubated.

[2] A habitat inventory, as described by Flosi, et al., 1993, includes the identification of individual habitat units (e.g., pool, riffle, or flatwater) that are further defined by their origin and/or orientation (e.g., backwater pool, boulder-formed). The entire length of stream surveyed is the habitat length. A basin-level habitat inventory is designed to produce a thorough description of the physical fish habitat.

[3] Stream order is based on the relative position of stream segments in the drainage basin network. For example, a first order stream is the smallest, unbranched, perennial tributary that terminates at the upper point. A second order stream is formed when two first order streams joined, and so forth.

Noyo and Lower Noyo Planning Watersheds, as defined by Matthews (1994). (See Figure 2).

The assessment area boundaries were chosen because: 1) they result in areas of roughly the same geographic size; 2) they delineate hydrologic sub-basins; 3) they roughly delineate areas of differing rainfall intensities; and 4) they represent varying land management histories.

Headwaters Assessment Area

HAA is composed of 17,390 acres or 27.17 mi^2, including the California Department of Forestry and Fire Protection's (CDF) Planning Watershed numbers 113.20010, 113.20011, 113.20012. It is located at the upper end of the basin, immediately west of the city of Willits and includes the upper Noyo River, Olds Creek, McMullen Creek and Redwood Creek. It is primarily underlain by Coastal Belt Franciscan geology; though, it also includes some Franciscan Melange at the upper end of the Noyo River main stem and Olds Creek. A thrust fault separates the Coastal Belt Franciscan from the Franciscan Melange. The headwaters is mapped with large translational/rotational slides and earth flows (DMG, 1984). The average annual rainfall is approximately 65 inches, which falls primarily between October and April (Matthews, 1999). Mendocino Redwood Company is the largest landowner in HAA.

North Fork Noyo River Assessment Area

NFAA is composed of 16,045 acres or 25.07 mi^2, including CDF's Planning Watershed numbers 113.20013, 113.20014, and a portion of 113.20015. It is located at the upper end of the basin, immediately northwest of the city of Willits and includes the North Fork Noyo River, the Middle Fork of the North Fork Noyo River, Hayworth Creek, and the North Fork of Hayworth Creek. NFAA is primarily underlain by Coastal Belt Franciscan geology. Many of the tributaries to the North Fork Noyo River and Hayworth Creek are mapped with steep inner gorges. Similarly, the upper reaches of nearly all the streams in this assessment area are mapped with large translational/rotational slides, earth flows, and numerous debris slides (DMG, 1982). NFAA has an average annual rainfall of approximately 65 inches, which falls primarily between October and April (Matthews, 1999). Mendocino Redwood Company is the largest landowner in NFAA.

South Fork Noyo River Assessment Area

SFAA is composed of 17,575 acres or 27.46 mi^2, including CDF's Planning Watershed numbers 113.20030, 113.20031, and 113.20033. It is located near the lower end of the basin, immediately southeast of the city of Fort Bragg and includes the South Fork Noyo River, Parlin Creek, the North Fork of the South Fork Noyo River, and Kass Creek. SFAA is primarily underlain by Coastal Belt Franciscan geology. Kass Creek, the North Fork of the South Fork and some of the South Fork Noyo River and Parlin Creek are all mapped with steep inner gorges. The North Fork of the South Fork Noyo River is also mapped with extensive debris slide amphitheaters, as are various small tributaries throughout SFAA (DMG, 1982). SFAA has an average annual rainfall of approximately 50 inches that fall primarily between October and April (Matthews, 1999). CDF is the largest landowner in SFAA.

Mainstem Noyo River Assessment Area

MAA is composed of 21,314 acres or 33.30 mi^2, including CDF's Planning Watershed numbers 113.20015 (partial), 113.20020, 113.20021, and 113.20040. It is located in the middle of the basin, between the cities of Fort Bragg to the west and Willits to the east. It is primarily underlain by Coastal Belt Franciscan geology with the exception of Marine Terrace Deposits and Beach Deposits along the coast (DMG, 1983). Much of the Noyo River mainstem and its smaller tributaries are mapped with steep inner gorges from Northspur (at the confluence of the North Fork Noyo River and the mainstem) to the west. Similarly, the upper reaches of nearly all the streams in the upper reaches of this assessment area are mapped with large translational/rotational slides, earth flows, and numerous debris slides, including reaches of the mainstem Noyo River (DMG, 1982). The average annual rainfall ranges from 40 inches at the coast to 55 inches further inland (Matthews, 1999). It falls primarily between October and April. MAA includes the mainstem Noyo River, Duffy Gulch, the Little North Fork Noyo River, and the lower estuary. The Timber Company is the largest landowner in MAA.

III.C Summary of findings for the Noyo River Watershed overall

Salmonid abundance

Brown, et al. (1994) reports that coho salmon previously occurred in as many as 582 California streams from the Smith River near the Oregon border to the San Lorenzo River on the central coast. There are now probably less than 5,000 native coho salmon spawning in California each year, many in populations of less than 100 individuals. Coho populations today are probably less than 6% of what they were in the 1940s and there has been at least a 70% decline since the 1960s. Brown, et al. (1994) conclude that the reasons for the decline of coho salmon in California include: stream alterations brought about by poor land-use practices and by the effects of periodic floods and drought, the breakdown of genetic integrity of native stocks, introduced diseases, over harvest, and climatic change.

There are no quantitative estimates of coho populations in the Noyo River watershed in the earlier part of this century. Anecdotal information, however, indicates that the Noyo River once had a thriving population of coho and steelhead. Coho salmon have since been listed by the National Marine Fisheries Service as a threatened species due to a steep decline in their numbers. Evidence of decline in their populations exists locally in the form of in-migrant fish trap data collected by the Department of Fish and Game since 1963 at its egg-taking station on the South Fork of the Noyo River (see Table 2). The average numbers of returning coho to this hatchery-influenced system prior to the drought of 1977 were 2,819; 2,669; and 2,132 for each of the three respective populations.[4] The numbers of returning coho subsequent to the 1993 drought represent a

[4] Coho salmon have a predictable life cycle in which three-year old fish return to their natal streams to spawn (Wendy Jones, DFG, 1997, pers. comm.. For example, a fish returning to the Noyo River in 1963 spawned fish that then returned in 1966. As such, there are three separate coho populations represented by the data in Table 1.

decline of the pre-1977 numbers of 93%, 60%, and 27% for each of the three respective populations. (Alan Grass, DFG, 1999, pers. comm.). Other qualitative evidence of the decline in coho populations exists in the form of historical accounts.

Stream Gradients

The stream gradients (as well as the climate, geology and vegetation) in the Noyo River watershed are appropriate for the development of aquatic habitat suitable for salmonids, including coho salmon. For example, the Department of Forestry and Fire Protection (CDF) has calculated that there are approximately 104 miles of Class I streams in the Noyo River watershed. Of these, 91 miles, or 88%, have gradients less than 5%. As such, 88% of the Class I streams in the Noyo River watershed may be capable of supporting spawning and rearing for salmonids. There are approximately 149 miles of Class II streams, some of which may be restorable fish-bearing streams. (Suzanne Lang, CDF, 1999, pers. comm.).

Aggradation

With respect to the issue of sedimentation, data collected at the USGS gaging station (located just below the confluence of the South Fork Noyo River with the mainstem) indicate aggradation on the order of 2 to 4 feet from 1957 through 1970. From 1970 to 1992, the data indicate channel degradation on the order of 1 to 2 feet. Another sharp increase is noted in the period of 1993 through 1998 with 3 to 4 feet of aggradation. The data indicate that since 1998 there may be a new trend toward degradation. (Matthews, 1999). Thus, in the period of 1957 to the present, total aggradation as measured at the USGS gaging station is estimated as 3 to 7 feet.

For comparison, dredging data from Noyo Harbor indicate two periods of elevated sedimentation (see Figure 4). Calculated as a 10-year rolling average and beginning in 1933, average dredging volumes peaked in 1947 then hit their lowest volume in 1957. From 1957 (the lowest average volume) to 1967, the average dredging volume climbed steadily, bypassing its 1947 peak and reaching a new peak in 1983. The 1983 average dredging volume was 158% of the 1947 peak dredge volume and 369% of the average dredging volume for the first ten years of dredging begun in 1933. Average dredging volumes steadily declined from 1983 to a low in 1994. The average dredging volume in 1994 was nonetheless 236% of the average volume in 1957 (the lowest average volume) and 127% of the average volume for the first ten years of dredging. The average dredging volume in 1995 climbed again and was 113% of that in 1994 (Larry Graham, ACOE, 1999, pers. comm.).

These two analyses indicate that sedimentation increased in the lower Noyo River from 1933 to 1942 then decreased to a low in 1957. From 1957 to sometime in the 1970s or early 1980s, sedimentation sharply increased and then decreased again through the early 1990s. Sedimentation in the lower river increased in the mid-1990s. It may be declining in the late-1990s.

Matthews (1999) concludes that estimates of sedimentation reflect far less dramatic changes in channel geometry as a result of high sediment production and delivery in the

Noyo River watershed than has been seen in areas with less stable geology, less dense vegetation cover, and higher precipitation rates. He also observes that the noted changes in channel geometry appear to correlate well with changes in sediment production and delivery associated with land management activities in the basin. Thus, while sediment delivery appears to have impacted salmonid habitat (see summary of findings below), it does not appear, on a large scale, to have substantially impacted the overall channel geometry. If true, the restoration of the Noyo River watershed may be achievable in a shorter time frame than elsewhere.

Turbidity data collected by the City of Fort Bragg between 1993 and 1997 also indicate that turbidity values have increased steeply through this period. These data suggest either a lag in the downstream transport of sediment produced in 1993 or the production of new sediment in this period (Matthews, 1999). In addition, it appears that turbidity levels have periodically obscured visibility and have remained elevated even after the cessation of rain.

III.D Summary of findings in HAA

The primary data available for assessing in-stream conditions in the Headwaters Assessment Area (HAA) come from the Mendocino Redwood Company (MRC), including:

- Fish distribution
- % pool by stream length surveyed
- % of all pools with residual depth ≥ 3 feet
- Shelter rating (using Flosi and Reynolds)
- % embeddedness (using Flosi and Reynolds)
- % fine sediment in gravel cores <0.85 mm and <6.3 mm in diameter (as dry weight)
- Board feet of large woody debris per 100 m of stream
- Amount of woody debris removed by the Department of Fish and Game between 1959-1964

The fish distribution data are augmented with data and estimates provided by the Department of Fish and Game.

Fish abundance

Steelhead trout are found throughout the Headwaters Assessment Area (HAA), including 18 sampling stations on: the Noyo River (3 sites), unnamed tributaries to the Noyo River (3 sites), Olds Creek (2 sites), unnamed tributaries to Olds Creek (2 sites), Redwood Creek (3 sites), McMullen Creek (2 sites), an unnamed tributary to McMullen Creek (1 site), and Burbeck Creek (2 sites) (MRC, unpublished). Coho have been found at 8 of the 18 stations sampled, including: 2 sites in the Noyo River, in 3 unnamed tributaries to the Noyo River, and all 3 sites in Redwood Creek (see Table 3). The most abundant populations were found in Redwood Creek (MRC, unpublished; DFG, unpublished (a); DFG, unpublished (b)). Both coho and steelhead were once more common in HAA (see

Table 4). Redwood Creek may have been producing as many as 3,700 coho and 1,500 steelhead in the 1960s (DFG, unpublished (b)).

Spawning habitat

Embeddedness measurements[5] and substrate composition data describe spawning habitat conditions in HAA. MRC rates other spawning habitat features (e.g., spawning gravel quantity); but they do not report actual measurements. There is one site on the Noyo River from which substrate composition data were collected. Embeddedness measurements were collected at 2 sites on the Noyo River, 1 site on Olds Creek, on 2 unnamed tributaries, 1 site on Burbeck Creek, and 2 sites on Redwood Creek. Table 5 summarizes these data.

The substrate composition data collected on the Noyo River were collected from one habitat reach, but from 4 separate tail-outs[6]. The data indicate that fine sediment at all of the tail-outs in the18-30 cm depth range is a higher proportion of the substrate core then may be necessary to ensure adequate oxygenation and waste removal from redds. At one of the tail-outs, the fine sediment in the 0-18 cm range was also elevated.

The embeddedness data indicate that cobble in one of the sites on Redwood Creek and one of the sites on the Noyo River are 25 to 50% embedded. The others sites are less than 25% embedded. This data set is limited; but, it suggests that coho may have difficulty digging redds reaches of the Noyo River mainstem and Redwood Creek.

Rearing habitat

Rearing habitat is described by the percent of pools by stream length, the percent of all pools with residual depth ≥ 3 feet, and shelter rating. These data were collected from 2 sites on the Noyo River, 1 site on Olds Creek, 2 unnamed tributaries, 1 site on Burbeck Creek and 2 sites on Redwood Creek. Table 5 summarizes these data.

The "percent of pools by stream length" and "percent of all pools with residual depth ≥ 3 feet" were combined to determine the percent of pools with depths of at least 3 feet. Of the 8 sites sampled, only one—on Redwood Creek—had numerous enough deep pools for coho rearing. Similarly, only one—on Burbeck Creek—had shelter well enough developed for coho rearing.

Overwintering habitat

Overwintering habitat provides protection to young coho from being washed out in winter and spring freshets. Such habitat includes backwater pools and large woody debris, other large obstructions and shelter. Large woody debris is also valuable for sediment metering, sediment grading, pool formation, and summer shelter. MRC reports data with respect to the removal of large woody debris between 1959 and 1964. It also

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[5] Embeddedness is the degree that larger particles (boulders, rubble or gravel) are surrounded or covered by fine sediment. It is usually measured in classes (<25%, 25-50%, 50-75%, and >75%) according to percentage of random large particles that are covered by fine sediment.

[6] The pool tail-out is the lower end of a pool where flow from the pool, in low flow conditions, discharges into the next habitat unit.

reports the results of a more recent large woody debris survey. There are no data with respect to the number, area or volume of backwater pool habitat in HAA. MRC reports the percent of habitat units dominated by cobble or boulder as a factor relevant to overwintering.

According to MRC, the Department of Fish and Game removed from 1959 to 1964 a total of 1,111,284 board feet (bf) of large woody debris from streams in HAA. This includes:

- Burbeck Creek 67,800 bf.
- Olds Creek 153,900 bf. or 2,224 bf./100 m of stream
- Redwood Creek 590,244 bf. or 7,053 bf./100 m of stream
- McMullen Creek 299,340 bf. or 6,889 bf./100 m of stream

Current levels of large woody debris have been measured at 2 sites in the Noyo River, 1 site in Olds Creek, 2 sites in Redwood Creek, 1 site Burbeck Creek, and sites in 2 tributaries to the Noyo River. There are ≤ 1.8 board feet/100 m of stream at each of the 8 sites. Table 5 summarizes these data.

Potential limiting factors

Based on the available data, the following appear to be potentially limiting factors in HAA.

- Fine sediment intrusion of redds throughout HAA
- Embedded spawning gravels in reaches of Redwood Creek and the Noyo River
- Few deep pools throughout HAA except in reaches of Redwood Creek
- Poorly developed shelter throughout HAA, except in Burbeck Creek
- Limited large woody debris throughout HAA

Due to the lack of data regarding the backwater pool habitat, a conservative approach requires that backwater pools be considered a potentially limiting factor until further data can be developed.

III.E Summary of findings in NFAA

The primary data available for assessing in-stream conditions in the North Fork Noyo River Assessment Area (NFAA) come from the Mendocino Redwood Company (MRC), including:

- Fish distribution
- % pool by stream length
- % of all pools with residual depth ≥ 3 feet
- Shelter rating
- % embeddedness
- % fine sediment in gravel cores <0.85 mm and <6.3 mm in diameter (as dry weight)
- Board feet of large woody debris per 100 m of stream

- Amount of woody debris removed by the Department of Fish and Game between 1959-1964

The fish distribution data are augmented with data and estimates provided by the Department of Fish and Game.

Fish abundance

Steelhead trout are found throughout NFAA, except in Soda Creek, as demonstrated by samples collected at 28 stations located in: the North Fork Noyo River (4 sites), Marble Gulch (3 sites), Gulch 7 (2 sites), Hayworth Creek (5 sites), 2 unnamed tributaries to Hayworth Creek (2 sites), the North Fork of Hayworth Creek (3 sites), Soda Creek (2 sites), the Middle Fork of the North Fork Noyo River (4 sites), DeWarren Creek (2 sites), and an unnamed tributary to DeWarren Creek (1 site) (see Table 3). They were found in each year between 1994 and 1996, except in 1996 at a station on the North Fork of Hayworth Creek (#70-16)—2 rainbow trout were identified-- and at a station on Soda Creek (#70-23). Coho salmon were found at 10 of the 28 stations, and only sporadically over time. Coho were found in: the North Fork Noyo River, Marble Gulch, Hayworth Creek, the North Fork of Hayworth Creek, and the Middle Fork of the North Fork Noyo River (MRC, unpublished).

Both coho and steelhead were once more common in NFAA (see Table 4). The North Fork Noyo River may have been producing as many as 11,200 coho salmon and 1,500 steelhead trout in the 1960s. Similarly, Hayworth Creek may have been producing as many as 2,340 coho and 11,600 steelhead in this same time period (DFG, unpublished (c)).

Spawning habitat

Embeddedness measurements and substrate composition data describe spawning habitat conditions in NFAA. MRC rates other spawning habitat features (e.g., spawning gravel quantity); but, they do not report actual measurements. Substrate composition data were collected from 3-4 tail-outs within four streams, including: Hayworth Creek, the North Fork Noyo River, Marble Gulch, and the Middle Fork of the North Fork Noyo River. Embeddedness measurements were collected at 5 sites on the North Fork Noyo River, 1 site on Marble Gulch, 1 site on Gulch #7, 3 sites on Hayworth Creek, 1 site on North Fork Hayworth Creek, 1 site Soda Creek, 3 sites on the Middle Fork of the North Fork Noyo River, and 1 site on DeWarren Creek. Table 5 summarizes these data.

Of the 15 substrate cores collected, only 2 were free of elevated fines: Tail-out #5 on Hayworth Creek and Tail-out #5 on Marble Gulch. All the others had fines exceeding 14% wet volume (an estimated 7% dry weight using Shirazi, et al., 1979).

The embeddedness data indicate that cobble in 4 of the 5 North Fork Noyo River sites are 25 to 50% embedded, as are 2 of the 3 sites in Hayworth Creek, and 1 of the 3 sites in the Middle Fork of the North Fork Noyo River. Cobble at the site on DeWarren Creek is more than 50% embedded. This data set suggests that coho may have difficulty digging redds in reaches of the North Fork Noyo River, Hayworth Creek, the Middle Fork of the North Fork Noyo River and DeWarren Creek.

Rearing habitat

Rearing habitat is described by: the percent of pools by stream length, the percent of all pools with residual depth ≥ 3 feet, and shelter rating. These data were collected from the same sites from which embeddedness data were collected. Table 5 summarizes these data.

The "percent of pools by stream length" and "percent of all pools with residual depth ≥ 3 feet" were combined to determine the percent of pools with depths of at least 3 feet. None of the 16 sites sampled had numerous enough deep pools or well enough developed shelter for coho rearing.

Overwintering habitat

Overwintering habitat provides protection to young coho against being washed out in winter and spring freshets. Such habitat includes backwater pools and large woody debris, other large obstructions, and shelter. Large woody debris are also valuable for sediment metering, sediment grading, pool formation, and summer shelter. MRC reports data with respect to the removal of large woody debris between 1959 and 1964. It also reports the results of a more recent large woody debris survey. There are no data with respect to the number, area or volume of backwater pool habitat in NFAA. MRC reports the percent of habitat units dominated by cobble or boulder as a factor relevant to overwintering.

According to MRC, the Department of Fish and Game removed from 1959 to 1964 a total of 2,854,920 board feet of large woody debris from streams in NFAA. This includes:

- North Fork Noyo River 18,000 bf. or 135 bf./100 m of stream
- Hayworth Creek 2,232,480 bf. or 23,512 bf./100 m of stream
- Marble Gulch 604,440 bf.

Current levels of large woody debris have been measured at 4 sites on the North Fork Noyo River, 3 sites on Hayworth Creek, 1 site on Marble Gulch, 1 site on Gulch #7, 3 sites on the Middle Fork of the North Fork Noyo River, 1 site on DeWarren Creek, 1 site on the North Fork Hayworth Creek, and 1 site on Soda Creek. With the exception of these last 3, there are less than 6 board feet of large woody debris per 100 m at each of the sites in NFAA. The sites in DeWarren Creek, North Hayworth Creek and Soda Creek each have ≤ 15 board feet of large woody debris per 100 m of stream. (See Table 5).

Potential limiting factors

Based on the available data, the following appear to be potentially limiting factors in NFAA.

- Fine sediment intrusion of redds throughout NFAA except reaches in Hayworth Creek and Marble Creek

- Embedded spawning gravels in reaches of North Fork Noyo River, Hayworth Creek, Middle Fork of the North Fork Noyo River, and DeWarren Creek
- Few deep pools throughout NFAA
- Poorly developed shelter throughout NFAA
- Poorly developed overwintering habitat throughout NFAA, including limited large woody debris

Due to the lack of information regarding backwater pool habitat, a conservative approach requires that backwater pools be considered a potentially limiting factor until further data can be developed. The V-shaped valleys of NFAA may preclude the development of an abundance of backwater pool habitat in this region, however.

III.F Summary of finding in SFAA

The primary data available for assessing in-stream conditions in the South Fork Noyo River Assessment Area (SFAA) come from the Department of Fish and Game, including:
- Annual count of up-stream migrants
- Pool frequency
- % of all pools with residual depth ≥ 2 feet and ≥ 3 feet
- Pool type
- Shelter rating
- % embeddedness

These data are augmented with MRC's estimates of large woody debris removal between 1959-1964 and Chris Knopp's V* data from 1992.

<u>Fish abundance</u>
Coho salmon raised in Department of Fish and Game hatcheries from eggs collected on the South Fork Noyo River have been released to the South Fork Noyo River since 1963 (Alan Grass, DFG, 1999, pers. comm.). As such, coho populations have been highly managed in SFAA. Returning coho fish counts are included in Table 2. Table 4 indicates that Kass Creek may have been producing as many as 6,800 coho in the 1960s (DFG, unpublished (d)). Steelhead trout and coho salmon have been found throughout SFAA during the 1980s and early 1990s, including the North Fork of the South Fork Noyo River, the South Fork Noyo River and Kass Creek (see Table 6) (DFG, 1995(a) and (b); DFG, unpublished (d)).

<u>Spawning habitat</u>
Spawning habitat conditions in SFAA are primarily described by embeddedness measurements collected by the Department of Fish and Game (DFG) in habitat inventories conducted in the Parlin Creek watershed and South Fork Noyo River watershed.

In Parlin Creek, DFG measured the embeddedness of cobbles in 249 pool tail-outs. Of these pool tail-outs,16% were less than 25% embedded, 49% were between 25-50% embedded, 28% were between 50-75% embedded, and 7% were more than 75% embedded. In three tributaries to Parlin Creek, 11%, 29%, and 3% of the pool tail-outs, respectively, had cobble less than 25% embedded (DFG, 1995(b)). In the South Fork Noyo River, DFG measured the embeddednesss of cobbles in 351 pool tail-outs. Of these pool tail-outs, 29% were less than 25% embedded, 37% were between 25-50% embedded, 28% were between 50-75% embedded, and 6% were more than 75% embedded. In two tributaries to the South Fork Noyo River, 22% and 3% of the pool tail-outs had cobble less than 25% embedded (DFG, 1995(a)). These data indicate that coho may have difficulty digging redds in a majority of the pool tail-outs in SFAA.

Rearing habitat

Rearing habitat conditions in SFAA are described by pool frequency, the percentage of pools deeper than 3 feet, and the shelter rating as collected by DFG in habitat inventories in Parlin Creek and the South Fork Noyo River.

In Parlin Creek, 45% of the habitat length inventoried (20,736 feet) were pool units, 31% were flatwater, and 21% were riffle units. The mean pool depth was 1.0 foot. Approximately 12% of the pools had depths ≥ 3 feet. Pool habitat types had a mean shelter rating of 24 and flatwater habitat had a mean shelter rating of 7. The main channel pools had the highest mean shelter rating at 30. Large woody debris (49%) followed by bedrock ledges (15%) and undercut banks (12%) dominated shelter in pools. DFG concluded that shelter was generally lacking in complexity and extent. In the three tributaries to Parlin Creek, pools made up 52%, 40% and 30% of the habitat units (5,036 feet) surveyed, respectively. No more than 18%, 8%, and 8% of the pools in each tributary, respectively, had depths greater than 2 feet. The mean shelter ratings were 38, 42 and 33, respectively (DFG, 1995(b)). These data indicate that the infrequency of deep pools may be limiting coho rearing success in the Parlin Creek watershed as may the lack of adequate shelter.

In the South Fork Noyo River, 56% of the habitat length surveyed (49,762 feet) was in pool units, while 32% were in flatwater and 12% in riffles. The mean pool depth was measured at 1.4 feet. Approximately 32% of the pools had a maximum depth ≥ 3 feet. Pool habitat units had a mean shelter rating of 21. Flatwater habitats had a mean shelter rating of 7. Undercut banks were the dominant cover type (35%) followed by bedrock ledges (22%). DFG concluded that large and small woody debris were lacking in nearly all habitat types. In two tributaries to the South Fork Noyo River, pools made up 30% and 43% of the habitat units surveyed (2,922 feet). No more than 19% and 12% of the pools had maximum depths greater than 2 feet. The mean shelter ratings for pools were 37 and 69 (DFG, 1995(a)). These data indicate that the infrequency of deep pools may be limiting coho rearing success in the South Fork Noyo River watershed as may the lack of adequate shelter. The lack of large woody debris was particularly noted.

In a study of North Coast streams, Chris Knopp collected, among other parameters, V* measurements in the North Fork of the South Fork Noyo River, Parlin Creek and Kass

Creek. V* (pronounced "vee star") is a measure of the ratio of the volume of sediment filling a pool to the scoured volume of a pool. A V* measurement of 0.50, therefore, indicates that 50% of the pool is filled with sediment. The sediment residing in pools is thought to be annually mobile. V* measurements for the North Fork of the South Fork Noyo River, Parlin Creek and Kass Creek were 0.35, 0.31, and 0.60, respectively (Knopp, 1993). Reference data were collected from the North Fork Caspar Creek. The mean V* measurement there was 0.27. These data indicate that pools in the North Fork of the South Fork Noyo River, Parlin Creek and Kass Creek have excessive sediment filling them.

Overwintering habitat

Overwintering habitat provides protection to young coho from being washed out in winter and spring freshets. Such habitat includes backwater pools and large woody debris, other large obstructions, and shelter. Large woody debris is also valuable for sediment metering, sediment grading, pool formation, and summer shelter. DFG reports backwater pool frequencies and mean depths. MRC reports data with respect to the removal of large woody debris between 1959 and 1964. There are no data with respect to current levels of large woody debris in SFAA, with the exception of DFG's observation that large woody debris is lacking in the South Fork Noyo River (DFG, 1995(a)).

In Parlin Creek, backwater pools make up 7% of the pool units identified. The mean backwater pool depth is 1.5 feet (DFG, 1995(b)). In the South Fork Noyo River, backwater pools make up 5% of the pool units identified. The mean backwater pool depth is 1.4 feet (DFG, 1995(a)).

According to MRC, the Department of Fish and Game removed from 1959 to 1964 a total of 132,024 board feet (or 2,413 bf./100 m of stream) of large woody debris in Kass Creek. Additional large woody debris is reported to have been removed in later years, as well (Peter Cafferata, CDF/Stillwater Sciences, 1999, pers. comm.).

Potential limiting factors

Based on the available data, the following appear to be potentially limiting factors in SFAA.

- Embedded spawning gravels throughout SFAA
- Few deep pools throughout SFAA, including excessive filling by sediment
- Poorly developed shelter throughout SFAA
- Infrequent backwater pools throughout SFAA

Due to the lack of data regarding substrate composition and large woody debris, a conservative approach requires that these factors be considered potentially limiting, as well, until further data can be developed.

III.G Summary of findings in MAA

There is no primary data source for assessing in-stream conditions in the Mainstem Noyo River Assessment Area (MAA). Instead, individual pieces of data are combined from the Department of Fish and Game, the Department of Forestry and Fire Protection, The Timber Company, and Mendocino Redwood Company. Data include:

- Fish distribution (DFG and MRC)
- Pool frequency (DFG)
- Mean pool depth (CDF)
- Shelter rating (DFG)
- Substrate composition (DFG and CDF)
- Large woody debris (CDF)

Salmonid abundance

J.W. Burns of the Department of Fish and Game (DFG) studied conditions in the Little North Fork Noyo River before and after road building and logging in the late 1960s. Brad Valentine and Marc Jameson of the California Department of Forestry and Fire Protection (CDF) replicated elements of Burns' study in the early 1990s. With respect to salmonid abundance, Valentine, et al. (1994) reports that total salmonid biomass was similar between the two studies. The difference, however, was that steelhead trout made up 80% of the 1992 sample, but only 17% of the 1966-1969 samples (averaged).

Wendell Jones of the Department of Fish and Game (DFG) has surveyed Duffy Gulch, the Little North Fork Noyo River, and the mainstem Noyo River at Matson Hole for the presence of coho salmon and steelhead trout. Steelhead trout were observed at all three locations. Coho salmon were observed in the Little North Fork Noyo River, only. (See Table 6).

Mendocino Redwood Company (MRC) surveyed 2 locations on the Noyo River and locations on two unnamed tributaries to the Noyo River less than 2 miles above the gaging station in MAA. Steelhead were observed at all 8 stations. Coho salmon were observed at 3 of the 8 stations.

Spawning habitat

Spawning habitat conditions in MAA are primarily described by substrate composition data collected in the Little North Fork Noyo River by Burns (1970) and Valentine, et al. (1994).

Burns (1970) measured substrate composition using a McNeil-like core sampler before and after road building and logging in the late 1960s. Fine sediment < 0.8 mm in diameter was 20.0% (mean) of the total substrate sample (wet volume) in 1966 prior to the construction of a new road for logging second growth forest. In 1968, the mean was 31.0%. In 1969, the mean was 33.3%. For particles < 3.3 mm in diameter, the mean in 1968 was 42.1% and 44.4% in 1969. No data were reported for particles < 3.3 mm in diameter in 1966. Valentine, et al. (1994) reproduced Burns' study and found that fine sediment <0.85 mm in diameter was 25.4% (mean) of the total substrate sample (wet volume) in 1992. These data indicate that fine sediment may be a higher proportion of the substrate composition than is necessary to ensure adequate oxygenation and waste removal from redds. They also indicate that the proportion of fine sediment in the substrate was lower in 1992 than in 1968 or 1969. The mechanism by which fine sediment has been reduced, however, is unclear. It could be related to changes in management practices since 1969. It could also be related to the difference in climatic regime represented by the two study periods. For example, Burns' conducted his study immediately after two large peak flows in Water Years 1965 and 1966 (the 2nd and 5th largest annual peak flows, respectively). Valentine, et al. (1994), on the other hand, conducted their study at the tail end of a drought year.

<u>Rearing habitat</u>
Rearing habitat conditions in MAA are described by pool frequency, mean pool depth, and shelter ratings.

Burns (1971) reports a pool frequency of 68% in the Little North Fork Noyo River as measured in 1966. He reports no pool depth data. Valentine et al. (1994) report a mean pool depth of 1.4 feet as measured in 1992. They report no pool frequency data. Jones (DFG, unpublished (a)) reports a pool frequency in the Little North Fork Noyo River of 50% as measured in 1984 and in Duffy Gulch of 5% as measured in 1986. He reports no mean pool depth. He does, however, report shelter ratings for the Little North Fork Noyo River and Duffy Gulch of 65 and 110, respectively. These data are limited; but, they indicate that the frequency of deep pools in the Little North Fork Noyo River may be limiting the rearing success of coho salmon as may poor shelter. The frequency of pools of any sort in Duffy Gulch also may be limiting the rearing success of coho salmon.

<u>Overwintering habitat</u>
Overwintering habitat provides protection to young coho from being washed out in winter and spring freshets. Such habitat includes backwater pools and large woody debris, other large obstructions, and shelter. Large woody debris is also valuable for sediment metering, sediment grading, pool formation, and summer shelter. MRC reports data with respect to the removal of large woody debris between 1959 and 1964. Valentine, et al., (1994) report large woody debris volumes and site lengths in the Little North Fork Noyo River. There are no data with respect to the availability of backwater pools in MAA.

According to MRC, a total of 563,460 board feet of large woody debris was removed from MAA in the period of 1959 to 1964:

- Little North Fork Noyo River 201,420 bf. or 2,503 bf./100 m of stream
- Duffy Gulch 362,040 bf.

In 1992, Valentine, et al. (1994) measured 89 m^3 of large woody debris (LWD) in 518 m of stream in the Little North Fork Noyo River (e.g., 17 m^3/100m or 7208 board feet/100m where m^3 = 424 board feet).

<u>Potential limiting factors</u>

Based on the available data, the following appear to be potentially limiting factors in MAA:

- Fine sediment intrusion of redds in the Little North Fork Noyo River, and throughout MAA
- Few deep pools throughout MAA
- Poorly developed shelter in the Little North Fork Noyo River and throughout MAA (except Duffy Gulch)

Due to the limited availability of data regarding substrate composition, embeddedness, backwater pools, and large woody debris throughout MAA (except the Little North Fork Noyo River), a conservative approach requires that these factors be considered potentially limiting throughout MAA, until further data can be developed.

III.H Relevant findings in the Caspar Creek watershed

A fair amount of data are available for the assessment of current conditions in the Noyo River watershed. However, immediately south of the Noyo River watershed lies the Caspar Creek watershed in which long-term studies have been conducted, thereby illuminating issues that the Noyo River watershed data are insufficient to address. A summary of relevant findings from the Caspar Creek watershed are provided here so as to highlight additional issues, beyond the potential limiting factors identified above, that should be considered in the Noyo River watershed. It is the current intention that these issues, where not addressed as numeric targets or load allocations, be considered in the development of a TMDL implementation plan. Caspar Creek is similar in many respects to the coastal sub-basins of the Noyo River watershed, such as the South Fork Noyo River. In addition, Caspar Creek, the South Fork Noyo River, and portions of the Big River now comprise the Jackson Demonstration State Forest, owned and managed by the California Department of Forestry and Fire Protection. Thus, there are similarities in the management practices that have been employed over time.

The Caspar Creek watershed has been the subject of paired watershed studies in the 1960s and 1970s. The South Fork Caspar Creek was roaded and selectively logged and tractor yarded in the late 1960s and early 1970s. Upslope and in-stream measurements in the South Fork Caspar Creek were compared to those for the unlogged second-growth forest in the North Fork Caspar Creek watershed. The North Fork Caspar Creek was clear-cut in patches and cable and tractor yarded in the late 1980s and early 1990s. Comparisons between pre-Forest Practices Act logging and post-Forest Practices Act logging have since been made (Lewis, 1998).

Relevant issues illuminated by the Caspar Creek studies include:

- Activities which increase peak flows or decrease the stability of the armor layer may elevate the risk of poor ova survival (Lisle, 1989).
- Cable yarding substantially reduces the risk of immediate landsliding as well as post-harvest landsliding (Cafferata, et. al., 1998).

- Suspended sediment loads increase after road building and logging but return to normal levels after 7 years of rest (Lewis, 1998).
- There is a statistically significant, positive relationship between ground disturbance and suspended sediment (Lewis, 1998; Jack Lewis, USFS, 1999, pers. comm.).
- Suspended sediment discharges resulting from pre-Forest Practices Act logging are an average of 3 times greater than those resulting from post-Forest Practices Act logging when no more than 50% of the basin is logged and cable yarding is used on at least 80% of the harvest area (Lewis, 1998).
- Post-Forest Practices Act-related excess sediment loads are mostly related to increases in storm flow volumes. Reductions may be achieved by reducing or preventing disturbance to small drainage channels (Lewis, 1998).
- Peak flows, except those during very large storms, and annual runoff increase as a result of logging. Clear-cutting causes greater such increases than selective harvest. These effects subside within 15 years of rest as the trees re-grow (Ziemer, 1998).
- Deep pools are important to salmonid success in small, low-gradient streams where water depth and habitat complexity are otherwise reduced (Harvey, et. al., 1996).
- The presence of juvenile steelhead has a negative effect on the growth of 0+ coho salmon and such effects may have population-level ramifications. When the two species are found together, coho occupy the middle of pools whereas steelhead are more widely distributed. The availability of large pools, then, is paramount to coho successful competition (Harvey, et. al., 1996).
- While windthrow and bank erosion are the most common *known* sources of large woody debris to the channel, *unknown* sources are responsible for the largest percentage of noted large woody debris (O'Connor, et. al., 1989; Surfleet, et. al., 1996).

Studies conducted in the Caspar Creek watershed, therefore, indicate that the Noyo River Watershed TMDL and a plan designed to implement it should include measures to: reduce clear-cutting, increase cable yarding, increase periods of rest between harvests, reduce overall ground disturbance, and reduce or prevent disturbance in small drainages.

CHAPTER IV
SOURCE ANALYSIS

The Source Analysis provides an assessment of the sources of sediment to the Noyo River watershed that may be contributing to the impairment of aquatic habitat and salmonid success. It includes a history of land use in the watershed with respect to increased erosion and elevated sediment delivery. It also includes an assessment of landsliding, surface erosion, fluvial erosion, and changes to in-channel stored sediment, over time. This is given in the form of a sediment budget, including supporting discussion.

IV.A Land use history

Early Industrial Activity

The first industrial activity on the Noyo River watershed began with the development of the Richardson-Hegenmeyer water-powered sawmill in 1853. The mill was washed out by a spring freshet the following year. However, the lower Noyo River mainstem still has the remnants of several mid-channel booms which were erected to assist in the floating of logs down the river to the mill (Stebbins, 1986).

A second sawmill was built on the Noyo River in 1858. By 1880, it was estimated that the mill owners had cut about 5,700 acres of timber land to supply the mill, producing approximately 120,000,000 board feet of lumber in that time (Stebbins, 1986). As with the Richardson-Hegenmeyer mill, logs reached this second mill via transport down the Noyo River. The history is unclear; but, splash dams may have occasionally been used to assist in river transportation (Marc Jameson, CDF, 1999, pers. comm.).

In 1885, the Fort Bragg Lumber Company was formed and included the purchase of property on the Noyo River, as well as the site of Fort Bragg, itself. Relying exclusively on ships for the transport of logs to market, the Fort Bragg Lumber Company formed the Fort Bragg Railroad in hopes of improving transportation. (The Fort Bragg Railroad was the precursor to the current-day Skunk Train) (Crump, 1998). In 1893, the Fort Bragg Lumber Company incorporated with White and Plummer, a partnership owning substantial stands of redwoods, to form the Union Lumber Company. “Thriving, Union proceeded to buy more tracts of timber and soon supplied much of America’s redwood.”[7]

By 1930, more than half of the Noyo River watershed had been logged with yarding conducted in the watercourse channels. During the 1960s, logging of second-growth began, primarily in the lower main drainage area. The harvesting of second growth continues today. Removal of residual old-growth stands began in the 1960s and continued into the mid-1980s (Marc Jameson, CDF, 1999, pers. comm.).

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[7] Crump, page 22.

Modern Industrial Activity

Today, the Noyo River watershed is primarily owned by three large land owners, including: Mendocino Redwood Company, The Timber Company, and the State of California at Jackson Demonstration State Forest. Property now owned by Mendocino Redwood Company was previously owned by Louisiana-Pacific Corporation. The Timber Company was previously known as Georgia-Pacific Corporation and Rex Timber Company. Together the three major land owners own approximately 70% of the basin (Jones & Stokes, 1997; MRC, unpublished; Peter Caferrata, CDF/Stillwater Sciences, 1999, pers. comm.). The predominant land use in the Noyo River watershed is timber production and harvest.

Since 1986, the Department of Forestry and Fire Protection has been digitizing into a Geographic Information System (GIS) Timber Harvest Plans (THP) submitted and approved in the Noyo River watershed. Among other data, included in the GIS are: land owner, road location and type, hydrography, topography, harvest location and type, and yarding type. Below is a summary of these data. The GIS does not distinguish between harvest activities that were permitted and those that actually occurred. That is, THPs may have been submitted that were never implemented or were implemented only in part. Similarly, the data contained in the GIS do not indicate the degree to which approved THPs were faithfully implemented. For the purpose of this assessment, however, all permitted activities are assumed to have occurred in the year and in the manner in which they were permitted.

Timber Harvest Activity

As depicted in Table 7, THPs approved by the Department of Forestry and Fire Protection from 1986 through 1998 allowed for timber harvest activity on 44,764 acres of a 72,323 acre basin (62%).

- 54% of the Headwaters Assessment Area
- 76% of the North Fork Noyo River Assessment Area
- 64% of the South Fork Noyo River Assessment Area
- 56% of the Mainstem Noyo River Assessment Areas

Rates in individual sub-basins, however, are higher. For example, the rate of harvest in the Little North Fork Noyo River, a tributary in the Mainstem Noyo River Assessment Area, was approximately 229% from 1964 to 1993 (Valentine, et al., 1994). This means that 29% of this 2443 acre tributary sub-basin was harvested three times in 28 years while the rest was harvested twice. Impacts, then, in the Little North Fork Noyo River are likely to be even greater than would be assumed by an average harvest rate since 1986 in MAA of 56%.

As depicted in Table 7, the 9 largest landowners conducted the majority of the timber harvest activity from 1986 through 1998 (90% of all activity). The percent of harvest conducted by each of them includes:

- Mendocino Redwood Company (formerly Louisiana-Pacific Corporation)-- 30%
- The Timber Company (formerly Georgia-Pacific Corporation and Rex Timber Company)-- 28%

- The State of California at Jackson Demonstration State Forest-- 17%
- Congaree River, Ltd.-- 5%
- Barnum Timber-- 3%
- Harwood Investment-- 2%
- San Francisco Boys and Girls Club-- 2%
- Robert Whitaker-- 2%
- Bill Stone-- 1%

Table 8 shows the number of acres of property permitted for harvest in each assessment area and the percentage of the harvest conducted by each of the silivicultural methods described in the Forest Practices Act. These are categorized, following the categories contained in the Forest Practices Act, as: evenage management[8], unevenaged management[9], intermediate treatments[10], special prescriptions[11], and alternative prescriptions[12]. In summary:

- In HAA, silvicultural methods practiced are generally divided among evenaged methods (38%), unevenaged methods (28%) and alternative prescriptions (27%).
- In NFAA, evenaged management is the predominant series of methods practiced (61%) with the subdominant methods including unevenaged methods (19%) and alternative prescriptions (13%).
- In SFAA, unevenaged management is the predominant series of methods practiced (47%) with evenaged management as the subdominant series of methods (31%).
- In MAA, evenaged management is the predominant series of methods practiced (60%) with unevenaged management as the subdominant series of methods (35%).

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[8] Evenaged management techniques include clearcut regeneration, seed tree regeneration, and shelterwood regeneration. In a clearcut, timber is removed in one harvest and regeneration is accomplished by direct seeding, planting, sprouting or by natural seed fall. In seed tree regeneration, timber is removed in one harvest; but, seed trees are left distributed throughout the harvest area for natural regeneration. In shelterwood regeneration, timber is removed in three harvests: the preparatory step improves crown development; the seed step promotes natural reproduction from seed; and the removal step removes timber, including the protective overstory trees.

[9] Unevenaged management attributes include the establishment and/or maintenance of a multi-aged, balanced stand structure, promotion of growth on leave trees throughout a broad range of diameter classes, and encouragement of natural reproduction. Unevenaged management techniques include the selection regeneration method and transition regeneration method. In the selection method, trees are removed individually or in small groups sized from 0.25 to 2.5 acres. The transition method is used to create an unevenaged stand from a stand with an unbalanced, irregular or evenaged structure.

[10] Intermediate treatments include commercial thinning and sanitation salvage logging. Commercial thinning is the removal of trees in a young-growth stand to maintain or increase average stand diameter, promote timber growth, and/or improve forest health. Sanitation salvage logging is the removal of insect attacked or diseased trees in order to maintain or improve the health of the stand.

[11] Special treatment prescriptions include: 1) site-specific treatments for special areas such as ecological reserves, historical sites, or archaeological sites and 2) the rehabilitation of understocked areas. Rehabilitation includes the harvesting of an understocked area and subsequent restocking to meet stocking standards.

[12] Alternative prescriptions are site-specific regeneration or intermediate treatment methods that accomplish the goals of the Forest Practices Act in a more effective or more feasible way than the standard silvicultural methods.

With respect to sediment generation and delivery, there are pros and cons to evenaged, unevenaged, and intermediate timber management. For example, some argue that the advantage of evenaged management is that it requires fewer entries than do unevenaged and intermediate management techniques. As such, the landscape can theoretically be left to rest for longer periods of time with evenaged management. As described in Chapter III (Problem Statement), studies in Caspar Creek have demonstrated that 7 years of rest are necessary after road-building and timber harvest for elevated suspended sediment loads to return to normal (Lewis, 1998). On the other hand, some argue that the removal of large blocks of vegetation in a clearcut reduces slope stability via the loss of root strength and increases surface erosion and water yield via the loss of rainfall interception (Dietrich, 1997; Ziemer, 1998). Increased water yields may be responsible in part for increases in sediment loads (Lewis, 1998).

Since the subject matter is complex, the specific relationship between timber management techniques and sediment delivery in the Noyo River watershed is not currently clear. However, some issues are raised regarding timber management techniques that are deserving of further attention in the implementation of this TMDL:

- The value of rest after road building and timber harvests (Lewis, 1998)
- The protection of small drainages from disturbance, including clearcut management (Lewis, 1998)

Yarding Activity

Table 9 shows the yarding methods used per area and per year in the Noyo River watershed. According to CDF's GIS, tractor yarding[13] is the predominant yarding method used in the Noyo River watershed. It accounts for 66% of the yarding conducted since 1986. Further, tractor yarding accounts for the majority of yarding conducted in each of the assessment areas except the SFAA. It accounts for 75% of the yarding in HAA, 83% in NFAA, and 64% in MAA.

Cable yarding methods[14] have been used in the SFAA and MAA since 1986. This method of yarding accounts for 56% of the yarding in the SFAA and 36% in the MAA since 1986. Cable yarding accounts for 32% of the yarding conducted in the watershed, overall.

Helicopter yarding was first used in the Noyo River watershed by Louisiana-Pacific Corporation in 1994. Several other operations have since used helicopter yarding in the NFAA and SFAA. In all, 1,062 acres (or 2% of the area logged) were yarded by helicopter in the period between 1986 and 1998.

The relationship between yarding technique and sediment delivery is well established. As described in Chapter III (Problem Statement), there is a statistically significant, positive relationship between ground disturbance and suspended sediment (Lewis, 1998;

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[13] Tractor yarding means that system of skidding (transporting) logs by a self-propelled vehicle, generally by dragging the logs with a grapple or chokers.

[14] Cable yarding means that system of skidding (transporting) logs by means of cable (wire rope) to the yarding machine (yarder) or a landing while the yarder remains stationary.

Lewis, personal communication). Further, it is clear that cable yarding substantially reduces the risk of immediate landsliding as well as post-harvest landsliding (Cafferata, et al., 1998). As such, it can be generally concluded that tractor yarding causes the most ground disturbance and sediment delivery while cable and helicopter yarding cause the least. Thus, reductions in sediment delivery due to yarding are best accomplished by altering current management practices in favor of greater use of cable and helicopter yarding.

Roads

Table 10 shows the density and classification of roads proposed for use in timber harvest operations permitted since 1986. Aerial photographs going back to 1942, where available, were used to estimate the miles of road added in each period up to the present. The calculated road densities are similar to those estimated via aerial photographs. The aerial photographic analysis resulted in estimates for HAA, NFAA, SFAA, and MAA that differ from CDF's GIS estimates by –0.1%, -9.3%, +0.3%, and +5.1%, respectively.

According to CDF's GIS, the road density is highest in MAA at 7.67 mi/mi^2. The lowest road density is found in HAA with 5.74 mi/mi^2. The average road density for the watershed overall is 6.71 mi/mi^2.. Road densities in individual tributary basins, however, are higher. For example, the road density in the lower portion of the South Fork Noyo River is 10.04 mi/mi^2; and, it is 9.97 mi/mi^2 in the Little North Fork Noyo River (Matthews, 1994).

According to CDF's GIS, the roads are classified as per the Forest Practices Act as permanent[15], seasonal[16], or temporary[17]. CDF's data indicate that the majority (72%) of recently used roads (since 1986) were classified in individual THPs as "existing seasonal roads." Only 13% of the miles of road contained in THPs were classified as "existing permanent roads." Less than 0.01% of the roads were classified as "proposed permanent roads" while more than 8% were classified as either "proposed seasonal roads" or "proposed temporary roads." Only 0.2% of the roads were identified for abandonment.

Road density and road classification adds fundamental information regarding the potential for sediment delivery from roads.

- The higher the road density, the higher the ground disturbance, and therefore the higher the potential management-related sediment delivery (Lewis, 1998).

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[15] A permanent road is defined as one that is planned and constructed to be part of a permanent all-season transportation facility. These roads have a surface that is suitable for the hauling of forest products throughout the entire winter period and have drainage structures, if any, at watercourse crossings that will accommodate the fifty-year flood flow. Normally they are maintained during the winter period.

[16] A seasonal road is defined as one that is planned and constructed as part of a permanent transportation facility; but, it has a surface adequate for hauling of forest products in the non-winter periods, and in the extended dry periods or hard frozen conditions occurring during the winter period, only. A seasonal road has drainage structures, if any, at watercourse crossings that will accommodate the fifty-year flood flow. Some maintenance usually is required.

[17] A temporary road is defined as one that is to be used only during the timber operation. It must have a surface adequate for seasonal logging use and have drainage structures, if any, adequate to carry the anticipated flow of water during the period of use.

- Permanent roads are theoretically designed for all-season use and theoretically receive regular wet-weather maintenance. Seasonal roads are designed primarily for non-wet weather use and do not receive regular winter maintenance. Both permanent and seasonal roads are intended to have watercourse crossings capable of passing a fifty-year flood event. But, because of the difference in maintenance, the failure of a watercourse crossing on a seasonal road is more likely to go unchecked than one on a permanent road.
- Permanent roads are more likely to be surfaced than a seasonal road and therefore theoretically contribute less sediment from the road surface, as long as the surfacing is well designed.

Other useful information with respect to sediment delivery from roads, includes:
- Number and type of drainage facilities (e.g., miles of inside ditch, number and spacing of water bars, number and sizes of culverts, number of rolling dips, miles of outsloped road, number of bridges, etc.)
- Proximity to a Class I[18] stream
- Hillslope, geology, and watershed size
- Road width, fill depth, and hydraulic setting

The Regional Water Board was provided road-related data regarding hillslope and proximity to Class I streams. However, technical difficulties made it impossible to assess the data prior to the development of this TMDL. Current plans are to assess the data prior to the development of a TMDL implementation plan and to incorporate the findings, as appropriate, there. At present, the following general statements can be made:
- Roads on steep or convergent hillslopes are more likely to fail and/or deliver sediment then those on ridge tops or above wide, flat riparian zones.
- Streamside roads are more likely to deliver sediment generated by road-related causes than those outside a riparian buffer.
- Roads with well placed rolling dips are less likely then those with numerous culverts (particularly if they are undersized or prone to blockage by debris) to divert streams and deliver eroded road fill.
- Roads with well engineered outsloping are less likely than those with miles of inside ditch and waterbars to deliver eroded fill and elevated flow.

Based on the above data and discussion, then, the following can be said about roads in the Noyo River watershed:
- The road densities indicate a substantial degree of ground disturbance within individual sub-basins, within individual assessment areas, and throughout the Noyo River watershed overall.
- The density of seasonal roads (which is substantially greater than that of permanent or temporary roads) indicates a significant potential for minimally maintained

[18] A Class I stream is a watercourse that contains 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.

crossings and other road-related facilities. This suggests the possibility of failed crossings that go unfixed for some period. Further, as a general matter, unsurfaced roads have a greater potential for surface erosion than do surfaced ones.
- The lack of any significant road abandonment since 1986 indicates the potential for numerous old or poorly built, unused roads to chronically deliver sediment.

It appears as if reductions in sediment delivery from roads will be best accomplished by:
- Obliterating streamside roads, roads on steep or convergent hillsides, and other old or poorly built, unused roads, where possible.
- Converting more roads to permanent road status, based on site conditions.
- Surfacing permanent roads, where possible.
- Using well-placed rolling dips and well-engineered outsloping, where possible.
- Ensuring that culverts are properly sized, installed correctly, and incorporate mechanisms for preventing their blockage by debris.

<u>Public transportation routes</u>
Several public transportation routes exist within the Noyo River watershed. Highway 1 crosses the Noyo River at its estuary. Highway 20 follows the ridgetop at the Noyo River's headwaters before crossing into the Big River watershed and then back into the Noyo River watershed along the South Fork Noyo River. Other major and minor County roads also exist. The California Western Railroad operates the Skunk Trains from Willits to Fort Bragg following the Noyo River mainstem.

Public Roads
The Highway 1 bridge may introduce various issues with respect to sediment transport through the Noyo River watershed. Bridge abutments often serve to constrict a river channel causing flooding upstream and channel erosion downstream. At this time, however, the specific effects of Highway 1 are not known.

Highway 20 crosses from the Noyo River watershed into the Big River watershed and back into the Noyo River watershed before intersecting Highway 1 at the coast. In the Noyo River watershed headwaters, Highway 20 runs primarily along the ridgetop and is not expected to contribute significantly to the problem of sedimentation. Where it returns from the Big River watershed to the Noyo River watershed along the South Fork Noyo River, however, Highway 20, like any road in the watershed, may have the potential to contribute sediment via failed stream crossings, the downcutting of inside ditches, water diversions onto fill or unstable soils, etc. These potential issues may also face the various minor and major County roads in the watershed, as well. These effects are evaluated and addressed in the Chapter IV (Source Analysis) and Chapter (VII) (Load Allocations).

Skunk Train
Laying the tracks for what is now known as the Skunk Train began in the 1880s and was completed in 1911 (Crump, 1986). The tracks begin at the Fort Bragg railroad depot just south of Pudding Creek, follow lower Pudding Creek, and then travel a tunnel through a mountain dividing the Pudding Creek drainage from the Noyo River drainage. Most of

the length of the track follows the Noyo River mainstem corridor, until a second tunnel that delivers the train to Willits.

Forty miles of track were laid to reach a destination of only 22 airline miles (Crump, 1998). It originally required 113 bridges and trestles as it crossed back and forth over the river channel. That number has been reduced to 31 bridges and trestles, at present (Megan Scribner, CWR, 1999, pers. comm.). Landsliding associated with the railroad steadily increased from 1933 to 1957 when it was the largest cause of management-related landsliding. By 1996, the aerial photographs show no landslides specifically related to the railroad (Matthews, 1999).

Current maintenance primarily calls for the replacement of culverts and repair of damage due to gullies and chronic landslides. The maintenance engineer observes that larger and larger culverts are necessary to divert flow from upper drainages around or through the railroad road bed. He opines that logging has changed the hydrology of the drainages above the railroad track (Gary Richards, CWR, 1999, pers. comm.).

Other potential contaminant issues

According to the files maintained at the Regional Water Board, there are several other sources of contaminants within the Noyo River watershed, including underground tanks, sewage treatment facilities, etc. However, none of the other potential contaminant issues appears to have any bearing on the assessment of sedimentation in the basin.

IV.B Sediment budget

Graham Matthews and Associates conducted a desk-top analysis of sediment delivery and transport in the Noyo River watershed during the spring of 1999. The results of their study are reported in *Sediment Source Analysis and Preliminary Sediment Budget for the Noyo River* (1999). Matthews (1999) evaluated landsliding throughout the watershed using 1:24,000 scale aerial photographs for the years: 1942, 1952, 1957, 1963, 1965, 1978, 1988, 1996, and 1999[19]. Complete photo sets for 1942, 1952, 1957 and 1999 were not available for every region of the watershed. The 1942 aerial photos were assumed to give a snap shot of landscape events occurring over a 10 year period (i.e., back to 1933). For each additional photo year, only new features (i.e., those not seen on the previous year's photo) were tabulated. The following are the time periods evaluated via aerial photographic analysis: 1933-1942, 1943-1952, 1953-1957, 1958-1963, 1964-1965, 1966-1978, 1979-1988, 1989-1996, 1997-1999.

Surface erosion was estimated for roads and skid trails based on road/skid trail density and use patterns. Streamside fluvial erosion was estimated using data collected by Mendocino Redwood Company on its property in the upper watershed. Background

[19] Only landslides greater than 75 feet in width or length were evaluated due to the photo scale used. Landslides were associated with harvest units, roads, the railroad, or natural forest based on the judgement of the analyst.

surface erosion was estimated using regional figures described by the California Department of Forestry and Fire Protection for Jackson Demonstration State Forest (Peter Caferrata, CDF/Stillwater Sciences, 1999, pers. comm.). Fluvial erosion[20] related to roads, skid trails and harvesting were not estimated due to the lack of information.

Sediment delivery inputs are predicted to be under-estimates of the actual rates of sediment delivery (Matthews, 1999). This is because of the scale of aerial photos used, the lack of data or desk top tools with which to evaluate fluvial erosion rates and changes in channel storage, and the lack of time for field verification. Nonetheless, this is the best available data with which to assess sediment inputs and develop load allocations. As discussed in Chapter VII (Load Allocations), load allocations are not expressed as erosion or sediment delivery rates, but as a percent decrease in sediment delivery rates, over time. Percent reductions are used as a means of addressing the uncertainty associated with the estimated inputs.

Table 11 summarizes the sediment budget. The sediment budget indicates that sediment inputs are 40% less than sediment outputs. As described in Chapter III (Problem Statement), from 1957 to present the lower Noyo River appears to have aggraded 3 to 7 feet. Thus, rather than representing an overall sediment deficit, the discrepancy between inputs and outputs is more likely an artifact of the uncertainty in the analyses. Indeed, with desk-top analytical tools that tend to under-estimate sediment inputs and over-estimate sediment outputs, such a discrepancy is to be expected. As above, the load allocations are not expressed as sediment delivery rates, but as a percent decrease in sediment delivery rates so as to address this uncertainty.

Table 12 includes estimates for sediment inputs to the Noyo River watershed in nine time periods from 1933 through 1999 as described above. It includes estimates of sediment outputs for those periods, as well. Sediment inputs are divided into the following categories:

- Mass wasting,
- Background surface erosion,
- Surface erosion from skid trails,
- Surface erosion from roads,
- Bank erosion,
- Changes in channel storage

The estimate of mass wasting is a compilation of the estimates of mass wasting due to natural causes, harvest units, roads, and the railroad. Table 12 segregates the estimates into these finer categories. Bank erosion is estimated at 200 tons/mi^2/yr. This is likely an over-estimate; but, it is based on reasonably good data collected by MRC and is the best available information. The 200 tons/mi^2/yr rate is not applied to the length of the Noyo River mainstem where limited field observations indicate little streamside mass wasting

[20] Fluvial erosion is essentially synonymous with gully erosion and includes: downcutting in roadside ditches, streams diverted out of culverts and through road fill as a result of plugged culverts, gullies resulting from “shot gun” culverts, etc.

occurs (Matthews, 1999). Changes in channel storage are estimated based on analysis of historic removal of large woody debris. The estimate does not include consideration of other means by which channel storage is altered, over time. Again, this is due to the lack of available information regarding other changes in channel storage.

In short, the following is the overall estimate of sediment delivery to the Noyo River watershed from 1933 to 1999 (see Table 11):

- Sediment Input = MW + SE_B + SE_{ST} + SE_R + BE + STOR

  where MW = mass wasting, SE_B = background surface erosion, SE_{ST} = surface erosion from skid trails, SE_R = surface erosion from roads, BE = bank erosion, and STOR = changes in channel stored sediment.

- Sediment Input (tons) = 1,276,800 + 567,900 + 114,900 + 836,100 + 1,515,000 + 146,000 = 4,456,700

- Sediment Input (tons/mi^2/yr) = (4,456,700 tons)/(113 mi^2)/67 years = 589

Because of the uncertainty in this assessment, load allocations are designed as percent reductions in sediment delivery from future field-verified sediment delivery sources. This is in contrast to volumetric load allocations (e.g., tons/mi^2/yr) which could be derived from a sediment budget in which there was more certainty.

<u>Headwaters Assessment Area</u>
Table 12 summarizes sediment input data from 1933 to 1999. The aerial photo set for 1942 and 1952 were incomplete. Thus, the sediment delivery rates estimated for these periods include an unquantified level of uncertainty. As such, a more robust analysis of the data is conducted by comparing the rate of change among source categories from one time period to another.

With respect to landslides, the data show that the rate of sediment delivery from background sources increased from the 1933-1957 period to the 1958-1978 period by 179% and then from the 1958-1978 period to the 1979-1999 period by 109%. If these rates of change in sediment delivery due to landsliding are treated as a baseline in HAA, then the following can be said about management influences with respect to landsliding:

- The rate of sediment delivery due to the activities of the railroad also increased through these periods. The increase in the rate of sediment delivery from the 1958-1978 period to the 1979-1999 period, however, is only an eighth of the rate of increase in background sources.
- The rate of sediment delivery from harvest sites increased from the 1933-1957 period to the 1958-1978 period by 1150% or almost 6 times the background rate. However, harvest-related sediment delivery decreased from the 1958-1978 period to the 1979-1999 period by 68% at the same time that the background rate increased by 109%.
- The rate of sediment delivery from landslides associated with roads also increased through these periods. The increase in the rate of sediment delivery from the 1958-

1978 period to the 1979-1999 period, however, is only a quarter of the rate of increase in background sources.

The background rate of surface erosion was estimated using a uniform rate of sediment delivery across the watershed and over time. The estimate does not take into account fluctuations in the timing of rainfall, rainfall volumes, or rainfall intensities. As such, the relationship between background rates of surface erosion and management-related rates of surface erosion is undetermined. Nonetheless, the following can be said with respect to surface erosion:

- The rate of sediment delivery due to surface erosion from roads has increased over time. However, the rate of increase has slowed from 280% to 4% in the most recent period.
- The rate of sediment delivery from skid trails increased from the period of 1933-1957 to 1958-1978. However, it decreased from the period of 1958-1978 to 1979-1999.

Land management-related fluvial erosion was not evaluated because of the lack of existing data.

In summary, the background rate of sediment delivery due to landsliding increased throughout the 1933-1999 period. The rate of management-related sediment delivery due to landsliding increased from the 1933-1957 period to the 1958-1978 at rates significantly greater than that associated with background sources. In the transition from the 1958-1978 period to the 1979-1999 period (Forest Practices Act period), however, the rate of management-related sediment delivery due to landsliding changed at rates significantly less than that associated with background sources. Indeed, harvest-related sediment delivery due to landsliding actually decreased in the 1979-1999 period. If one assumes that there is a direct relationship between management practices and rates of sediment delivery due to landsliding, then the following can be surmised:

- Management practices conducted during the Forest Practices Act period (1979-1999) have contributed to a reduction in the rate of sediment delivery due to landsliding in harvest areas in HAA.
- Management practices conducted during the Forest Practices Act period (1979-1999) have contributed to a deceleration in the rate of sediment delivery due to landsliding from roads in HAA; but, they have not controlled it.
- Management practices conducted since 1979 have contributed to a deceleration in the rate of sediment delivery due to landsliding from the railroad in HAA; but, they have not controlled it.

With respect to surface erosion, sediment delivery from roads has increased from 1933-1999. However, the rate of increase has slowed since 1979. Sediment delivery due to surface erosion from skid trails, on the other hand, increased up through 1978; but, it has decreased since then to a rate less than that estimated for the 1933-1957 period. If one assumes that there is a direct relationship between management practices and rates of sediment delivery due to surface erosion, then the following can be surmised:

- Management practices conducted in the Forest Practices Act period (1979-1999) have contributed to a deceleration in the rate of sediment delivery due to surface erosion from roads; but, they have not controlled it.
- Management practices conducted in the Forest Practices Act period have contributed to the reduction in the rate of sediment delivery due to surface erosion from skid trails.

North Fork Assessment Area

Table 12 summarizes sediment input data from 1933 to 1999. The aerial photo sets were incomplete for 1942, 1952, 1957 and 1999. Thus, the sediment delivery rates estimated for these periods include an unquantified level of uncertainty. As such, a more robust analysis of the data is conducted by comparing the rate of change among source categories from one time period to another.

With respect to landslides, the data show that the rate of sediment delivery from background sources increased from the 1933-1957 period to the 1958-1978 period by 2317% and then from the 1958-1978 period to the 1979-1999 period by 8%. If these rates of change in sediment delivery due to landsliding are treated as a baseline in NFAA, then the following can be said about management influences with respect to landsliding:

- The rate of sediment delivery from harvest sites increased from the 1933-1957 period to the 1958-1978 period at a rate greater than that of background sources. However, it decreased from the 1958-1978 period to the 1979-1999 period by 63% during the same period in which background sources increased by 8%.
- The rate of sediment delivery due to landsliding from roads increased from the 1933-1957 period to the 1958-1978 period at a rate less than that of background sources. However, it increased from the 1958-1978 period to the 1979-1999 period and from the 1933-1978 period to the 1979-1999 period at a rate greater than that of background sources.

The background rate of surface erosion was estimated using a uniform rate of sediment delivery across the watershed and over time. The estimate does not take into account fluctuations in the timing of rainfall, rainfall volumes, or rainfall intensities. As such, the relationship between background rates of surface erosion and management-related rates of surface erosion is undetermined. Nonetheless, the following can be said with respect to surface erosion:

- The rate of sediment delivery from roads increased from the period of 1933-1957 to 1958-1978 but decelerated from the period of 1958-1978 to 1979-1999. It increased from the period of 1933-1978 to 1979-1999.
- The rate of sediment delivery from skid trails increased from the period of 1933-1957 to 1958-1978 but decreased from the period of 1958-1978 to 1979-1999. It decreased from the period of 1933-1978 to 1979-1999.

Land management-related fluvial erosion was not evaluated because of the lack of existing data.

In summary, the background rate of sediment delivery due to landsliding increased throughout the 1933-1999 period. On balance, the rate of management-related sediment delivery due to landsliding increased at rates comparable to those from background sources from the 1933-1957 period to the 1958-1978, the 1958-1978 period to the 1979-1999 period, and the 1933-1978 period to the 1979-1999. However, this balance was achieved by reductions in the rate of harvest-related landsliding as the rate of road-related landsliding increased at rates greater than those of background sources. If one assumes that there is a direct relationship between management practices and rates of sediment delivery due to landsliding, then the following can be surmised:

- Management practices conducted during the Forest Practices Act period have contributed to a reduction in the rate of sediment delivery due to landsliding in harvest areas in NFAA.
- Management practices conducted during the Forest Practices Act period have contributed to a deceleration in the rate of sediment delivery due to landsliding from roads in NFAA; but, they have not controlled it.

With respect to surface erosion, sediment delivery from roads has increased from 1933-1999. However, the rate of increase has slowed since 1979. Sediment delivery due to surface erosion from skid trails, on the other hand, increased up through 1978; but, it has decreased since then. If one assumes that there is a direct relationship between management practices and rates of sediment delivery due to surface erosion, then the following can be surmised:

- Management practices conducted in the Forest Practices Act period have contributed to a deceleration in the rate of sediment delivery due to surface erosion from roads; but, they have not controlled it.
- Management practices conducted in the Forest Practices Act period have contributed to the reduction in the rate of sediment delivery due to surface erosion from skid trails.

<u>South Fork Noyo River Assessment Area</u>

Table 12 summarizes sediment input data from 1933 to 1999. The aerial photo sets were complete for all years. As with the other assessment areas, however, analysis of the data is conducted by comparing the rate of change among source categories from one time period to another.

With respect to landslides, the data show that the rate of sediment delivery from background sources decreased from the 1933-1957 period to the 1958-1978 period by 69% and then increased from the 1958-1978 period to the 1979-1999 period by 4%. If these rates of change in sediment delivery due to landsliding are treated as a baseline in SFAA, then the following can be said about management influences:

- The rate of sediment delivery due to the activities of the railroad have decreased to 0 since 1933.
- The rate of sediment delivery from harvest sites decreased more steeply than background sources from the 1933-1957 period to the 1958-1978 period; and, it

increased more steeply than background sources from the 1958-1978 period to the 1979-199 period.
- The rate of sediment delivery due to landsliding from roads increased from the period of 1933-1957 to 1958-1978; but, it decreased slightly from the period of 1958-1978 to 1979-1999.

The background rate of surface erosion was estimated using a uniform rate of sediment delivery across the watershed and over time. The estimate does not take into account fluctuations in the timing of rainfall, rainfall volumes, or rainfall intensities. As such, the relationship between background rates of surface erosion and management-related rates of surface erosion is undetermined. Nonetheless, the following can be said with respect to surface erosion:
- Surface erosion from both roads and skid trails have increased since 1933, though more steeply from skid trails.

Land management-related fluvial erosion was not evaluated because of the lack of existing data.

In summary, the background rate of sediment delivery due to landsliding decreased significantly from the 1933-1957 period to the 1958-1978 period but has increased since then. The rate of management-related sediment delivery due to landsliding has steadily decreased since 1933. This has occurred because of decreases in sediment delivery due to landsliding from railroad sites and harvest areas even while there have been increases due to roads. Nonetheless, the decrease in management-related sediment delivery due to landsliding from 1933-1978 to 1979-1999 is still only half of that experienced from background sources. If one assumes that there is a direct relationship between management practices and rates of sediment delivery due to landsliding, then the following can be surmised:
- Management practices conducted since 1979 have contributed to a decrease in the rate of sediment delivery from management-related source, overall.
- Management practices conducted since 1979 have contributed to a decrease in the rate of sediment delivery from railroad sites.
- Management practices conducted in the Forest Practice Act period (1979-1999) have contributed to a decrease in the rate of sediment delivery from road sites.
- Management practices conducted in the Forest Practice Act period (1979-1999) have been unsuccessful in reducing sediment delivery from harvest areas.

With respect to surface erosion, sediment delivery from roads has increased from 1933-1999. However, the rate of increase has slowed since 1979. Sediment delivery due to surface erosion from skid trails, on the other hand, has accelerated up through 1999. If one assumes that there is a direct relationship between management practices and rates of sediment delivery due to surface erosion, then the following can be surmised:
- Management practices conducted in the Forest Practice Act period (1979-1999) have contributed to the deceleration in surface erosion from roads; but, they have not controlled it.

- Management practices conducted in the Forest Practice Act period (1979-1999)have been unsuccessful in reducing sediment delivery from skid trails.

<u>Mainstem Noyo River Assessment Area</u>
Table 12 summarizes sediment input data from 1933 to 1999. The aerial photo sets were incomplete for 1942, 1952, 1957 and 1999. Thus, the sediment delivery rates estimated for these periods include an unquantified level of uncertainty. As such, a more robust analysis of the data is conducted by comparing the rate of change among source categories from one time period to another.

With respect to landslides, the data show that the rate of sediment delivery from background sources decreased from the 1933-1957 period to the 1958-1978 period by 13% and then from the 1958-1978 period to the 1979-1999 period by 45%. If these rates of change in sediment delivery due to landsliding are treated as a baseline in MAA, then the following can be said about management influences:

- The rate of sediment delivery due to the activities of the railroad also decreased through these periods, but, at a greater rate than the decrease from background sources.
- Landslides associated with harvest units were not identified in the aerial photographs until the 1979-1999 period. As such, the increase from the early periods to the 1979-1999 is infinite.
- The rate of sediment delivery due to landsliding from roads increased from the 1933-1957 period to the 1958-1978 period by 1750% and from the 1958-1978 period to the 1979-1999 period by 105%. These are enormous rates of increase when compared to the decrease in sediment delivery from background sources in these same periods.

The background rate of surface erosion was estimated using a uniform rate of sediment delivery across the watershed and over time. The estimate does not take into account fluctuations in the timing of rainfall, rainfall volumes, or rainfall intensities. As such, the relationship between background rates of surface erosion and management-related rates of surface erosion is undetermined. Nonetheless, the following can be said with respect to surface erosion:

- The rate of sediment delivery from roads has increased over time. The rate of increase has slowed from 594% to 70% in the most recent period.
- The rate of sediment delivery from skid trails has increased over time. The increase has accelerated from 100% to 225% in the most recent period.

Land management-related fluvial erosion was not evaluated because of the lack of existing data.

In summary, the background rate of sediment delivery due to landsliding decreased throughout the 1933-1999 period. The rate of management-related sediment delivery due to landsliding also decreased from the 1933-1957 period to the 1958-1978 period and at a comparable rate (e.g., 14% vs. 13%). The rate of management-related sediment delivery due to landsliding increased, however, from the 1958-1978 period of the 1979-1999 period as compared to the decrease in background sediment delivery. If one assumes that there is a direct relationship between management practices and rates of sediment delivery due to landsliding, then the following can be surmised:

- Management practices conducted during the 1979-1999 period have contributed to an deceleration in the delivery of sediment due to mass wasting associated with the railroad.
- Management practices conducted during the Forest Practices Act period have been unsuccessful in controlling sediment delivery due to mass wasting from harvest areas and roads.

With respect to surface erosion, sediment delivery from roads has increased from 1933-1999. However, the rate of increase has slowed since 1979. Sediment delivery due to surface erosion from skid trails, on the other hand, has accelerated through 1999. If one assumes that there is a direct relationship between management practices and rates of sediment delivery due to surface erosion, then the following can be surmised:

- Management practices conducted in the Forest Practices Act period have contributed to a deceleration in the rate of sediment delivery increase due to surface erosion from roads; but, they have not controlled it.
- Management practices conducted in the Forest Practices Act period have been unsuccessful in controlling the acceleration in sediment delivery due to surface erosion from skid trails.

In summary, the data presented in Table 12 indicate that sediment delivery in the Noyo River watershed has generally increased over time: from an estimated 468 tons/mi^2/yr in the 1933-1957 period, to 620 tons/mi^2/yr in the 1958-1978 period, to 667 tons/mi^2/yr in the 1979-1999 period. Estimates of management-related sediment delivery indicate that rates increased from the 1933-1957 period to the 1958-1978 period by 167% and from the 1958-1978 period to the 1979-1999 period by 12%. As a general matter then, it appears that practices conducted in the Forest Practices Act period of 1979-1999 have contributed to a deceleration in the rate of sediment delivery from management-related sources; but, they have not controlled them.

The following general statements can be made with respect to individual sediment source categories in the Noyo River watershed:

- The estimated rate of sediment delivery from mass wasting associated with the railroad was at its greatest in the 1933-1957 period and has steadily declined since then. This is the only source category in which estimated rates of sediment delivery in the 1979-1999 period are equivalent to or less than the 1933-1957 rates. The estimated rate of sediment delivery in the 1979-1999 period for all other source categories ranges from 167% to 1420% greater than the estimated rates in the 1933-1957 period.
- The estimated rate of sediment delivery from mass wasting associated with harvest areas is at its greatest in the 1979-1999 period.
- The estimated rate of sediment delivery from mass wasting associated with roads is at its greatest in the 1979-1999 period.

- The estimated rate of sediment delivery from surface erosion associated with roads is at its greatest in the 1979-1999 period.
- The estimated rate of sediment delivery from surface erosion associated with skid trails was at its greatest in the 1958-1978 period and has declined since then. (It remains at its greatest in two of the assessment areas for the period of 1979-1999).

CHAPTER V
NUMERIC AND OTHER TARGETS

Numeric targets interpret water quality objectives, provide indicators of watershed health, and represent habitat conditions adequate for the success of salmonids. The water quality objectives of concern, as noted in Chapter II (Existing Water Quality Requirements), are narrative standards for suspended material, settleable material, sediment, and turbidity. In addition, two prohibitions on logging, construction and related activities further define water quality-related requirements. Indicators allow resource managers and others to assess the degree to which positive changes are occurring in the watershed that, over time, will result in a greater abundance and quality of habitat necessary to support the cold water fishery.

A TMDL is intended to promote the attainment of water quality suitable to support beneficial uses. To this end, it is necessary to monitor in-stream parameters to determine if water quality is in fact improving over time. Yet, the magnitudes of many in-stream parameters, identified in the scientific literature as critical to coho success, vary as a result of both natural and anthropogenic changes. Thus, using in-stream parameters as a means of quantifying the benefits to water quality that are derived from changes in upslope management practices is difficult and fraught with controversy. Targets that reflect the capacity of potential anthropogenic sources to deliver sediment to a watercourse provide a more direct assessment of successful sediment control. As such, both in-stream and upslope targets are identified for the Noyo River watershed.

V.A Watershed processes

The Noyo River watershed was listed on the 303(d) list because of the issue of sedimentation and its threat to water quality and the salmonid fishery. In assessing the available data for the Noyo River watershed and the scientific literature, however, it is clear that the degree to which sediment impacts the salmonid fishery is dependent not just on the rate of sediment delivery, but on the amount, type, size and placement of large woody debris in the watercourse and on the timing, rate and duration of water flow, among other factors.

Large woody debris provides numerous ecological services, including sediment metering, sediment grading, pool formation, and shelter. California coastal streams, in particular, are dependent on the presence of large woody debris to provide these ecological functions. Without the presence of adequate large woody debris, even a reduced rate of sediment delivery may not in itself provide adequate spawning, summer rearing and overwintering habitat. Indeed, the transport of sediment through a stream channel is dependent upon the channel geometry, including the roughness contributed by large woody debris. Any activities that serve to reduce the availability of functional large woody debris in the stream channel, then, have the secondary effect of increasing the potential for sediment-related impacts to aquatic habitat.

Similarly, the transport of sediment through a stream channel is dependent upon the magnitude and duration of flow through the channel. A hydrograph that rises and falls slowly delivers and transports sediment in a manner different from one that rises and falls abruptly. Activities that serve to increase the channel network or impede infiltration of rainfall have the secondary effect of altering the sediment delivery and transport regime, as well.

With these relationships in mind, the following numeric and other targets are developed as measures of water quality improvement and the contribution of altered management practices to that improvement.

V.B Summary of Numeric and Other Targets

Table 13 summarizes the in-stream numeric targets. The in-stream numeric targets are developed for parameters identified in Chapter III (Problem Statement) as potentially limiting the success of coho salmon. The turbidity, % fines <0.85 mm and embeddedness targets are intended to reflect the likely impacts due to elevated sediment delivery, particularly sediment from roads. The pool frequency/depth, backwater pools, and large woody debris targets are intended to reflect the likely impacts due to elevated sediment delivery, particularly in conjunction with limited large woody debris recruitment. The thalweg profile target is intended to reflect more general changes in channel complexity as they relate to the interaction of sediment delivery, large woody debris recruitment and flow.

Table 13: Summary of numeric targets

Parameter	Target	Reference(s)
Turbidity	No greater than 20% above background	Basin Plan, 1994; Reid, 1999
% fines <0.85 mm	≤14% (mean) as wet volume	Burns, 1970; CDF, 1994
Embeddedness	Increasing percentage of riffle habitat units which are less than 25% embedded	Flosi, et al., 1993; DFG, 1995 (a) and (b)
Pool frequency/depth	≥40% of habitat length in pools greater than 3 feet in depth	Flosi, et al., 1993; Gary Flosi, DFG, 1997, pers. comm.
Backwater pools	Increasing percentage of backwater pools per habitat length	Deitrich, 1998
V*	≤0.27	Knopp, 1993
Large woody debris	Increase in the number and total volume of key pieces of large woody debris per stream length	Bilby et al. 1989; Beechie et al. 1997; USDA, 1994
Thalweg profile	Increasing variation in the thalweg elevation around the mean thalweg profile slope	Trush, 1999; Madej, 1999

Table 14 summarizes the upslope targets. Upslope targets are developed for management-related parameters identified in Chapter III (Problem Statement) that are potentially important to the delivery and transport of sediment through a watercourse. The stream crossing targets are intended to focus on road-related sediment delivery, particularly sediment delivery that is highly controllable. The hydrologic connectivity target is intended to focus on the problem of an expanded channel network, particularly the accompanying issues of elevated sediment (as scour) and flow. The disturbed area target is intended to focus on the problem of increased erosion and flow potential accompanying unvegetated and/or compacted soil surfaces. The unstable area target is intended to focus on the problem of the increased risk of erosion and sediment delivery that is likely from unstable areas.

Table 14: Summary of other targets

Parameter	Target	Reference(s)
Stream crossing with diversion potential	≤ 1% of all stream crossings, as a result of a storm with a 100 year recurrence interval or less	Weaver, et al., 1994; Danny Hagans, PWA, 1997, pers. comm.
Stream crossing with significant crossing failure potential	≤ 1% of all stream crossings, as a result of a storm with a 100 year recurrence interval or less	Flanagan et al., 1998
Hydrologic connectivity	Decrease in the miles of road (including railroad) hydrologically connected to a watercourse	Ziemer, 1998; Furniss, 1999
Disturbed area	Decrease in the area disturbed by facilities*	Lewis, 1998
Activity in unstable areas	No activities (e.g., roads, harvest, yarding, etc.) in unstable areas (e.g., steep slopes, headwall swales, inner gorges, streambanks, etc.) unless a detailed geological assessment is performed that shows there is no potential for increased sediment delivery to a watercourse as a result.	Dietrich, et al., 1998; Weaver, et al., 1994; Pitlick, 1982; PWA, 1998.

*A facility is defined as any management-related structure such as a road, railroad roadbed, skid trail, landing, harvest unit, or agricultural field (e.g., pasture, vineyard, orchard, row crops). For the purpose of this target, a harvest unit or agricultural field that retains its natural characteristics with respect to rainfall interception, rainfall infiltration, and soil protection, is not considered a "facility."

V.C Discussion of numeric and other targets

What follows is a brief discussion of each of the targets summarized above. Chapter III (Problem Statement) provides the data or data references from which these numeric targets were chosen.

Turbidity
The turbidity data collected in the lower Noyo River by the City of Fort Bragg from 1992 to the present indicates that the turbidity occasionally obscures visibility and remains elevated even once rainfall has ceased. As described in Chapter III (Problem Statement), Matthews (1999) concludes that turbidity values have increased steeply in recent years. No study has yet been conducted by which the natural background levels of turbidity have been determined. As such, it is difficult to determine the degree to which the existing water quality objective for turbidity has been exceeded. To better ensure a thorough evaluation of this matter, a numeric target for turbidity is proposed which is simply a reiteration of the water quality objective for turbidity, as described in the Basin Plan. Turbidity measurements should be able to assist in identifying tributary watersheds requiring immediate upslope erosion control.

Percent fines
McNeil samples were collected at several locations throughout NFAA and HAA, as well as in the Little North Fork Noyo River. Valentine, et al. (1994) demonstrated a positive curvilinear relationship between coho biomass and percent fines in the Little North Fork. In addition, the Fredle Index calculation predicted a range of 0-80% coho survival-to-emergence as a function of particle size.

Burns (1970) developed substrate composition data for the Little North Fork Noyo River, the South Fork Caspar Creek and North Fork Caspar Creek prior to second growth logging and road building. In the Little North Fork Noyo River, 27 samples were collected in 1966. In the South Fork Caspar Creek, 20 samples were collected in 1967. In the North Fork Caspar Creek, 100 samples were collected between 1967 and 1969. The mean percentage of particles <0.8 mm in diameter in each year and in each stream ranged from 17.5% (as calculated from data collected in 1967 from North Fork Caspar Creek) to 23.2% (as calculated from data collected in 1969 from North Fork Caspar Creek). The mean of all years and all streams is 19.4%.

Burns (1970) began his study in October 1966 following the second largest annual peak flow in the Noyo River in December 1964 and the fifth largest in January 1966. These flows have recurrence intervals of 24 and 10 years, respectively. With respect to annual runoff, Water Years 1965 and 1969 were the 7^{th} and 11^{th} wettest years of record. With respect to magnitude and duration, Water Years 1965, 1966 and 1969 were the 2^{nd}, 12^{th}, and 16^{th} wettest years of record. With respect to annual precipitation, Water Year 1969 was wetter than either 1965 or 1966 with a rainfall of 66 inches in Willits (compared to a 50 inch mean) and 51 inches in Fort Bragg (compared to a 39 inch mean). The highest ranked storm of record with respect to 1-day precipitation intensity occurred in Water Year 1965 with 8.8 inches of rain in Willits. Indeed a quarter of the 20 most intense 1-day precipitation events in Willits occurred in the 1960s, a greater proportion than in any other decade of the 120-year record (Matthews, 1999).

It is useful to consider these climatological facts when determining the degree to which Burns' data represent a reference condition with respect to percent fines for the Noyo River watershed. The data were collected locally and from streams that had not yet been logged of second growth forest. As such, the geologic setting and management history clearly represent appropriate reference conditions. However, coho populations in the 1960s were already on the decline. And, the storm history of the 1960s suggests that erosion and sediment delivery were unusually high in that decade. Indeed with intense storms occurring just prior to and throughout the study period, the degree to which the data reflect the movement of landslides or other erosional features, is unclear. In the Little North Fork Noyo River, for example, landslides totaling an initial input of 14,668 tons of sediment were identified in aerial photos from 1957 to 1999. Of this, 6,341 tons (43%) is estimated to have been delivered in 1964 and 1965, alone. While this does not illuminate the degree to which landslides continued to deliver sediment during Burns' study period, it does indicate that a substantial amount of sediment entered the stream just prior to his study period.

There is uncertainty regarding the degree to which the mean of Burns' pre-logging and control stream data from the 1966 to 1969 represent a reasonable target for the protection of coho salmon today. Indeed, CDF (1994) reports that in all other studies on this matter, emergence of coho fry was high at < 5% fines but dropped sharply at ≥ 15% fines. For this TMDL, a conservative target of ≤ 14% fines <0.85 mm is established so as to maximize the potential for coho fry emergence.

Burns' Caspar Creek and Little North Fork Noyo River data appear to represent sediment conditions resulting from unusually inclement weather conditions and elevated sediment delivery. As such it can not be used as a mean target level across the range of possible rainfall and flow events. Since it was collected prior to second growth logging activities, however, it provides a realistic snap-shot of background conditions resulting from a particular series of events. As such, analysis of substrate composition data in the future should take into account rainfall, flow and sediment delivery preceding and during data collection. A mean stream reach value that exceeds 14% but not 19% fines < 0.85 mm, for example, might represent adequate water quality if the data were collected following a large storm (e.g., 20 year event) or a series of moderately large storms (e.g., 10 year events).

<u>Cobble embeddedness</u>

Excessive cobble embeddedness was noted as an issue at several sampling locations in the Noyo River watershed. The Department of Fish and Game generally looks for embeddedness measurements of less than 25% as an indicator of unembedded substrate (DFG, 1995 (a) and (b)). Unembedded substrate is necessary for the building of salmonid redds.

Current research appears insufficient to determine the number or area of riffles that must be unembedded to provide adequate potential spawning habitat. As such the embeddedness target requires an increasing trend in the number of riffle habitat units that are less than 25% embedded.

Pool frequency/depth

Habitat data in HAA, NFAA, SFAA, and MAA all indicate that pool frequency and/or pool depth may be factors limiting the success of salmonids. Deep and frequent pools are necessary as summer rearing habitat, particularly for coho salmon which are less able than steelhead trout to compete for food supplies in the absence of deep pools (Harvey, et al., 1996).

Flosi et al. (1993) report that

> "DFG habitat typing data indicate that the better coastal coho streams may have as much as 50 percent of their total habitat length in 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 fourth order streams the criteria is the same, except maximum depth must be at least three feet." [21]

A review of habitat typing data collected since 1993 indicate that better coho streams in California may rather have about 40 percent of their total habitat length in primary pools (Gary Flosi, DFG, 1997, pers. comm.). As such, the numeric target for pool frequency/depth requires that 40% of total habitat length be in 3 foot deep pools.

Backwater pools

The availability of overwintering habitat may be an important factor limiting the success of salmonids in the Noyo River watershed. To the degree that large woody debris is important to the formation of adequate overwintering habitat, then such habitat is almost certainly lacking. Other specific data, such as the abundance of backwater pools, are not currently available. A conservative approach requires that backwater pools be considered a potentially limiting factor until further data can be developed.

Backwater pools are generally formed by boulders, root wads or logs (Flosi et al., 1994). As these channel roughness elements are removed or buried by sediment, the habitat becomes less diverse, including the loss of backwater pools. In a letter to the Regional Water Quality Control Board commenting on the proposed TMDL for sediment in the Garcia River, Doctors Dietrich and Power identified the condition of the floodplain, particularly with respect to the availability of backwater pools, as critical to the success of coho salmon in California (Dietrich, 1998). There does not appear to have been sufficient research on overwintering habitat, however, to identify a specific number of backwater pools, for example, that is necessary for coho success. As such, the proposed numeric target for the Noyo River TMDL is simply an increasing trend in the number of backwater pools per habitat length.
This target will only apply to reaches of stream where the channel morphology otherwise supports the development of backwater pools. In steep, V-shaped valleys with little floodplain connection, such as found in tributaries in NFAA for example, a significant

[21] Flosi, Gary and Forrest L. Reynolds. 1994. California salmonid stream habitat restoration manual, second edition. California Department of Fish and Game, Inland Fisheries Division, Sacramento, CA; page V-12.

number of backwater pools would not be expected as a part of the natural array of habitat units. In such regions, the large woody debris and thalweg profile targets are presumed to adequately address the issue of overwintering habitat.

V*

V* (pronounced "vee star") is a measure of the fraction of a pool's volume that is filled by fine sediment and represents the in-channel supply of mobile bedload sediment (Lisle and Hilton, 1992). A study conducted on over 60 streams representing different levels of disturbance in the North Coast found that a mean V* value of 0.21 (21%) represented good stream conditions (Knopp, 1993). Sample sites for this study were located in Franciscan geology.

The data available in the Noyo River watershed indicate that pool depth and frequency are factors limiting the success of salmonids throughout the basin. Chapter IV (Source Analysis) indicates that excessive fine sediment is delivered via surface erosion throughout the basin, as well. The existing V* data include samples in the North Fork of the South Fork Noyo River, Parlin Creek and Kass Creek. All the Noyo River watershed V* data indicate excessive filling of pools by fines.

One of the control streams studied by Knopp (1993) was the North Fork Caspar Creek. The mean V* value in this stream was 0.27. As a general matter, numeric targets developed from local reference streams are preferable to those derived from the literature or from distant reference streams. As such, the numeric target established for V* is 0.27 even though it is higher (29% higher) then the coast-wide mean for control streams.

Thalweg profile

The thalweg profile is a profile, measured parallel to stream flow, of the lowest elevation of each of many channel cross-sections. As a stream descends from its headwaters to its mouth, the mean thalweg profile slope also descends. As the number of pieces and volume of large woody debris increases as well as the number and depth of pools, the thalweg profile develops more dramatic variation around the mean profile slope.

The availability of large woody debris and deep pools appear to be two of the main factors limiting the success of salmonids in the Noyo River watershed. The techniques proposed by the Forest, Fish and Farm Committee at its 1999 Workshop ("Using Stream Geomorphic Characteristics as a Long-term Monitoring Tool to Assess Watershed Function) include the measurement of the channel thalweg to determine the variation around the mean thalweg profile slope. Not enough research appears to have been conducted to establish a specific number that reflects a satisfactory degree of variation. As such, the numeric target proposed here is simply an increasing trend in variation from the mean thalweg profile slope.

Stream diversion potential and stream crossing failures

Truck roads, skid roads, and railroad roads generally cross ephemeral or perennial streams. Stream crossing structures are built to capture the stream flow and safely convey it through or around the roadbed. The Forest Practice Rules require that: 1) the number of watercourse crossings be minimized; 2) crossing structures allow for unrestricted passage of fish, where fish present; 3) crossings be constructed or maintained to prevent the diversion of stream overflow down the road; 4) crossings be constructed to allow a 50 year flood event pass; and 5) trash racks be installed to prevent debris from reducing the flow capacity of the crossing structure.

There is no existing data in the Noyo River watershed regarding the current rate of stream diversions or stream crossing failures or the contributions of sediment to the watercourse via these processes. In other north coast basins (Rolling Brook, a tributary of the Garcia River, and Redwood Creek in Redwood National Park), sediment from stream diversions and other sources associated with haul road and skid trail crossings have been estimated to contribute from 25-38% of the overall sediment budget. As such, this sediment process is likely to be a significant component of the Noyo River watershed sediment budget, as well.

Diversion potential is the potential for a road to divert water from its intended drainage system across or through the road fill thereby delivering road-related sediment to a watercourse. As described in the South Fork Trinity TMDL (U.S. EPA, 1998), the potential delivery of sediment to a watercourse can be eliminated from almost all potential road diversions by identifying and correcting sites with diversion potential. Correction measures include eliminating inboard ditches, outsloping roads, and/or installing rolling dips at crossings. No more than 1% of potential road diversion sites are expected to be either physically impossible to correct or of such a nature that their correction would make the road unsafe for travel.

Road crossing failures are generally related to undersized, poorly placed, plugged or partially plugged culverts. When a culvert fails, the sediment associated with the crossing is delivered directly into the watercourse. Indeed, in most crossing failures, the total sediment volume delivered is the volume of road fill associated with the crossing as well as sediment from collateral failures such as debris torrents that scour the channel and stream banks (U.S. EPA, 1998). The Forest Practice Act requires that road crossings be designed to pass a 50 year flood and be protected from damage by debris with trash racks. Given the large percentage of seasonal roads in the Noyo River watershed, however, maintenance of culverts and trash racks following storm events is likely to be irregular. To avoid failures, particularly on seasonal roads, road crossings should be designed to pass a 100-year flood. No more than 1% of all culverts are expected to fail as a result of a 100-year flood or less if all the culverts are properly sized, installed and maintained. Only those crossings where modification would endanger travelers or where there are other physical constraints should fall within this 1%.

<u>Hydrologic connectivity</u>

Increased flows result in increased suspended sediment discharge and can result in the destabilization of the stream channel's armor layer (Lewis, 1998; Ziemer, 1998). A decrease in a stream channel's armor layer, particularly during early spring flows can have a devastating effect on salmonid redds and growing embyros (Lisle, 1989).

Stream flows are increased as a result of logging, in part, because of the defacto increase in the channel network that often accompanies the construction of roads, particularly those with inboard ditches. Water that on a naturally graded hillside would be either intercepted by tree cover or infiltrate through the duff and into groundwater, instead hits an inboard ditch to become surface water delivered directly to a watercourse. Groundwater is also intercepted by inboard ditches.

The reduction of road densities and the reconstruction of roads (including the railroad) to reduce the miles of inboard ditches, for example, can reduce the amount of water that is directly delivered to watercourses, including any associated sediment load. Current research appears insufficient to identify a specific number of miles of road or road with inboard ditch that would adequately prevent excessive stream flows and sediment discharge. As such, only a reduction in the hydrologic connectivity of roads to watercourses is proposed.

Disturbed area

Studies in Caspar Creek (Lewis, 1998) indicate that the disturbed area in the South Fork Caspar Creek is 15% while that in the North Fork is 3.2%. There is a statistically significant relationship between the difference in the disturbed areas and the corresponding suspended sediment discharge rate (Lewis, 1998; Jack Lewis, USFS, 1999, pers. comm.). In addition, studies in Caspar Creek indicate that clearcutting causes greater increases in peak flows (and by extension suspended sediment loads) than does selective harvest (Ziemer, 1998). As with the "hydrologic connectivity" target above, increases in peak flows, annual flows, and suspended sediment discharge rates negatively effect the potential survivability of ova in redds (Lisle, 1989).

Research is insufficient to identify the percentage of disturbed area in the Noyo River watershed above, which increases in peak flows, annual flows and suspended sediment discharge would be insignificant. As such, only a reduction in the amount of disturbed area is proposed. With respect to this numeric target, "disturbed area" is defined as the area covered by 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 a facility is intentionally made broad to include managed agricultural areas, such as pastures and harvest areas, where the management activity (e.g., logging or grazing) results in substantial enough removal of vegetation to significantly reduce 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 "facilities." 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.

Activity in unstable areas

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 kept to a minimum. Such activities include: road building, harvesting, yarding, terracing for vineyards, etc.

Dietrich, et al., 1998 validated the SHALSTAB model[22] using data collected in the Noyo River watershed and elsewhere. The model predicts areas of chronic landsliding based on the ratio of effective precipitation to soil transmissivity (q/T). The data indicate that landslides in the Noyo River watershed observed on aerial photographs largely coincide with predicted chronic risk areas. Chronic risk areas include steep slopes, inner gorges and headwall swales, as well as other locations.

Weaver, et al. (1994) suggest methods for eliminating or decreasing the potential for road-related sediment delivery. They recommend avoiding construction of roads in unstable areas unless construction involves professional geotechnical assistance. Studies in the lower Eel River basin suggest that landslides in recently harvested second growth areas underlain by Franciscan geology are larger and more common than those in areas of unharvested second growth (PWA, 1998). In Redwood Creek basin, Pitlick (1982) found that slides in harvested inner gorge areas were no more common but were much larger than those in uncut inner gorge slopes. Thus, the avoidance of unstable areas, unless the activity involves the professional geotechnical assistance, appears warranted. The target calls for such avoidance.

[22] SHALSTAB is a coupled, steady-state runoff and infinite-slope stability model that can be used to map the relative potential for shallow landsliding across a landscape. Dietrich, et al., 1998 states that shallow landslides are a major source of sediment delivered to streams. Individual landslides may mobilize in the form of a debris flow, and subsequently travel several kilometers downstream, scouring stream channels of all sediment and wood, then depositing it in a large accumulation when the debris flow comes to rest in a low gradient channel.

CHAPTER VI
LINKAGE ANALYSIS

The goal of a linkage analysis is to develop a relationship between upslope processes and in-stream effects. With respect to the TMDL, a linkage analysis should provide a basis for numeric load allocations. The load allocations describe the amount of sediment that must be controlled from delivery to the stream channel so as to meet water quality objectives and protect beneficial uses.

Unfortunately, the science related to forest processes and the coastal watersheds of Northern California is not advanced enough to allow for the development of statistically meaningful relationships between upslope processes and habitat effects. The fact that there are habitat effects as a result of modifications to upslope processes is well documented; however, the mathematical relationships are not. As such, the linkage analysis must necessarily be based on assumptions and professional judgment, as well as what fledgling data relationships may exist.

With respect to the Noyo River TMDL, a theoretical link between in-stream and upslope condition is developed based on: 1) salmonid abundance in the early part of this century and 2) sediment delivery rates over time.

<u>Salmonid abundance in the early part of this century</u>
Brown, et al. (1994) reports that coho salmon previously occurred in as many as 582 California streams from the Smith River near the Oregon border to the San Lorenzo River on the central coast. There are now probably less than 5,000 native coho salmon spawning in California each year, many in populations of less than 100 individuals. Coho populations today are probably less than 6% of what they were in the 1940s and there has been at least a 70% decline since the 1960s. Brown, et al. (1994) conclude that the reasons for the decline of coho salmon in California include: stream alterations brought about by poor land-use practices and by the effects of periodic floods and drought, the breakdown of genetic integrity of native stocks, introduced diseases, over harvest and climatic change.

There are no quantitative estimates of coho populations in the Noyo River watershed in the earlier part of this century. Anecdotal information, however, indicates that the Noyo River once had a thriving population of coho and steelhead. As indicated by data from the South Fork egg taking station, coho populations have declined since 1963 by an average of 68%. If coho populations today are less than 6% of what there were in the 1940s as suggested by Brown, et al. (1994), then there may have existed an average of 19,000 coho in the South Fork of the Noyo River watershed at that time.

There are two assumptions necessary to this analysis. First, one must assume that the freshwater habitat found in the Noyo River watershed in the early part of this century supported coho salmon. The success of coho at that time suggests that this is a reasonable assumption. Second, one must assume that the freshwater habitat found in the

Noyo River watershed in the early part of this century is equivalent to that described by the in-stream targets in Chapter V. Quantitative targets are identified for substrate composition (e.g., % fines < 0.85 mm), pool frequency/depth, and V*. All the other identified in-stream targets simply call for an improving trend. The % fines target represents the results of a myriad of in-stream and laboratory studies and is conservatively based specifically on coho fry emergence success. The pool frequency/depth target is based on a large data set representing today's "good" coho streams. And, the V* target is based on conditions in a local reference stream. With respect to habitat conditions in the early part of the century, then, the % fines target may be slightly over-estimated, the pool frequency/depth may be slightly under-estimated, and the V* target is probably accurate. The second assumption, then, appears reasonable.

Sediment delivery rates over time

The assessment of sources of sediment to the Noyo River watershed covers a period of 67 years from 1933 to 1999 (Matthews, 1999). The 67-year period of study has been divided into 3 periods: 1933-1957, 1958-1978, and 1979-1999. The period of 1933-1957 is assumed to include a quiescent period between the logging of old growth at the turn-of-the-century and logging of second growth in the middle of the 20th century. The period of 1958-1978 is assumed to include an intensive period of second growth logging, prior to the enactment and implementation of the California Forest Practices Act. This is assumed to be the period in which the most significant modifications to upslope and in-stream processes has occurred. The period of 1979-1999 is assumed to include an intensive period of second growth logging, but mitigated by the enactment and implementation of the California Forest Practices Act. The average sediment delivery in the 1933-1957 period is estimated at 475 tons/mi^2/yr. The average sediment delivery in the 1979-1999 period is estimated at 649 tons/mi^2/yr.

Linkage

For the purpose of the linkage analysis, the period of 1933-1957 is assumed to be the period just prior to the steep decline in salmonid populations, most notably coho salmon. If coho salmon were relatively successful in the Noyo River prior to 1958, as suggested by Brown, et al. (1994), then habitat conditions in that period are assumed to have supported coho salmon. Though the specific habitat conditions of that period are unknown, it is assumed that they were equivalent to those defined by the numeric targets in Chapter V, as described above. If the in-stream conditions found in the Noyo River watershed in the period of 1933-1957 supported coho salmon, then the average rate of sediment delivery in that period is assumed to have had an insignificant negative effect on the in-stream condition. Therefore, achieving a rate of sediment delivery equivalent to the rate of sediment delivery in the period of 1933-1957 is assumed to be sufficient to achieve the in-stream targets, protect water quality and support beneficial uses.

A caveat, however, is that the sediment delivery rate of the 1933-1957 period existed in conjunction with an unknown loading of large woody debris. These two factors together likely influenced the quality and quantity of coho habitat in the basin. The implementation of the sediment load allocation, then, must occur in conjunction with a broad-scale effort to increase the loading of large woody debris as well. Without an increase in the loading of large woody debris, the sediment loading requirements, as described in Chapter VII (Load Allocations) may be insufficient to support the salmonid fishery. The numeric targets for large woody debris should be further supported by implementation measures specifically designed to ensure an increase in the number and volume of key pieces of large woody debris, over time. Similarly, the targets for hydrological connectivity and disturbed area should also be supported by implementation measures designed to decrease connectivity and disturbance.

Conclusion

Chapter IV (Source Analysis) indicates that the current total rate of sediment delivery (estimated at 649 tons/mi^2/yr) must be decreased by 27% to return to an average sediment delivery rate equivalent to that of the 1933-1957 period (estimated at 475 tons/mi^2/yr). This is a reduction in management-related sediment delivery of 63%.

CHAPTER VII
LOAD ALLOCATIONS

Load allocations are developed to establish the level of sediment delivery that is allowable to a sediment-impaired river while still promoting the recovery of water quality and the protection of beneficial uses. For the Noyo River watershed, the TMDL is expressed as a percent reduction in sediment delivery in each assessment area, over time. The Source Analysis provides estimates of past and present sediment delivery rates. These rates, however, are likely under-estimates (Matthews, 1999). As such, the sediment load allocations, as percent reductions, are intended to be applied to field-based assessments of sediment sources conducted by individual landowners on their properties.

Table 15 summarizes the load allocations developed for individual assessment areas in the Noyo River watershed. Appendix A contains a detailed description of the derivation of these load allocations. The process by which the load allocations are derived is as follows:

- The current rate of sediment delivery (1979-1999), the sediment delivery rate in the period of 1933-1957, and the long-term average background rate of sediment delivery (1933-1999) are estimated using the sediment budget developed by Matthews (1999)
- The portion of the sediment delivery rate in the period of 1933-1957 that is attributable to management-related sources is estimated by subtracting the background rate. The resulting rate represents the "desirable" rate of management-related sediment delivery. The "desirable" rate of management-related sediment delivery is that management-related rate of sediment delivery that the Noyo River watershed can assimilate while still providing adequate coho habitat as is presumed to have existed in the period of 1933-1957.[23]
- Roads are identified as the largest and most easily controlled source of management-related sediment delivery in the Noyo River watershed. The reduction in road-related sediment delivery that is necessary to achieve the "desirable" rate of management-related sediment delivery is calculated.
- There is no data with respect to the proportion of the sediment budget attributable to fluvial erosion from roads. Because this source is a significant component of sediment budgets for other similar North Coast watersheds, it is assumed to be significant in the Noyo River watershed, as well. A conservative load reduction requirement for fluvial erosion from roads is established.
- Harvest area, skid trail and railroad sediment delivery sources that contribute sediment well above (i.e., >25%) the basin wide average rate for each of these categories are targeted for additional sediment delivery reduction in the assessment areas where they are elevated. This is to ensure that: 1) landowners are treated equivalently throughout the watershed, 2) the critical sources of sediment are

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[23] The control of sediment delivery alone can not achieve the goals of the TMDL. Sedimentation, for which the Noyo River was listed on the 303(d) list, is a function of sediment delivery, large woody debris availability, and flow. Management-related impacts to the availability of large woody debris and peak flows must also be controlled if water quality improvement are to be made and beneficial uses are to be protected.

controlled in each assessment area; and 3) an adequate margin of safety is built into the load allocations.

Table 15: Summary of sediment load allocations for the Noyo River watershed

	HAA load allocations (% reduction*)	NFAA load allocations (% reduction)	SFAA load allocations (% reduction)	MAA load allocations (% reduction)
Mass wasting from roads	82	82	0	75
Surface erosion from roads	73	76	70	78
Fluvial erosion from roads	90	90	90	90
Mass wasting from the railroad	0	0	0	25
Mass wasting from harvest areas	0	0	0	53
Surface erosion from skid trails	0	0	0	0

* % reductions are to be measured against a baseline survey of potential and existing sediment delivery sites conducted by landowners or their representatives on their respective properties.

CHAPTER VIII
MARGIN OF SAFETY AND SEASONAL VARIATION

Section 303(d) of the Clean Water Act and the regulations at 40 CFR 130.7 require that TMDLs be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards with seasonal variations, and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and 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 (EPA, 1991).

<u>Annual and seasonal variation</u>
There is inherent annual and seasonal variation in the delivery of sediment to stream systems as the result of variation in rainfall patterns. There is also considerable spatial variation resulting from numerous factors, including: slope, geology, aspect, vegetation, soil type, etc. Surface erosion, including erosion from roads, occurs on an annual basis, but primarily as a result of winter rains. Surface erosion from ridge top roads, however, is much less likely to enter a watercourse then that from stream-side roads. Mass wasting occurs as a result of large storms, but is more likely in inner gorges and headwall swales, for example, then on gently sloping terrain.

Because of the large temporal and spatial variation in erosion and sediment delivery, the sediment load allocations are designed to apply to the *sources* of sediment, not the movement of sediment across the landscape or delivery of sediment to the stream channel. They are also expressed as a percent reduction rather than an absolute volume or rate. If implemented as envisioned, potential and existing sediment delivery sites will be identified and the quantity of sediment associated with each site measured or estimated. Then, as a result of mitigation or altered land management, the amount of potential sediment saved from delivery to waters of the State will be measured or estimated. The relationship between the original measurement or estimate and the amount saved by mitigation will indicate the degree to which the allocation (as a percent reduction) has been achieved. Applied in this way, the effects of spatial and temporal variation on the implementation of load allocations is minimal. Only following mitigation, when large storms occur, will the effects of temporal and spatial variation be important. Mitigation measures that do not hold up to the variation in rainfall patterns, for example, should be redesigned and re-implemented, as appropriate.

There is also inherent annual and seasonal variation in the condition of the in-stream environment resulting from variation in sediment delivery, flow, and the longevity of large woody debris, for example. In addition, there is considerable spatial variation resulting from variation in channel slope, geology, aspect, vegetation, topography, etc. The in-stream and upslope targets established as part of this TMDL take into account this variation; but, in different ways. The in-stream targets are indicators that are generally collected during the summer months when stream flows are low and field crews can safely enter the stream for monitoring. (Turbidity is the exception). The indicators are ones that are directly related to factors potentially limiting the success of coho salmon in the Noyo River watershed. And, they are all related to the issue of sedimentation, either as a primary factors (e.g., % fines) or as a secondary factor (e.g., pool depth/frequency, large woody debris). If the monitoring plan is developed and implemented as envisioned, monitoring will be conducted on an annual basis for some parameters (e.g., % fines) and after storms of a specific recurrence interval for other parameters (e.g., % large woody debris). The data will be analyzed with respect to mean and maximum values per stream reach. They will be analyzed as a long-term rolling average (e.g., 10 years). And, they will be analyzed in conjunction with rainfall and/or stream flow data to ensure that climatic influences are considered. Finally, the monitoring plan will locate or propose a process for locating monitoring sites appropriate for answering specific critical questions regarding habitat value, changes in habitat over time, and impacts on habitat from upslope activities.

The upslope targets, on the other hand, are specifically designed with variation in rainfall and peak flows in mind. The road crossing failure and flow diversion targets will require regular assessment of road facilities before and after the effects of storms of a specific recurrence interval (e.g., 10 years). Conformance with the disturbance area and hydrologic connectivity targets can be assessed remotely via GIS, for example. However, they specifically track critical changes in the landscape over time that influence the rates of erosion and peak flows resulting from variable climatic events.

It is difficult to accurately predict the specific impacts of sediment loading at particular times and places on particular salmonid life stages a they occur throughout a watershed. There are substantial and poorly defined spatial and temporal lags between sediment delivery and the occurrence of sediment–related impacts on beneficial uses. Therefore, the approach taken in this TMDL is to:

- Select in-stream targets that interpret narrative WQS and address the factors potentially limiting the success of salmonids in the Noyo River watershed, including factors that are secondarily related to sedimentation such as large woody debris and peak flows;
- Establish conservative in-stream targets based on scientific literature, reference streams, and best professional judgement;
- Select upslope indicators that are directly related to management-induced sedimentation, including targets associated with sediment delivery and hydrologic modification;
- Establish conservative upslope targets based on scientific literature, reference streams, and best professional judgement; and,
- Establish conservative load allocations based on estimates of current and historic rates of sediment delivery.

If implemented as envisioned, the sediment load allocations and upslope targets will be augmented with management measures designed to increase the availability of large woody debris to the watercourse and reduce the small to moderately sized peak flows. Consideration of these additional watershed products will ensure that sediment delivery and transport processes are aided in their return to a background condition. Further, the in-stream targets should be augmented with measures to ensure that potential refuge streams are protected via restoration efforts and prioritized source control efforts.

Margin of safety

The Noyo River TMDL for sediment includes both qualitative and quantitative margins of safety. A 14% margin of safety has been incorporated into the load allocations as a means of addressing the following uncertainties:

- The degree to which the rate of management-related sediment delivery estimated for the 1933-1957 period accurately reflects that which is protective of salmonids and their habitat.
- The degree to which reductions in sediment delivery from roads alone will effectively reduce sedimentation in potential salmonid habitat throughout the watershed.

The qualitative margins of safety include the following:

- Consideration of limiting factors that are both primarily and secondarily related to sedimentation, such as percent fines (primary), V* (primary), pool depth/frequency; (secondary), and number and volume of key pieces of large woody debris (secondary)
- Development of conservative numeric targets where the scientific literature supports them (e.g., percent fines);
- Conservative assumptions, where data are sparse, regarding which limiting factors are potentially effecting coho salmon;
- Conservative assumption with respect to the direct nature of the relationship between upslope sediment production and in-stream effect;
- Development of the load allocation as a percent reduction in sediment delivery rather than an absolute sediment volume or delivery rate;
- Conservative assumption that fluvial erosion from roads is a potentially significant source of sediment delivery despite the lack of existing data.

Appendix A contains a more detailed description of the derivation of the load allocations and the accompanying margins of safety.

CHAPTER IX
IMPLEMENTATION, MONITORING, AND TIMEFRAME

An approvable Total Maximum Daily Load (TMDL) need not include an implementation plan, monitoring plan, or schedule for implementation. This TMDL, developed by the Regional Water Board, is a "technical" TMDL, only. That is, the Regional Water Board has been funded through grants from the U.S. EPA to develop the technical basis for a TMDL. Neither the U.S. EPA nor the State Water Resources Control Board have funded the Regional Water Board to develop an implementation plan, monitoring plan, schedule or conduct extensive public outreach for the Noyo River TMDL. U.S. EPA will use the Regional Water Board's "technical" TMDL to develop its own TMDL for the Noyo River which will then be circulated for public review and comment in a formal public review process. U.S. EPA does not have responsibility for developing an implementation plan, monitoring plan and schedule when it promulgates its own TMDL. The State has responsibility for establishing the means of implementation and implementing the TMDL.

The following are issues to be considered in the development of an implementation plan:

- The existing data provide an under-estimate of current sediment delivery rates. The implementation plan should include a means of identifying, mapping, and measuring and estimating actual and potential sediment delivery sites through on-the-ground, baseline surveys.
- The implementation plan should provide procedures for identifying immediate threats to water quality, especially potential refuge streams, and a means of reducing or eliminating those threats as soon as physically possible.
- The implementation plan should focus on the control of sediment delivery from road sites (i.e., timber, ranch, public, and railroad), including procedures for: inventorying roads, abandoning or obliterating roads, maintaining roads, upgrading roads, and building new roads.
- The implementation plan should include procedures for estimating the amount of disturbed area on a given property and reducing the disturbed area, over time. Similarly, it should include procedures for estimating the miles of road (i.e., timber, ranch, public and railroad) hydrologically connected to watercourses and reducing that hydrologic connection, over time. Further, the implementation plan should include procedures for inspecting stream crossings, evaluating causes of failure and diversion, and reducing the rate of stream crossing failures and diversions, over time.
- The implementation plan should include procedures identifying unstable areas and reducing the risk of sediment delivery from them, including existing landslides, inner gorges, headwall swales, other potential landslide-prone areas, and stream banks.
- The implementation plan should include procedures for characterizing the potential of the riparian zone to produce large woody debris, over time, and increasing the rate of large woody debris production. Similarly, it should include procedures for evaluating the need for large woody debris installations in potential refuge streams and identify options for their funding/implementation.

- The implementation plan should include procedures for characterizing the potential of the riparian zone to filter eroded soil prior to its discharge as sediment and increase the filtering potential, as possible.
- The implementation plan should include procedures for evaluating appropriate lag times between timber harvests, timber harvest rates, and timber harvest locations (e.g., in small drainages) to determine likely effects on peak flows, annual flows and suspended sediment. It should include procedures for increasing lag times, reducing harvest rates and reducing harvest in small drainages, over time.

The following are issues to be considered in the development of a monitoring plan:
- The monitoring plan should specifically state the hypotheses that are to be tested via monitoring as a way of assessing, over time, the degree to which the program as designed is accomplishing the goals.
- The monitoring plan should include methods, locations, and frequency of monitoring necessary to determine compliance with the load allocations.
- The monitoring plan should include methods, locations, and frequency of upslope and/or in-stream monitoring necessary to assist landowners in the identification of tributaries requiring immediate modification to management practices or mitigation.
- The monitoring plan should include methods, locations, and frequency of monitoring necessary to establish trends in habitat and stream channel conditions, over time.
- The monitoring plan should include methods, locations, and frequency of monitoring necessary to characterize regions of the watershed for which there is little or no existing data.

The following are issues to be considered in the development of an implementation schedule:
- An implementation schedule should ensure that immediate threats to water quality, especially to potential refuge streams, are reduced or eliminated as soon as physically possible.
- An implementation schedule should be as short as possible to ensure timely protection of endangered and threatened species.
- An implementation schedule should provide adequate time for landowners to assess their property and design a TMDL-sensitive management strategy.
- An implementation schedule should provide adequate time for landowners to fix existing and potential sediment delivery sites.
- An implementation schedule should ensure that any activities conducted after the adoption of a Basin Plan amendment are conducted in a manner consistent with the TMDL.
- An implementation schedule should provide adequate time for monitoring data to reflect upslope changes and changes in the in-stream environment, including changes to management-related facilities (i.e., roads, skid trails, etc.); the riparian zone; the stream bank; and instream habitat.

CHAPTER X
PUBLIC PARTICIPATION

A Total Maximum Daily Load (TMDL) which is approvable by the U.S. Environmental Protection Agency (U.S. EPA) must include ample public participation, including: public notice, public comment, and consideration of public comment. The opportunities made available for public participation are normally demonstrated with copies of public notices and a document containing comments and responses to comments.

This TMDL, developed by the Regional Water Board, is a "technical" TMDL, only. That is, the Regional Water Board has been funded through grants from the U.S. EPA to develop the technical basis for a TMDL. Neither the U.S. EPA nor the State Water Resources Control Board have funded the Regional Water Board to develop an implementation plan, monitoring plan, schedule or conduct extensive public outreach for the Noyo River TMDL. U.S. EPA will use the Regional Water Board's "technical" TMDL to develop its own TMDL for the Noyo River which will then be circulated for public review and comment in a formal public review process. U.S. EPA will hold public workshops and/or hearings, as necessary, to ensure adequate public consideration of their proposed TMDL prior to its final approval. Regional Water Board staff will participate, as needed, in the public forums.

Regional Water Board staff, mean while, will develop an implementation plan, monitoring plan, and schedule for its "technical" TMDL. The implementation plan, monitoring plan, and schedule will form the basis for a proposed amendment to the Regional Water Board's Basin Plan. At the point that a draft of the implementation plan, monitoring plan, schedule, and proposed Basin Plan amendment are ready for public review, the Regional Water Board will circulate these materials and the "technical" TMDL as part of a formal, State-sponsored, public review process. The formal public review process will include opportunities to review and comment on draft and final proposals both in writing and in public forums. The Regional Water Board will consider the adoption of an amendment to its Basin Plan that describes the means by which a TMDL for the Noyo River watershed is to be implemented and monitored and the schedule for action. Once the Basin Plan is amended, the TMDL will become an enforceable program of the Regional Water Board.

To date, the Regional Water Board has solicited the following public involvement:

- A newsletter (*Noyo River Watershed News: Watershed Planning for the Future,* Winter 1998/99) was sent to the Noyo River mailing list requesting information and data relevant to the development of the TMDL (January 1999)
- Telephone and face-to-face meetings were conducted with those who responded to the request for information/data (February-May 1999)
- A rough draft of the TMDL and summary of existing supporting data was circulated to interested parties for review and comment (May 1999)
- Comments were considered in the development of the final draft of the TMDL (May-June 1999)

- A newsletter (*Noyo River Watershed News: Watershed Planning for the Future,* Summer 1999) was sent to the Noyo River mailing list announcing the availability of the final draft of the TMDL for review (June 1999)
- The final draft of the TMDL and supporting document were circulated to interested parties for review
- Comments were considered in the development of the final TMDL (June-August 1999)

Appendix B contains copies of the newsletters that have been circulated.

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TABLES

FIGURES

APPENDIX A

APPENDIX B