U.S. Environmental Protection Agency
Region IX

Albion River
Total Maximum Daily Load
for Sediment

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Approved by:

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CHAPTER 1: INTRODUCTION

The Albion River Total Maximum Daily Load (TMDL) for Sediment is being established in accordance with Section 303(d) of the Clean Water Act, because the State of California has determined that the water quality standards for the Albion River are exceeded due to sediment. In accordance with Section 303(d), the State of California periodically identifies those waters that are not meeting water quality standards. In its latest Section 303(d) list, adopted through Resolution 98-45 on 23 April 1998, the North Coast Regional Water Quality Control Board (Regional Water Board) identified the Albion River as impaired due to elevated sedimentation.

In accordance with a consent decree (*Pacific Coast Federation of Fishermen's Associations, et al. v. Marcus*, No. 95-4474 MHP, 11 March 1997), 2001 is the deadline for establishment of this TMDL. Because the State of California will not complete adoption of a TMDL for the Albion River by this deadline, EPA is establishing this TMDL, with assistance from Regional Water Board staff.

The primary adverse impacts associated with excessive sediment in the Albion River pertain to the anadromous salmonid fishery. The water quality conditions do not adequately support several anadromous salmonid species present in the Albion River and its tributaries, which has contributed to severe population declines. The populations of coho salmon (*Oncorhynchus kisutch*), chinook salmon (*O. tshawytscha)*, and steelhead trout (*O. mykiss*) in this watershed are all listed as threatened under the federal Endangered Species Act.

The purpose of the Albion River TMDL is to identify the total load of sediment that can be delivered to the Albion River and its tributaries without causing exceedence of water quality standards, and to allocate the total load among the sources of sediment in the watershed. Although factors other than excessive sediment in the watershed may be affecting salmonid populations (e.g., ocean rearing conditions), this TMDL focuses on sediment in the watershed, the pollutant for which the Albion River is listed under Section 303(d). EPA expects the Regional Water Board to adopt the TMDL and to develop an implementation strategy that will result in implementation of the TMDL in accordance with the requirements of 40 CFR 130.6. The load allocations, when implemented, are expected to result in the attainment of the applicable water quality standards for sediment for the Albion River and its tributaries.

1.1. Information Sources

Information for this TMDL came from a variety of sources. Much of the analysis is summarized from an assessment of watershed conditions conducted by staff of the North Coast Regional Water Quality Control Board (NCRWQCB 2001a, 2001b), and a sediment source analysis developed by Graham Matthews and Associates (GMA 2001), who conducted the analysis for EPA as a subcontractor to Tetra Tech, Inc. Primary sources of data for those studies were: the California Department of Fish and Game (CDFG), California Department of Forestry and Fire Protection (CDF), U.S. Geological Survey (USGS), Mendocino Redwood Company, LLC (MRC) and its predecessor, Louisiana-Pacific, Inc. (LP), and Campbell Timberlands Management and its predecessor, Georgia-Pacific West, Inc. (Campbell/GP). DFG provided historic aquatic surveys as well as some fish distribution and aquatic habitat data. CDF provided Timber Harvest Plan (THP) data. USGS provided stream flow and topographic data. MRC and Campbell/GP provided data and qualitative assessments of watershed conditions. MRC's Level 2 watershed analysis for their ownership on the Albion River watershed was used for sediment source information as well as instream conditions. Most sources cited in this TMDL were originally cited in NCRWQCB (2001a, 2001b) and GMA (2001). Additional detail can be found in the two supporting documents.

1.2. Watershed Characteristics

The Albion River drains a 43.0 mi^2 watershed located in the northern California Coast Range in western Mendocino County (Figure 1), entering the Pacific Ocean at the town of Albion, about 16 miles south of Fort Bragg. It drains primarily from the east to the west, sharing ridges with the Big River watershed to the north and northeast and the Navarro River watershed to the southeast and south. There is relatively little human occupation in the watershed, with scattered ranches and residences, and only one small town, Comptche. The town of Albion is located at the base of the watershed, at Highway 1. Elevations within the Albion River watershed range from sea level at the basin outlet to 1,566 feet. The basin is almost entirely privately owned, with MRC owning about 54% of the watershed. Smaller industrial timberland ownerships, a few ranches, and numerous small parcels, typically private residences, make up the balance. No other property owner owns more than 5% of the watershed. The eight largest property owners own about 70% of the watershed. Over a third of the parcels are less than 5 acres, but these parcels comprise only 2% of the watershed. Public ownership is limited to several parcels owned by Mendocino County and various school districts and community services districts.

The Mediterranean climate in the watershed is characterized by a pattern of low-intensity rainfall in the winter and cool, dry summers with coastal fog. Mean annual precipitation varies from about 38 inches at Fort Bragg near the western margin of the watershed to over 55 inches at Willits to the east (GMA 2001). About 90% of the precipitation in this area falls between October and April, with the highest average precipitation in January (CDF 1999, in NCRWQCB 2001a, 2001b). Snowfall in this watershed is very rare and hydrologically insignificant (CDF 1999, in 2001a, 2001b). Large flood events are thus generally associated with intense periods of rainfall, rather than rain-on-snow events. Only limited stream gauging records exist for the Albion River watershed, having been collected by the USGS from 1961 to 1969.

The watershed is dominated by two distinct landforms: the relatively flat marine terraces extending several miles inland, and the intervening deeply incised inner gorges of the major river channels and streams that dissect these surfaces. The western end of the Albion River is distinguished by a drowned and filled estuary occupying a relatively narrow inner gorge characterized by steep slopes that extend up to the flat coastal terraces. Tidal influence extends as much as five miles up the river (Maahs and Cannata 1998, in NCRWQCB 2001a, 2001b). The central part of the watershed is generally characterized by narrow incised drainages. Steep slopes and narrow summits and ridgelines border these drainages. The headwaters area is characterized by moderate relief and relatively wide valleys, although these valley floors are rarely functional floodplains due to the incised nature of the present channel system. Existing floodplains are generally quite narrow. Redwood and Douglas Fir forest dominate the Albion River watershed (Dolphin 1996, in NCRWQCB 2001a, 2001b).

The geology of the Albion River watershed is primarily comprised of Coastal Belt Franciscan Complex. A large part of the geology of the upper Albion River watershed is Coastal Belt Franciscan Complex – greenstone formation. Terrace deposits are found in the upper Albion River watershed around Comptche and around the North Fork Albion above Soda Spring Creek. Marine Terrace deposits are in the lower Albion River watershed Small deposits of Quaternary sedimentary rocks and areas of alluvial fan/colluvium are found in limited locations (GMA 2001).

History

The history of the Albion River watershed is dominated by timber harvest. The following brief history has been compiled from Carranco and Labbe (1975), Andrews (1985, 1994), and Mendocino County Historical Society (1996), as described in GMA 2001. Logging began in the lower basin about 1852, around the time that the first mill was constructed near the lagoon upstream from the mouth of the Albion River. The capacity of the mill was quite small initially, but was expanded to well over 10 times its original capacity by 1906. The Albion River Railroad, later sold to Southern Pacific Railroad, began in 1885. The first mill operated until 1928. A number of smaller mills operated in the Comptche area between the mid 1930s and the 1960s.

Early harvesting employed hand methods and teams of oxen. The logs were hauled or floated to the mill at the mouth of the river. Five temporary dams that were used have been documented in the Albion River watershed for transport of logs to the downstream mill (Mendocino County Historical Society 1964). It is probable that these were only used in the early years before the expansion of the railroad system. Railroad logging appears to have been the primary method of removing timber through the closure of the mill in 1928. Following the closure of the railroad in 1930, most of the railroad grades were converted to roads, as tractor logging and hauling by truck became the principal method of harvesting.

Since 1940, tractor yarding and the construction of roads, skid trails and landings have been the primary types of logging practices. Until the Forest Practices Act was passed in 1973, logging practices were unregulated. This Act required road construction and timber harvesting practices intended to protect aquatic habitat and watershed resources. During the past twenty years, the use of cable yarding on steeper slopes has increased substantially, and tractor logging is generally restricted to gentler slopes. Cable yarding creates far less ground disturbance than tractor yarding. Tractor yarding is still responsible for a significant amount of the harvest on some ownerships.

Relative to the 1890-1928 period, harvest levels were apparently far lower between 1930 and 1960, because the forest was fairly well depleted and was left to regenerate. Current harvest levels have increased significantly with the maturity of second growth forests.

Planning Watersheds

The Albion River watershed is divided into four Planning Watersheds ("PW"), corresponding to the CalWater California Watershed Map watersheds (Interagency California Watershed Mapping Committee 1999 in NCRWQCB 2001a, 2001b). These are shown in Figure 1 (frontispiece) and described in Table 1. The PWs range in size from 7.6 to 13.6 mi^2, and are generally divisions of the Albion River mainstem and its associated tributaries. The four PW have been divided again into a total of 8 Sub-Watersheds ("SW"), ranging in size from 4.0 to 7.6 mi^2.

1.3. Endangered Species Act Consultation

EPA initiated informal consultation with the National Marine Fisheries Service and the U.S. Fish and Wildlife Service (the Services) on this action, under Section 7(a)(2)of the Endangered Species Act (ESA). Section 7(a)(2) states that each federal agency shall ensure that its actions are not likely to jeopardize the continued existence of any federally-listed endangered or threatened species. EPA's consultation with the Services has not yet been completed. EPA believes it is unlikely that the Services will conclude that the Total Maximum Daily Load (TMDL) that EPA is establishing violates Section 7(a)(2), since the TMDL and load allocations are calculated in order to meet water quality standards, and water quality standards are expressly designed to "protect the public health or welfare, enhance the quality of water and serve the purposes" of the Clean Water Act, which are to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." Additionally, this action will improve existing conditions. However, EPA retains the discretion to revise this action if the consultation identifies deficiencies in the TMDL or allocations.

Table 1. Planning Watersheds

Planning Watershed Sub-Watershed	Major Tributaries	Approx. Size (sq. mi.)
Upper Albion (CalWater 113.40003)		**13.6**
North Fork Albion	Soda Spring Creek	5.2
Upper Albion	McDonald Gulch, Marsh Creek	8.4
Middle Albion (CalWater 113.40002)		**7.6**
Middle Albion	Tom Bell Creek, Kaisen Gulch, East Railroad Gulch	7.6
South Fork Albion (CalWater 113.40003)		**9.1**
Lower South Fork Albion	Anderson Gulch, Norden Gulch, Little North Fork Albion	4.0
Upper South Fork Albion	Bull Team Gulch, Winery Gulch	5.1
Lower Albion (CalWater 113.40001)		**12.6**
Albion Estuary		4.1
Lower Albion	Duck Pond Gulch	4.0
Railroad Gulch	Pleasant Valley Creek, Railroad Gulch	4.5
TOTAL	**Albion River Watershed**	**43.0**

1.4. Organization

This report is divided into seven chapters. Chapter 2 (Problem Statement) describes the nature of the environmental problem addressed by the TMDL. Chapter 3 (Water Quality Indicators) identifies specific stream and watershed characteristics to be used to evaluate whether the Albion River is attaining water quality standards. Chapter 4 (Source Analysis) describes what is currently understood about the sources of sediment in the watershed. Chapter 5 (TMDL and Allocations) identifies the total load of sediment that can be delivered to the Albion River and its tributaries without causing exceedence of water quality standards, and describes how EPA is apportioning the total load among the sediment sources. Chapter 6 (Implementation and Monitoring Recommendations) contains recommendations to the State regarding implementation and monitoring of the TMDL. Chapter 7 (Public Participation) describes public participation in the development of the TMDL.

CHAPTER 2: PROBLEM STATEMENT

This chapter summarizes how sediment is affecting the beneficial uses of the Albion River and its tributaries associated with the decline of the cold water salmonid fishery. It includes a description of the water quality standards and salmonid habitat requirements related to sediment, and a qualitative assessment of existing instream and watershed conditions in the Albion River basin.

2.1. Water Quality Standards

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

The beneficial uses and water quality objectives for the Albion River are contained in the *Water Quality Control Plan for the North Coast Region* (Basin Plan) as amended in 1996 (NCRWQCB 1996). The beneficial uses impaired by excessive sediment in the Albion River are primarily those associated with the Albion River's salmonid fishery, specifically: Commercial or Sport Fishing (COMM), Cold Freshwater Habitat (COLD), Estuarine Habitat (EST), Migration of Aquatic Organisms (MIGR), and Spawning, Reproduction, and/or Early Development (SPWN).

The Basin Plan (NCRWQCB 1996) identifies both numeric and narrative water quality objectives for the Albion River. Those pertinent to the Albion River TMDL are listed in Table 2.

Table 2. Water Quality Objectives Addressed in the Albion River TMDL

Parameter	Water Quality Objective
Suspended Material	Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.
Settleable Material	Waters shall not contain substances in concentrations that result in deposition of material that causes nuisance or adversely affect beneficial uses.
Sediment	The suspended sediment load and suspended sediment discharge rate of surface water shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.
Turbidity	Turbidity shall not be increased more than 20 percent above naturally occurring background levels. Allowable zones of dilution within which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof.

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

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

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

2.2. Decline of Salmon and Steelhead

Some surveys have been conducted to estimate presence or absence of coho and steelhead in selected stream segments in the Albion River watershed, but no information is available for chinook (the chinook population is likely extremely low). The NCRWQCB (2001a, 2001b) summarized what is known about salmonid populations on the Mendocino Coast. The following is abstracted from that summary.

There are no quantitative data from which to estimate the historic population size of coho and steelhead in the Albion River watershed, although there is general agreement that the populations of both have decreased substantially and continue to decline. Although greatly reduced from historical levels, coho and steelhead are found throughout most of the basin. Coho have declined more significantly than steelhead, and population levels appear to be severely depressed (NMFS 2001).

It is believed that native California coho populations have declined by 80 to 90% from their numbers in the 1940s (Brown et al. 1994; Weitkamp et al. 1995; Clark 1988, as cited by Hassler et al. 1991, in NCRWQCB 2001a, 2001b). Steelhead populations also are in decline. Statewide, Brown et al. (1994, in NCRWQCB 2001a, 2001b) cited sources stating that there were approximately 200,000 to 500,000 coho spawning in the 1940s. They estimated that the statewide population had declined to about 100,000 fish in the 1960s and about 30,000 in 1984-1985. The NMFS status review of west coast steelhead concluded that steelhead stocks in the northern California ESU are very low relative to historic estimates, and recent trends are also downward (Weitkamp et al. 1995, NCRWQCB 2001a, 2001b).

There are no known quantitative analyses of historic salmonid abundance and distribution specific to the Albion River watershed. The coho population was recently estimated at 4,950 fish in Mendocino County (Brown et al., 1994; Weitkamp et al. 1995, in NCRWQCB 2001a, 2001b). Adams et al. (1999, in NCRWQCB 2001a, 2001b) reported that coho are found in 51% of the streams in which they were historically present in California and 64% of the streams in Mendocino County in which they were historically present.

Declining numbers of salmonids led the National Marine Fisheries Service to list several populations under the federal Endangered Species Act. The populations of coho, chinook, and steelhead in the Albion River and its tributaries have been listed as threatened (i.e., they are likely to become endangered in the foreseeable future). Coho in the Albion River and its tributaries are included in the population known as the Central California Coast Evolutionarily Significant Unit (ESU), which was listed by NMFS as threatened in 1996. Chinook in the Albion River and its tributaries are included in the California Coast ESU, which was listed as threatened in 1999. Steelhead in the Albion River and its tributaries are included in the Northern California ESU, which was listed as threatened in 2000.

2.3. Fishery Information Specific to the Albion Watershed

CDFG Surveys. Various qualitative surveys of fish presence and absence or habitat conditions were conducted by CDFG beginning in the 1960s. Even in that early period, surveyors noted very poor conditions. On the mainstem Albion River and the South Fork Albion River above the Little North Fork, CDFG attributed low numbers of coho to poor conditions related to effects from logging and post-logging fires, although numbers increased slightly by 1966. By contrast, the lower South Fork Albion, below the Little North Fork confluence, was deemed to have excellent spawning grounds and fair nursery grounds. Poor conditions were also found in the North Fork, Railroad Gulch, and Morrison Gulch in 1961. In 1962, Kaisen Gulch appeared to support some steelhead and coho (CDFG 1961a, 1961b, 1961c, 1961d, 1961e, 1966a, 1966b, in NCRWQCB 2001a, 2001b). CDFG also conducted fish counts in 1983 and 1996, finding only 2 young-of-year coho in 1983 and no yearlings on the mainstem. In 1996, they found 19 young-of-year coho and no yearlings, and 21 young-of year coho on the North Fork. They found 6 young-of-year steelhead and 2 yearlings in 1983, and 16 young-of-year and 7 yearling steelhead in 1996 in the Albion. Two young-of-year steelhead were counted in the North Fork (CDFG, unpublished data, in NCRWQCB 2001a, 2001b).

MRC Surveys. MRC reported on presence of juvenile coho and steelhead in the Albion and South Fork Albion from 1993-1995, finding from 7-154 coho and 52-211 steelhead at various stations, depending on the year (Daugherty 1996, in NCRWQCB 2001a, 2001b). Fish surveys from 1994 to 1996 at 33 sampling locations in the watershed were also conducted by MRC (2000a, in NCRWQCB 2001a, 2001b). Coho were reported at 20 of the 33 stations, including 10 in the Lower Albion PW, 7 in the Middle Albion PW, and two in the South Fork Albion PW. Yearlings were observed in Railroad Gulch, lower and middle Albion, South Fork and North Fork Albion. All other coho that were observed were young-of-year fish. No coho were found at three stations in the Lower Albion PW, one station in the Middle Albion PW, four stations in the South Fork Albion PW, and two stations in the Upper Albion PW. Steelhead are not in as great a decline as are coho. The same study from 1994-1996 found steelhead (young-of-year, yearling and two-year fish) at all stations except for Deadman Gulch, in the Lower Albion PW.

Upper Albion Survey. Wehren (1996, in NCRWQCB 2001a, 2001b) sampled stations in the upper Albion mainstem and North Fork in the winter of 1995-96 and estimated between 4-43 coho (depending on the estimation method), and few steelhead.

Hatchery Fish. While it is probable that some hatchery fish were released into the Albion River watershed, it is likely that most of the fish observed in the watershed are of native origin (G. Bryant, NMFS, pers. comm., 2000).

2.4. Salmonid Life Cycle and Water Quality Requirements

The Albion River TMDL addresses sediment impairments to water quality. Salmonids are affected by a number of factors, some of which (e.g., ocean rearing conditions) occur outside of the watershed. This TMDL focuses on achievement of water quality standards related to sediment, which will facilitate, but not guarantee, population recovery.

Salmonids have a five-stage life cycle. Healthy habitat conditions are crucial for the survival of each life stage. First, adult salmonids lay their eggs in clean stream or lake gravels to incubate. Second, the eggs hatch into alevins, which depend upon the water flow through the gravel to survive and grow. Then the young fish (known as fry at this stage) emerge from the gravel and seek shelter in the pools and adjacent wetlands. Third, juvenile fish leave the stream or lake, migrate downriver, and reside in the estuary to feed and adjust to saltwater for up to a year before continuing onto the ocean. Fourth, juvenile fish mature in the ocean. And fifth, adult fish return to their home stream or lake to spawn. This cycle from freshwater spawning areas to the ocean and back defines Pacific salmonids as “anadromous.” Most Pacific salmonids die after spawning: their total energies are devoted to producing the next generation, and their bodies help enrich the stream for that generation.

Salmonids have a variety of requirements related to sediment, which vary by life stage. Sediment of appropriate quality and quantity (dominated by gravels, without excess fine sediment) is needed for redd (i.e., salmon nest) construction, spawning, and embryo development. Excessive quantities of sediment or changes in size distribution (e.g., increased fine sediment) can adversely affect salmonid development and habitat.

To build the redd, the salmon needs an adequate supply of appropriately sized gravel, which varies by species but is generally around 64 mm. The female salmon turns horizontally, parallel to the channel bed, and uses her tail fin to slap the gravel, moving it downstream. She then lays her eggs, while the male swims beside her to fertilize the eggs. The excavated area where the eggs have been deposited is then covered by the female using the same technique, moving the gravel onto the nest from just upstream. With adequate water flow, the process of moving the gravels also serves to clean some of the fine sediment out of the redd. Additional fine sediment may be deposited from winter flood flows, while the eggs are incubating.

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

Excessive fine or coarse sediment can also adversely affect the quality and availability of salmonid habitat by changing the morphology of the stream. It can reduce overall stream depth and the availability of shelter, and it can reduce the frequency, volume, and depth of pools. CDFG habitat data indicate that coho in Northern California tend to be found in streams that have as much as 40% of their total habitat in primary pools (Flosi et al. 1998). Pools in first- and second-order streams are considered primary pools when they are at least as long as the low-flow channel width, occupy at least half the width of the low-flow channel, and are two feet or more in depth. Primary pools in third-order and larger channels are defined similarly, except that pool depth should be three feet or more. Pools provide salmon with protection from predators, food supplies, and resting locations.

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

2.5. Habitat Conditions in the Albion River Watershed

In general, the most sensitive beneficial use in the Albion River watershed – protection of the cold water fish species – is limited by habitat conditions that include excess sediment, lack of complex, deep pools, fair to poor spawning gravels and limited shelter. Excess sediment is adversely impacting the number and volume of pools. Sediment is also causing a moderate to high embeddedness of substrate and spawning gravels in the basin. Shelter is poor throughout the basin. In general, habitat conditions in most locations in the watershed are moderately degraded. However, recently increased road building and timber harvest activities may cause additional degradation in the future, not yet reflected in current stream habitat conditions. Conditions are more degraded in the South Fork PW than in the other three planning watersheds. Low dissolved oxygen concentrations in the estuary may be a limiting factor for salmonid use of the estuary (NCRWQCB 2001a, 2001b).

Coho salmon and steelhead spawn and rear in the watershed; however, both species are present in very low numbers compared to historic levels and are continuing to decline. Steelhead are relatively more abundant and have more age classes represented than do coho. Chinook may also be present in the Albion River, but in very low numbers. Relative to some watersheds on the Mendocino Coast, habitat decline is not as severe, and coho are slightly more abundant in the Albion watershed.

2.6. Influence of Historic Harvest Practices on Channel Conditions

It is well known that historic logging practices, including the typical harvest sequence of falling, burning, yarding by Dolbeer donkey, and railroad transport, were highly destructive and have had long-term, pervasive effects on the stream channels of many watersheds. One of the most damaging logging practices in Mendocino County involved the construction and operation of artificial dams to transport logs downstream. This was a widely used practice in Mendocino County, particularly where difficult access precluded more reliable transportation methods (i.e., railroads), and has been documented in the nearby Big River and Caspar Creek watersheds. In the Albion watershed, at least five dam sites that were used in a synchronized fashion to transport logs downstream have been identified (Mendocino County Historical Society 1964, in GMA 2001).

During the winter, when the reservoirs behind the dams were full, the gates were tripped, timed so that a flash flood would move downstream, picking up tiers of logs that had been carefully stacked in channels downstream. These "log drives" could occur one or more times per winter. Before these log drives could be undertaken, however, the entire stream channel between the dam and the estuary had to be cleared of any obstructions that would interfere with the downstream movement of the logs, which involved cutting, burning, and blasting of boulders, large rocks, leaning trees, sunken logs or obstructions of any kind (Brown 1936, in GMA 2001). Because these activities were not documented in the Albion River, it is not known precisely how the dams were operated. However, it is likely that they were operated similarly to those in the Big River, which were documented. Construction of the railroad probably resulted in an end to the logging dam activity, since it was a more reliable way to move logs.

The geomorphic effect of logging dam operation and associated channel clearing on downstream channels must have been immense. The greatly increased peak flows, combined with the battering-ram effect of transport of thousands of logs, would likely have caused channel erosion and incision. Removal of all in-channel debris jams undoubtedly released a tremendous amount of sediment that had previously been stored behind these jams. In the Caspar Creek watershed, Napolitano (1996, 1998, in GMA 2001) concluded that the log drives resulted in channel incision, and the current entrenched condition indicates that valley fills have been converted from long-term sediment sinks (floodplains) to substantial sediment sources (terraces). Napolitano (1998, in GMA 2001) found this conversion to be a major change of trends in valley sediment storage and a pervasive alteration in the sediment budget for the basin. Furthermore, the channel has not recovered its previous morphology because jams in the channel are now less stable due to the more deeply entrenched geometry that concentrates stream energy. Comparison of old-growth to second-growth channels also shows that pools are much more frequent and their average depth is greater in the old-growth channels (Keller et. al. 1981, Montgomery et. al. 1995, in GMA 2001).

Although data do not exist to confirm explicitly that a similar sequence of events occurred in the Albion River watershed, the current condition certainly resembles that in Caspar Creek of a deeply entrenched stream system, in many places cut down to bedrock, lacking functional floodplains, and substantially depleted in large instream woody debris. Lack of instream log jams is allowing sediment delivered to the main channels to move through the system far more quickly, and ultimately reach the estuary in greater quantities, than historically occurred pre-disturbance. The recovery from these historic practices was hindered in relatively recent times by CDFG log jam removal programs, which were documented by MRC (1999, in NCRWQCB 2001a, 2001b), which occurred through much of the channel system in the 1960s.

Generally speaking, comparison of 1936 or 1952 aerial photos with the 2000 photos provides an indication that there has been a substantial increase over the period in road density, an increase in tree density and height (and thus canopy closure in most riparian areas), little visible change in channel planform, and the return of many cleared areas in lower portions of the watershed to forest. In part, the increased height and canopy cover reflects the regeneration of the second-growth forest. The increased road density is clearly linked to the increase in timber harvest as the trees have matured. Evidence of recent harvest is visible in some areas, including the Middle and South Fork Albion PWs. The Upper Albion River PW showed fewer new roads than other areas (GMA 2001).

The following summarizes conditions in each of the four PW. Chapter 3 describes data and qualitative information for the watershed relative to targeted water quality conditions.

Upper Albion River PW

There is little information on stream conditions and salmonid population in the Upper Albion River planning watershed. Limited surveys found relatively good spawning habitat with moderately embedded to unembedded gravels. The rearing habitat is fair due to shallow pools and low shelter complexity. The overwintering habitat is good with LWD and frequent pools (NCRWQCB 2001a, 2001b). A significant number of water diversions in this PW, mainly along Marsh Creek in the vicinity of Comptche, may also be influencing sediment transport and deposition by limiting the water supply (EPA unpublished document, 2001).

Air Photo Comparison. Few roads are visible in early air photos, except in the vicinity of the North Fork. The upper basin near the North Fork is sparsely vegetated, much of it becoming more densely vegetated by the 2000 photos. There are few roads visible in early photographs, and fewer new roads visible in the 2000 photo than in other areas of the watershed (GMA 2001).

Middle Albion River PW

The Middle Albion River spawning habitat is fair with moderate to low levels of embeddedness and fair to good gravel quality. East Railroad Gulch has relatively unembedded spawning gravels. The overall rating for spawning habitat in the Middle Albion is negatively affected by the amount of fine sediment in the watercourses. Rearing habitat was negatively affected by the low percentage of deep pools. Overall, the Middle Albion subwatershed has sparse LWD (NCRWQCB 2001a, 2001b).

Air Photo Comparison. In early air photos, roads were not visible and the railroad grade was difficult to find. By 2000, an extensive road network had been constructed, and landings and cable yarding corridors were the most readily apparent feature. Evidence of extensive recent harvest was visible. Trees appear to be taller in the 2000 photo than in earlier photos (GMA 2001).

South Fork Albion River PW

The South Fork planning watershed has by far the highest sediment input to watercourses in the Albion River watershed, with most of the sediment coming from roads. The habitat quality is adversely affected by the amount of embeddedness of spawning gravels and the abundant deposition of fine sediment. The spawning gravels on the South Fork Albion River are of lower quality than those on the mainstem and other areas in the watershed. Although LWD and deep pools are ample, rearing habitat is only fair due to low numbers of pools, the high levels of embeddedness and lack of shelter complexity. In various population surveys, the numbers of observed coho were highest or second highest in the streams of the South Fork planning watershed, notwithstanding the low total number of pools and the high reported water temperatures. The greater density of coho in this subwatershed as compared to other tributaries in the Albion River watershed may be partially explained by the availability of deeper pools (NCRWQCB 2001a, 2001b).

Air Photo Comparison. In 1936, the only visible road was the former railroad grade, but by 2000 an extensive road network had been developed. Sparsely vegetated areas have become dense by 2000, and harvest areas are now visible in aerial photographs (GMA 2001).

Lower Albion River PW

The habitat quality of the Lower Albion is fair, limited by low shelter complexity. Compared to the rest of the watershed, only in the Lower Albion do pools of at least three feet in depth comprise a sizeable portion of the reach. The canopy closure is fair to good. Low dissolved oxygen concentrations may be related to excess sediment, shallower water due to sediment deposition, increased vegetation, lower water flows, or some combination of these and other factors. Shallower depths from sediment deposition may also be causing additional problems for other beneficial uses

The mouth of the river is defined by a narrow opening along the south side of the bay protected by rock headlands, allowing the stream to remain open to the sea year-round, which is fairly unusual for small to medium-sized coastal watersheds. The estuary is currently used as a commercial fishing, sport fishing, and recreational boat harbor. Historically, the estuary was extensively used as a mill pond for the transport and storage of logs. As a result of this development, significant changes to the estuary likely occurred, although quantitative information does not exist. Photos from the late 19^{th} and early 20^{th} century indicate that the channel at the mouth widened with the expansion of mill operations. A variety of anecdotal sources cited by Maahs and Cannata (1998, in GMA 2001) estimated the average depth of the estuary at 20 to 25 feet deep in the 1940s, average depth of five feet with a maximum depth of 20 feet in 1961, and average depth of 8 feet in 1966. It is not clear why the estuary would have been deepest in the 1940s, since considerable landsliding was taking place in that period, although it is possible that transport from the upper part of the watershed to the estuary had not yet occurred.

Air Photo Comparison. Changes over the 1921-2000 time period that are obvious from aerial photographs include a noticeable increase in the number and widths of roads, a modest increase in residential development, reforestation of areas apparently previously cleared for haying or grazing, and an increase in the overall age and density of the forest stands (GMA 2001).

CHAPTER 3: WATER QUALITY INDICATORS

This chapter identifies water quality indicators. They are interpretations of the water quality standards expressed in terms of instream and watershed conditions. For each indicator, a target value is identified to define the desired condition for that indicator. EPA expects that these indicators, and their associated target values, will provide a useful reference in determining the effectiveness of the TMDL in attaining water quality standards, although they are not directly enforceable by EPA.

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

Both instream and watershed indicators are appropriate to use in describing attainment of water quality standards. Instream indicators reflect sediment conditions that support salmonids. They relate to instream sediment supply and are important because they are direct measures of stream "health." Watershed indicators describe conditions that reflect protection against future degradation of water quality. These indirect measures of stream health support the antidegradation policy by focusing on imminent threats to water quality that can be detected and corrected before the sediment is actually delivered to the stream. Watershed indicators are often easier to measure than instream indicators, and they identify conditions in the watershed needed to protect water quality.

Both instream and watershed indicators are set at levels associated with well-functioning stream systems. This TMDL contains both instream and watershed indicators in order to improve water quality in the short-term and long-term, by protecting from immediate and future threats of degradation. Watershed indicators reflect conditions in the watershed at the time of measurement, whereas instream indicators can take years or decades to respond to changes in the watershed, because linkages between hillslope sediment production and instream sediment delivery are complicated by time lags from production to delivery, instream storage, and transport through the system. Accordingly, watershed targets can potentially be achieved sooner than instream targets, and can serve as checks on the progress toward achievement of water quality standards.

In addition, both types of indicators are included to help ensure the attainment of water quality standards throughout the system. Watershed indicators tend to reflect local conditions, whereas instream indicators often reflect conditions from unknown locations upstream or up-basin as well as local conditions. Meeting target watershed conditions helps ensure that instream conditions will be met.

3.1. Summary of Water Quality Indicators and Targets

Table 3 lists the water quality indicators for the Albion River TMDL and their respective target values. In several cases, targets are expressed as improving trends, since information on watershed processes is inadequate to develop appropriate thresholds.

Table 3. Water Quality Indicators and Targets

INDICATOR	TARGET	DESCRIPTION	PURPOSE	REFERENCES
Instream	Monitoring recommendations: annually (e.g., sediment substrate, embeddedness, V*, aquatic insect abundance) or periodically following large storms (thalweg profile, pool distribution, turbidity, LWD)			
Sediment Substrate Composition	$\leq$ 14% < 0.85 mm $\leq$ 30% < 6.4 mm	McNeil (bulk) sample during low-flow period, at riffle heads in potential spawning reaches	Indirect measure of spawning support: improved quality & size distribution of spawning gravel	Burns 1970, CDF 1994, McHenry et al. 1994, Mangelsdorf & Lundborg 1998, Valentine 1997 (in EPA 1998b, EPA 1999)
Riffle Embeddedness	$\leq$ 25% or improving (decreasing) trend toward $\leq$ 25%	Estimated visually at riffle heads where spawning is likely, during low-flow period	Indirect measure of spawning support; improved quality & size distribution of spawning gravel	Flosi et al. 1998, Mangelsdorf & Clyde 2000, Mangelsdorf & Clyde 2000
V*	< 0.21 (Franciscan) or < 0.10 (other)	Residual pool volume. Measure during low-flow period.	Estimate of sediment filling of pools from disturbance	Lisle & Hilton 1992, Knopp 1993, Lisle 1989 (in EPA 1999); Lisle & Hilton 1998
Thalweg profile	increasing variation from the mean	Measured in deposition reaches during low-flow period.	Estimate of improving habitat complexity & availability	Trush 1999, Madej 1999 inEPA 1999
pool/riffle distribution & depth of pools	increasing trend toward >40% length in primary pools	Primary pools (>2' in low order, >3' in 3rd & higher order), measured low-flow period.	Estimate of improving habitat availability	Flosi et al. 1998
Estuary depth	increasing trend	Overall deepening	Estuary beneficial uses	NCRWQCB 2001a, 2001b
Turbidity	˜ 20% above naturally occurring background	Measured during storm flows. Future data may suggest a modified turbidity indicator	Indirect measure of overall water quality, feeding/growth ability related to sediment, protection of water supplies	Basin Plan (NCRWQCB 1996)
Aquatic Insect Production	improving trends	EPT, Richness & % Dominant Taxa indices.	Estimate of salmonid food availability, indirect estimate of sediment quality.	Bybee 2000, Plafkin et al. 1989, in EPA 1998b
Large Woody Debris (LWD)	increasing dist., vol. & no. of key pieces	Incr. no. & vol. key pieces or incr. dist. LWD-formed habitat.	Estimates improving habitat availability	Flosi et al. 1998
Watershed	Monitor recommendations: pre-winter			
Diversion potential & stream crossing failure potential	$\leq$ 1% of crossings divert or fail in 100 yr storm	Measured prior to winter.	Estimate of potential for reduced risk of sediment delivery from hillslope sources to the watercourse	Weaver and Hagans 1994, Flanagan et al. 1998, in EPA 1998a
Hydrologic connectivity of roads	decreasing length of connected road to $\leq$ 1%	Measured prior to winter.	Estimate of potential for reduced risk of sediment delivery from hillslope sources to the watercourse	Ziemer 1998 in EPA 1999; Flanagan et al. 1998, Furniss 1999 in EPA 1998a
Annual road inspection & correction	increasing proportion of road to 100%	Roads inspected and maintained, or decommissioned or hydrologically closed prior to winter. No migration barriers.	Estimate of potential for reduced risk of sediment delivery from hillslope sources to the watercourse	EPA 1998a
Road location, surfacing, sidecast	decr. length next to stream, incr. % outsloped and hard surfaced roads	see text	Minimized sediment delivery	EPA 1998a
Activities in unstable areas	avoid and/or /eliminate	Subject to geological/ geotechnical assess. to minimize delivery and/or show no increased delivery would result	Minimized sediment delivery from management activities	Dietrich et al. 1998, Weaver and Hagans 1994, PWA 1998, in EPA 1999
Disturbed area	decrease	see text	Measure of chronic sediment	Lewis 1998, in EPA 1999.

3.2. Instream Indicators

Sediment Substrate Composition

Target: ≤ 14% fines < 0.85 mm, ≤ 30% fines < 6.4 mm

The indicator and target selected represent adequate spawning, incubation, and emergence conditions relative to substrate composition. Excess fine sediment can decrease water flow through salmon redds. Sufficient water flow through the redd is critical for maintaining adequate oxygen levels and removing metabolic wastes. Deposits of these finer sediments can also prevent the hatching fry from emerging from the redds, resulting in smothering. Monitoring should be conducted by bulk sampling during low-flow periods at the heads of riffles, in potential spawning reaches. We recommend collecting and reporting the full range of sizes, but emphasize that the smallest size fraction is the most important indicator of the "fines" that are likely to clog and embed the spawning gravels. In addition, we recommend reporting the method by which the data is analyzed (e.g., size of total sample, measurements by dry weight v. wet volume), so that sources of uncertainty are known. Future indicators for permeability or turbidity may supplement or replace this indicator when additional information becomes available.

Conditions in the Watershed:

Very few data are available in the watershed. MRC collected McNeil samples (McNeil and Ahnell 1964) in 1998, and reported the findings in terms of dry weight (MRC 1999). GMA collected McNeil samples in spring of 2001, reporting dry weight as well. Data are available for the size fraction <0.85 mm, and for <5.6 mm (GMA 2001) or <6.3 mm (MRC 1999). These are summarized for informational purposes in Table 4. Although the data are limited (22 samples total), the very fine sediment data (<0.85 mm) do not suggest sediment impairment. However, several of the data sources do exceed target levels for the larger size fractions. Of all the samples, only two samples slightly exceed the target for the fraction that is <0.85mm. These stations are both in the Albion mainstem above the South Fork (MRC 1999). Those two stations also exceed the target for the size fraction that is <6.4 mm. All but 6 of the samples exceed the target for the larger size fraction, although most exceed it only slightly. The data appear to suggest a moderate impairment for this target value. Additional data in the future may confirm this, or may trend in either direction.

MRC also began to collect permeability data at its bulk sample sites. In the future, this may prove to be a more effective measure of the water quality than analysis of sediment substrate composition, since it directly measures the amount of water flow through the gravels, which is essentially what the bulk samples are representing indirectly. Table 4 also includes the MRC permeability rating (derived from the permeability rates). Of their eight sites on the Middle Albion above the South Fork, the ratings were divided fairly evenly from low to high permeability, with higher permeability representing more water flow and therefore better conditions. The four sites on the South Fork were low to moderate, and the four sites on the Lower Albion were moderate to high. The two sites with the highest concentrations of fine sediments both had low permeability; however, fine sediment concentration and permeability at the sites were not necessarily correlated. Some sites with slightly high levels of sediment in the <5.6 mm class had high permeability, and some sites with no apparent excess of fine sediments had low permeability.

Table 4: Summary of Sediment Substrate Samples

PW - ***SW*** Location	**Site No.***	**Year**	**% Exceeding Size Fraction (mm) targets: <14% < 0.85mm, <30% <6.4mm**					**Permeability Rating****
			0.85	**4.75**	**5.6**	**6.3**	**8**	
Upper Albion PW - *North Fork SW*								
NF Albion above Albion	GMA-NFAAA 1&2	2001	7%		**40**%		50%	
Upper Albion PW - *Upper Albion SW*								
Albion above NF	GMA-AANFA 1&2	2001	5%		**31**%		39%	
Middle Albion PW-***SW***								
Albion below NF	GMA-ABNFA 1&2	2001	3%		19%		25%	
Albion above SF	GMA-AASFA 1&2	2001	9%		**39%**		47%	
Albion above SF	MRC-Seg 43 (2) #5	1998	5%	16%		21%		Low-Moderate
	MRC-Seg 43-2 #3	1998	6%	25%		**31%**		Moderate-High
	MRC-Seg 43-2 #1	1998	7%	**31%**		**36%**		High
	MRC-Seg 43-2 #2	1998	7%	**35%**		**41%**		Low-High
	MRC-Seg 43 (1) #1	1998	1%	22%		**33%**		High
	MRC-Seg 43-1 #3	1998	1%	15%		21%		High
	MRC-Seg 43-1 #7	1998	**18%**	**41%**		**47%**		Low
	MRC-Seg 43-1 #6	1998	**16%**	**43%**		**49%**		Low
South Fork Albion PW - *Lower SF SW*								
SF above Albion	GMA-SFAAA 1&2	2001	8%		**35**%		43%	
SF above Albion	MRC-Seg 76 M #7	1998	8%	22%		26%		Low
	MRC-Seg 76 M #3	1998	7%	29%		**34%**		Low-Moderate
	MRC-Seg 76 M #4	1998	4%	24%		29%		Low-Moderate
	MRC-Seg 76 M #2	1998	8%	**33%**		**36%**		Low-Moderate
Lower Albion PW - *Lower Albion SW*								
Albion below SF	GMA-ABSFA 1	2001	6%		**33**%		42%	
Albion below SF	MRC-Seg 3(2) #6	1998	7%	24%		**30%**		High
	MRC-Seg 3(2) #3	1998	2%	17%		21%		High
	MRC-Seg 3(2) #7	1998	7%	26%		**35%**		High
	MRC-Seg 3(2) #4	1998	7%	24%		**30%**		Moderate-High

Source: GMA 2001, MRC 1999, GMA unpublished data and files from GMA using data provided by MRC.
*GMA: Graham Matthews & Associates Sampling; MRC: Mendocino Redwoods Sampling
**Permeability rating from MRC 1999
Shaded areas represent target exceedence.

Riffle Embeddedness
Target: $\leq$25% or improving (decreasing) trend
Embeddedness is an indication of fine sediment that surrounds and packs-in gravels. A heavily embedded riffle section may make spawning impossible. When constructing its redd, generally at a pool tail-out (i.e., the head of the riffle), the spawning fish slaps its tail against the channel bottom, which lifts unembedded gravels and removes some of the fine sediment. This process results in a pile of cleaner and more permeable gravel, which is more suited to nurturing the eggs. Embedded gravels do not generally lift easily, which can prevent spawning fish from building their redds. Flosi et al. (1998) suggest that gravels that are less than 25% embedded are preferred for spawning. This target should be estimated during the low-flow period, generally at riffle heads, in potential spawning reaches. Because this indicator is visually estimated, and thus subject to operator variability, it may be appropriate to substitute the use of pebble counts that also note embeddedness of individual pebbles that are counted.

Conditions in the Watershed:
Where MRC conducted surveys (in fish-bearing streams), they found that gravels throughout the watershed are moderately embedded (25-50%). Only in three locations are gravels relatively unembedded and generally meeting target conditions: Lower Albion, East Railroad Gulch, and North Fork Albion. Poor spawning conditions were found in the South Fork and Little North Fork, with gravel embeddedness greater than 50% (NCRWQCB 2001a, 2001b)

Coastal Land Trust conducted a habitat inventory in the summer of 1996 in the upper Albion, on non-MRC land. The survey on the upper Albion River, North Fork Albion River and Soda Spring Creek concluded that about half of the substrate is moderately embedded (Dolphin 1996, in NCRWQCB 2001a, 2001b).

V*
Target: <0.21 (Franciscan geology) or <0.10 (stable geology)
V* is a measure of the fraction of a pool's volume that is filled by fine sediment, and represents the in-channel supply of mobile bedload sediment (Lisle and Hilton 1992). It reflects the quality of pool habitat, since a lower filled pool volume reflects deeper, cooler pools offering protection from predators, a food source, and resting location. Lisle and Hilton (1992) also describe methods for monitoring, which should be conducted in low-flow periods. V* is not appropriate for large rivers, but in large river systems it is appropriate for tributaries.

Conditions in the Watershed: No data are currently available.

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

Streambed elevations along a profile generally reflect the overall balance of sediment transport at that location. If sediment delivered to the channel is greater than the transport capacity of the channel (which is a function of flow and channel geometry), then the channel will aggrade or rise in elevation. When sediment loads are less than transport capacity, the channel will degrade or scour as long as suitably sized alluvial deposits (i.e. capable of being mobilized) are present on the channel bed. (GMA 2001).

The thalweg is the deepest part of the stream channel at a given cross section. The thalweg profile is a plot of the elevation of the thalweg as surveyed along the length of the stream. The profile appears as a jagged but descending line, relatively flat at pool areas, and descending sharply at cascades. The comparison between the mean slope (i.e., the overall trend of the descending stream) and the details of the slope is a measure of the complexity of stream habitats. More variability in the profile indicates more complexity in stream habitat. Inadequate availability of pool-forming features, such as bedrock or LWD, can be revealed by this indicator of channel structure, particularly if information on channel features is included in the survey. Because the change in the profile will occur relatively slowly, and because not enough is yet known about channel structure to establish a specific number that reflects a satisfactory degree of variation, the target is simply an increasing trend in variation from the mean thalweg profile slope. The information is most useful if the water surface elevation is also surfaced at each thalweg point (to distinguish in the profile between individual pools). Comparisons among individual profiles over time or can be made visually if the plots are on the same scale. This indicator should be measured during the low-flow period every 5-10 years, after large storm seasons.

Conditions in the Watershed:
MRC (1999) surveyed six channel profile segments, each approximately 1000 ft in length, for their 1998-1999 watershed analysis, which can provide some information as a baseline to determine future trends.

Pool Distribution and Depth
Target: increasing inventory of reaches where length >40% pools
Pools generally account for more than 40% of stream length in streams with good salmonid habitat (Flosi et al. 1998). Frequent pools are important for providing food and shelter, and may also serve locally as refugia. This indicator should be measured during the low-flow period every 5-10 years, after large storm seasons. The data can be gathered simultaneously with a thalweg profile. Reported data should include length and depth of pools, and number of primary pools, usually defined as pools greater than two feet in depth in 1st and 2nd order streams, and greater than three feet in depth in 3rd and 4th order streams. Furthermore, additional information can be gathered during this process, without hindering the monitoring process greatly. For example, general habitat type can be noted. This may be particularly useful for determining the distribution of pool types, such as backwater pools, which can be indicative of overwintering habitats, or lateral scour pools, which tend to be heavily used by fish (Flosi et al. 1998).

Conditions in the Watershed:
Pools are too shallow in most of the basin to provide adequate rearing habitat for coho salmon. MRC's (1999) watershed analysis supports this conclusion, showing that only in the Lower Albion do pools of at least three feet deep comprise a sizeable portion of the reach (40% of the habitat unit by length). The middle portion of the South Fork contained a high proportion of deep pools to shallow pools, but the total number of pools in the reach was small. The availability of deeper pools in the South Fork may partially explain the greater density of coho salmon in the South Fork as compared to other tributaries in the Albion watershed (NCRWQCB 2001a, 2001b).

The Coastal Land Trust survey of the Upper Albion, North Fork Albion and Soda Spring Creek concluded that pools are relatively abundant, but the percentages of deep pools is not great. In the Upper Albion, pools comprised 36-58% of survey length, but only 23% of the pools are greater than three feet deep. In the North Fork Albion, pools comprise 36% of the stream length, and 42% of the pools are deeper than two feet deep. Pools comprise slightly more than half of the stream length in Soda Spring Creek, and 61% of the pools are greater than two feet deep, which is probably adequate (Dolphin 1996, in NCRWQCB 2001a, 2001b).

Estuary Depth

Target: Increasing depth

Historically, the estuary was used as a mill pond for the transport and storage of harvested logs, which likely caused changes to the estuary, although precise, quantitative information does not exist. The estuary is currently used as a commercial fishing, sport fishing, and recreational boat harbor. The estuary was estimated to be 20 to 25 feet deep in the 1940s and 1960s (Maahs and Cannata in GMA 2001 and NCRWQCB 2001a, 2001b), but apparently filled with sediment over the next several decades. CDFG (1961c, in NCRWQCB 2001a, 2001b) estimated the average depth at 5 feet and maximum depth of 20 feet in 1961, and an average depth of 8 feet in 1966 (CDFG 1996a, in NCRWQCB 2001a, 2001b). It is possible that the accelerated pace of estuary filling are related both to the intensive timber harvest activities in much earlier periods in the watershed and to the large volume of landsliding that occurred during the 1937-1952 period (GMA 2001). Maahs and Cannata (1998, in NCRWQCB 2001a, 2001b) also conducted fish surveys to assess salmonid estuary use during outmigration, and determined that the estuary-rearing phase is likely essential to provide the growth needed to survive the period that immediately follows ocean entry.

Decreased sediment production in the watershed is expected to lead toward increased depths in the estuary, as in-stream and watershed sediment is transported through the watershed and out through the estuary. However, because the estuary's tidal influence extends up to five miles upstream (Maahs and Cannata 1998, in GMA 2001), and because significant amounts of sediment are also produced in areas adjacent to the estuary (GMA 2001), achievement of beneficial uses in the watershed suggests that a closer look at the improving conditions in the estuary is warranted.

Conditions in the Watershed: Current depth information is not available.

Turbidity

Target: <20% above naturally occurring background levels

Turbidity is a measure of the ability of light to shine through water (higher turbidity indicating more material in the water that blocks the light). Although turbidity levels can be elevated by both sediment and organic material, in California's North Coast, stream turbidity levels tend to be highly correlated with suspended sediment. High turbidity in the stream affects fish by reducing visibility, which may result in reduced feeding and growth. Elevated suspended sediment, particularly over a long period, may also result in direct physical harm, for example, by clogging gills. This indicator should be measured during storm flows, particularly during the winter. Although determinations of background levels are sometimes problematic, it is reasonable to measure levels upstream and downstream of a management activity to compare changes in the turbidity levels that are likely attributable to that activity. Information should include both magnitude and duration of elevated turbidity levels.

The NCRWQCB has been working on developing a more descriptive indicator of turbidity, which could supplement or substitute for this indicator once it is sufficiently developed The work may result in a more precise definition of background levels, or a target related to level and duration of exposure, or a downward shift in the turbidity/discharge relationship.

Conditions in the Watershed:
GMA (2001) collected turbidity and suspended sediment samples at 7 sites in the Albion watershed during the 2000 and 2001 water years. However, the data were collected primarily to establish a relationship with suspended sediment concentration, in order to estimate sediment discharge in the watershed, and the turbidity data were not continuously collected. Therefore, there is no information on duration, which is a major factor both in determining turbidity impacts and in differences over background levels. Table 5 summarizes the data that were collected. The highest measurement was 220 NTU, and the average throughout the watershed was 58 NTU. These levels may be elevated above background levels. However, no data on background levels were collected, so a clear determination as to whether target levels are met cannot be made. The lowest values were in the Albion River above the South Fork and the South Fork Albion above the Albion River (average 38-40 NTU, maximum 68-71 NTU). The highest maximum values (197-220 NTU) were found in the North Fork, Marsh Creek, and Albion River at the USGS gage site. The highest average value was found in Marsh Creek (91 NTU).

Table 5: Summary of Turbidity Values Winter 2000 and 2001

Sample Site	Number of Samples	Average Value (NTU)	Maximum Value (NTU)
ALL	102	58	220
Albion River above North Fork Albion River	17	61	138
Albion River above South Fork Albion River	11	38	68
Albion River at USGS Gage site near Comptche	21	59	220
Marsh Creek above Albion River	12	91	197
North Fork Albion River above Albion River	19	54	204
South Fork Albion River above Albion River	12	40	71
Tom Bell Creek above Albion River	10	61	135

Source: GMA 2001, unpublished data

GMA (2001) determined that the relationship between turbidity and suspended sediment is strong (r^2=0.80). Table 6 shows the computed sediment loads at the sample sites. Two sites appeared to be outliers compared to the others: Marsh Creek appears to have a higher sediment load per unit area of discharge, and North Fork Albion appears to have a slightly lower unit sediment load. This is particularly interesting in that Marsh Creek has a large pond that should trap a considerable amount of the sediment from its contributory watershed (GMA 2001).

Table 6: Computed Sediment Loads in the Albion Watershed

Sample Site	WY2001 Suspended Sediment Load (tons)	Drainage Area (mi^2)	WY2001 Unit SSL* ($tons/mi^2$)
Albion River above North Fork Albion River	92.6	8.4	11.0
Albion River above South Fork Albion River	206.0	21.1	9.8
Albion River at USGS Gage site near Comptche	215.0	14.5	14.8
Marsh Creek above Albion River	54.7	1.8	29.9
North Fork Albion River above Albion River	32.3	5.2	6.2
South Fork Albion River above Albion River	98.7	9.1	10.9
Tom Bell Creek above Albion River	25.4	1.6	16.2

Source: GMA 2001
*SSL = suspended sediment load

Aquatic Insect Production

Target: improving trends in EPT, % dominant taxa and species richness indices

Benthic macroinvertebrate populations are greatly influenced by water quality and are often adversely affected by excess fine sediment. This TMDL recommends that several indices be calculated, following the CDFG Water Pollution Control Laboratory Stream Bioassessment Procedures (1996, in Mangelsdorf & Clyde 2000).

1) EPT Index. The EPT Index is an indicator of the number of species divided by the total number of taxa found within the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT), more commonly known as mayflies, stoneflies and caddisflies. These organisms require higher levels of water quality and respond rapidly to improving or degrading conditions (EPA 1998b; Bjornn et al. 1997, in Bybee 2000).

2) Percent Dominant Taxa. This index is calculated by dividing the number of organisms in the most abundant taxa by the total number of organisms in the sample. Collections dominated by one taxa generally represent a disturbed ecosystem.

3) Richness Index. This is the total number of taxa represented in the sample. Higher diversity can indicate better water quality.

Conditions in the Watershed: No information is available.

Large Woody Debris (LWD)

Target: increasing distribution, volume and number of key pieces

California coastal streams are especially dependent on the presence of LWD to provide ecological functions, such as sediment metering and sorting, pool formation, and shelter. Large pieces of woody debris in streams influence the physical form of the channel, the movement of sediment, the retention of organic matter and the composition of the biological community (Bilby and Ward 1989). LWD can be instrumental in forming and stabilizing gravel bars (Bilby and Ward 1989; Lisle 1986 in EPA 1999), or in accumulating fine sediment, which keeps it from clogging spawning areas (Zimmerman et al. 1967, Megahan 1982, in Bilby and Ward 1989). LWD can also form pools by directing or concentrating flow in the stream in such a way that the bank or bed is scoured, or by impounding water upstream from the obstruction (Lisle and Kelsey 1982, in EPA 1999). LWD plays a more significant role in routing sediment in small streams than in large ones (Bilby and Ward 1989). This indicator should be measured during the low-flow period, and should report the number and volume of key pieces or the distribution of LWD-formed habitat.

Conditions in the Watershed:
The operation of logging dams probably contributed to the current degraded condition of the Albion watershed, which is largely depleted in LWD. Lack of instream log jams is allowing sediment delivered to the main channel to move through the system far more quickly and ultimately reach the estuary in greater quantities than prior to disturbance (NCRWQCB 2001a, 2001b). Removal of log jams in the 1960s by CDFG probably hindered recovery (MRC 1999, in NCRWQCB 2001a, 2001b).

MRC Survey. MRC (1999) inventoried “functional” and “key” LWD in the active channel and bankfull channel for selected stream segments on their ownership. These are summarized in NCRWQCB (2001a). “Functional” LWD was defined as LWD that provides habitat or morphologic function in the stream channel (i.e., pool formation, scour, debris dam, bank stabilization, or gravel storage). No minimum length or diameter characteristics were used to define “functional” LWD. A “key” piece of LWD was defined using minimum length and diameter characteristics associated with bankfull width, as described in Table 7 (MRC 1999 in NCRWQCB 2001a).

Although MRC classified relatively small debris sizes as key pieces, the data provide some information for comparative purposes. According to the analysis, Railroad Gulch, East Railroad Gulch, Pleasant Valley Creek, Tom Bell Creek, North Fork Albion River, reaches of the Albion River and reaches of South Fork Albion River each contain densities of wood and “key” pieces of LWD that exceed the basin wide averages. Because the data are somewhat qualitative, it is not clear whether the existing supply of LWD is sufficient to provide conditions to adequately support salmonids (NCRWQCB 2001a).

Table 7. Size Requirements for “Key” LWD

Bankfull width (ft)	Diameter (in.)	Length (ft.)
0-20	12	20
20-30	18	30
30-40	22	40
40-60	24	60

Source: MRC 1999 , in NCRWQCB 2001a

On average, in the active channels of the watershed: 18.1 pieces of LWD are found per 100 m, two of these pieces are defined as key LWD, and key pieces account for 11% of the LWD. In addition, for the bankfull channels, 20.5 pieces of LWD are found per 100 m, 2.3 of these pieces are defined as key LWD, and key pieces account for 11% of the LWD (NCRWQCB 2001a).

MRC also identified “recruitment potential” qualitatively as the potential for streamside trees to fall into the channel to provide LWD. In general, the riparian zone of the upper portion of MRC’s ownership, with the exception of the South Fork Albion River, has a greater potential to recruit LWD than does the riparian zone in the lower portion of their ownership. Areas with higher than average recruitment potential include the North Fork Albion and Middle Albion. Areas with low recruitment potential include Railroad Gulch, Pleasant Valley Creek and parts of the South Fork Albion.

The MRC watershed analysis (1999, in NCRWQCB 2001a) also reported the mechanisms by which observed pools are formed in the Albion River watershed. Coho salmon are typically associated with accumulations of LWD both because of the shelter afforded as well as the pool/riffle sequence that is created by LWD. Those stream reaches with a majority of their pools formed by LWD are similar to the C-type and E-type channels (as defined by Rosgen 1996) and include the Lower Albion River, Middle Albion River, Railroad Gulch, Pleasant Valley Creek, Duck Pond Gulch, South Fork Albion River, East Railroad Gulch, and Little North Fork Albion River.

Coastal Land Trust Survey. In the Coastal Land Trust survey of the Upper Albion, Soda Spring Creek and North Fork Albion, the amount of LWD-formed habitat varied from 25%, for the Upper Albion, 10% for Soda Spring Creek, and only one LWD-formed pool on the North Fork Albion in the study reach (Dolphin 1996 in NCRWQCB 2001a, 2001b). No information was provided on key pieces or quantity of LWD in the study reaches.

3.3. Watershed Indicators

Stream Crossings with Diversion Potential or Significant Failure Potential
Target: <1% of all stream crossings divert or fail as a result of a 100-year or smaller flood
Most roads, including skid trails and railroads, cross ephemeral or perennial streams. Crossings are built to capture the stream flow and safely convey it through, under, or around the roadbed. However, stream crossings can fail, adding sediment from the crossing structure (i.e., fill) or from the road bed directly into the stream. Stream crossing failures are generally related to undersized, poorly placed, plugged, or partially plugged culverts. When a crossing fails, the total sediment volume delivered to the stream usually includes both the volume of road fill associated with the crossing and sediment from collateral failures such as debris torrents that scour the channel and stream banks. Diversion potential is the potential for a road to divert water from its intended drainage system across or through the road fill, thereby delivering road-related sediment to a watercourse. The potential to deliver sediment to the stream can be eliminated from almost all stream crossings by eliminating inboard ditches, outsloping roads, or installing rolling dips (M. Furniss, pers. comm., in EPA 1998a). Less than 1% of stream crossings have conditions where modification is inappropriate because it would endanger travelers or where modification is impractical because of physical constraints.

Stream crossings with diversion potential or significant failure potential are high risks for sediment delivery to streams in the Albion River watershed. Although there are no data for the Albion River watershed regarding the current rate of stream diversions or stream crossing failures, or the quantities of sediment delivered to watercourses from these processes, 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 in some other North Coast basins (e.g., Rolling Brook, a tributary of the Garcia River, and Redwood Creek in Redwood National Park, and Navarro River (EPA 1998b, EPA 2000a)).

Conditions in the Watershed: No information is available.

Hydrologic Connectivity

Target: decreasing length to ≤1%
A road is hydrologically connected to a stream if it drains water directly to the stream. A hydrologically connected road increases the intensity, frequency, and magnitude of flood flows and suspended sediment loads in the adjacent stream, which can result in destabilization of the stream channel. This can have a devastating effect on salmonid redds and growing embryos (Lisle 1989, in Mangelsdorf and Clyde 2000). The connectivity can be reduced by outsloping roads, creating road drainage that mimics natural drainage as much as possible, and other factors (M. Furniss, pers. comm., 1998, and Weaver and Hagans 1994, in EPA 1998).

The reduction of road densities and the reconstruction of roads 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.

Conditions in the Watershed: No information is available.

Annual Road Inspection and Correction
Target: increasing proportion to 100%
EPA's analysis indicates that in watersheds with road networks that have not experienced excessive road-related sedimentation, roads are either (1) regularly inspected and maintained; (2) hydrologically maintenance free (i.e., they do not alter the natural hydrology of the stream); or (3) decommissioned or hydrologically closed (i.e., fills and culverts have been removed and the natural hydrology of the hillslope has largely been restored). If not, they are potentially large sources of sediment (D. Hagans, pers. comm., 1998, in EPA 1998). In general, road inspection should be undertaken annually, and could in most cases be accomplished with a windshield survey. The areas with the greatest potential for sediment delivery should be corrected prior to the onset of winter conditions. This target calls for an increase in the proportion of roads that are either (1) inspected annually and maintained prior to winter, (2) hydrologically maintenance free, or (3) decommissioned or hydrologically closed, until all roads in the Albion River watershed fall into one of these categories.

Conditions in the Watershed: No information is available.

Road Location, Surfacing, Sidecast
Target: decreasing road length next to streams, increasing proportion outsloped or hard surfaced roads
This indicator is intended to address the highest risk sediment delivery from roads not covered in other indicators. Roads located in inner gorges and headwall areas are more likely to fail than roads located in other topographic locations. Other than ephemeral watercourses, roads should be removed from inner gorge and potentially unstable headwall areas, except where alternative road locations are unavailable and the road is clearly needed. Road surfacing and use intensity directly influence sediment delivery from roads. Rock surfacing or paving is appropriate for frequently used roads. Sidecast on steep slopes can trigger earth movements, potentially resulting in sediment delivery to watercourses. These factors reflect the highest risk of sediment delivery from roads, and should be the highest priorities for correction (C. Cook, M. Furniss, M. Madej, R. Klein, G. Bundros, pers. comm., 1998, in EPA 1998).

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

Conditions in the Watershed: The lengths of roads by surface type are listed in Table 8.

Activity in Unstable Areas
Target: avoid or eliminate, unless detailed geologic assessment by a Certified Engineering Geologist concludes there is no additional potential for increased sediment loading
Unstable areas are those areas that have a high risk of landsliding, and include: steep slopes, inner gorges, headwall swales, stream banks, existing landslides, and other locations identified in the field. Because of the high risk of landsliding inherent in these features, any activity that might trigger an erosional event should be avoided, if possible, and kept to a minimum if unavoidable. Such activities include road building, harvesting, yarding, terracing for vineyards, etc. Analysis of chronic landsliding in the Noyo River basin indicated that landslides observed on aerial photographs largely coincide with predicted chronic risk areas including steep slopes, inner gorges and headwall swales (Dietrich et al. 1998, in EPA 1999). Several other studies have shown that landslides are larger or more common in some harvest areas, particularly in inner gorges (GMA 2000, in EPA 2000). Weaver and Hagans (1994) also suggest methods for eliminating or decreasing the potential for road-related sediment delivery.

Conditions in the Watershed: No information is available.

Table 8. Existing Road Types

Planning Watershed Sub-watershed	**Miles of Indicated Road Type**			**Total (mi)**	**Road Density (mi/mi^2)**
	Paved	**Rocked**	**Native**		
Upper Albion PW	**6.38**	**21.61**	**90.15**	**118.14**	**8.66**
North Fork Albion SW	0.06	7.92	43.55	51.52	9.87
Upper Albion SW	6.32	13.69	46.61	66.62	7.91
Middle Albion PW - SW	**4.56**	**11.70**	**42.96**	**59.22**	**7.77**
South Fork Albion PW	**1.49**	**23.53**	**54.66**	**79.68**	**8.75**
Upper south Fork Albion SW	1.49	13.06	28.16	42.70	10.68
Lower South Fork Albion SW	0.00	10.47	26.50	37.00	7.24
Lower Albion PW	**6.66**	**14.05**	**84.70**	**105.41**	**8.36**
Lower Albion SW	1.65	1.88	34.42	37.95	9.54
Railroad Gulch SW	2.60	3.56	27.80	33.97	7.56
Albion River Estuary	2.40	8.60	22.48	33.49	8.09
TOTAL ALBION WATERSHED	**19.08**	**70.89**	**272.47**	**362.44**	**8.43**
% of Total	5%	20%	75%	100%	

Source: GMA 2001

Disturbed Area

Target: decrease, or decrease in disturbance index

Studies in Caspar Creek (Lewis, 1998, in EPA 1999) indicate that there is a statistically significant relationship between disturbed areas and the corresponding suspended sediment discharge rate (Lewis 1998; J. Lewis pers. comm. w/ A. Mangelsdorf, in EPA 1999). In addition, studies in Caspar Creek indicate that clearcutting causes greater increases in peak flows (and, by extension, increased suspended sediment loads) than does selective harvest (Ziemer 1998, in EPA 1999). As with the "hydrologic connectivity" target, increases in peak flows, annual flows, and suspended sediment discharge rates negatively affect the potential survivability of ova in redds (Lisle 1989, in EPA 1999).

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

Conditions in the Watershed: GMA (2001) defined a relative disturbance index for current conditions as the product of SW road density, the percent of SW area harvested in the 1989-1999 period, and the volume (tons) of landslides mapped in the 1989-1999 period. Data are not sufficient at this time for EPA to develop a disturbance index, but the NCRWQCB may develop information in the future either to strengthen this index, or determine an alternate disturbance index to represent chronic sediment inputs.

CHAPTER 4: SOURCE ANALYSIS

The purpose of the sediment source analysis is to identify the various sediment delivery processes and sources in the watershed and to estimate sediment delivery from those sources. This analysis is largely abstracted from GMA (2001). Detail on the methods and results can be found in that report.

4.1. Summary of Results

GMA estimated sediment delivery to streams in the watershed from 1921-2000 (see Table 9). The quantity of sediment delivered typically varied with the amount of timber harvest, with an average 602 t/mi^2/yr over the 80-year study period. In earlier periods, timber harvest was very intensive, and harvest practices generally caused more erosion than today. Sediment production in the watershed was greatest in the 1937-1952 period (799 t/mi^2/yr). Most of the timber stock was depleted by the 1950s, and sediment production was lower during the periods of 1966-1978 (459 t/mi^2/yr) and 1979-1988 (381 t/mi^2/yr), because the second-growth timber stocks were not mature enough to harvest. In the 1989-2000 period, harvesting activity increased and the quantity of roads increased dramatically, with almost half of the roads in the watershed being built in the last two decades. Thus, sediment generation increased to 691 t/mi^2/yr in the current period, even though road building and timber harvest practices improved. Most of the increase is attributable to the increased number of roads that accompanied higher timber harvest levels. In general, the landsliding rates have declined, while surface erosion rates, primarily from roads, have increased. (Table 9 indicates an increase in landsliding in the latest period, but this largely reflects additional data provided by MRC.[1])

The sediment delivery rates in Table 9 can be grouped into background and management-related categories. With a long-term average background rate of 275 t/mi^2/yr, the background sediment inputs over the study period comprise about 45% of the total. Management inputs averaged 55% of the total over the long term, but have been as high as 63-66% in the present period and in 1937-1952, and as low as 25% in the 1966-78 period, when very little management activity took place. Road-related sediment, from surface erosion and landslides, has been increasing in absolute quantity and as a proportion of to the total sediment during the study period. The contribution was as low as 37 t/mi^2/yr in the 1921-1936 period (6% of total sediment), but has increased to 260 t/mi^2/yr in the current period (38% of the total).

4.2. Analysis Methods and Results

Existing data were compiled from a variety of sources, including data collection and air photo analysis in the Albion River watershed, the *Albion River Watershed Analysis* developed by MRC (1999), and TMDL or sediment source analyses for similar basins such as the Noyo (GMA 1999, in GMA 2001), Ten Mile (GMA 2000, in GMA 2001), Navarro (Entrix et al. 1998, in GMA 2001) and Garcia Rivers (PWA, 1997, in GMA 2001). GIS data were obtained from CDF Coast-Cascade GIS, Mendocino County, Mendocino Redwoods Company (ownership, landslides, roads), and Campbell Timberland (ownership).

[1]The estimates for the 1979-1988 and 1989-2000 periods have been adjusted (see discussion later in this chapter regarding the use of MRC data), so they are not directly comparable to earlier periods. The estimates for the two recent periods reflect the greater number of landslides that were included in the MRC database, compared to those found in the GMA database. If larger-scale photographs were available and analyzed for earlier periods, the data might reveal higher sediment production for earlier periods as well. In addition, the 1921-1936 estimate is probably low, as the aerial photograph coverage was incomplete.

TABLE 9

ALBION RIVER WATERSHED SEDIMENT SOURCE ANALYSIS

Preliminary Sediment Budget -- Sediment Input Summary -- Average Annual Unit Area Rates

STUDY PERIOD	NO. OF YEARS	INPUTS: BKGRND LANDSLIDES (tons/mi2/yr)	TOTAL MGMT LANDSLIDES (tons/mi2/yr)	HARVEST RELATED LANDSLIDES (tons/mi2/yr)	ROAD RELATED LANDSLIDES (tons/mi2/yr)	GRASSLAND LANDSLIDES (tons/mi2/yr)	TOTAL LANDSLIDES (tons/mi2/yr)	SURFACE EROSION: BKGRND (tons/mi2/yr)	SURFACE EROSION: SKID TRAIL (tons/mi2/yr)	SURFACE EROSION: ROAD (tons/mi2/yr)	FLUV/BANK EROSION (tons/mi2/yr)	TOTAL NON-MGMT INPUTS (tons/mi2/yr)	TOTAL MGMT INPUTS (tons/mi2/yr)	TOTAL INPUTS (tons/mi2/yr)
1921-1936	16	134	332	317	15	0	466	75	6	22	66	275	360	635
		21%	52%	50%	2%	0%	73%	12%	1%	3%	10%	43%	57%	100%
1937-1952	16	134	490	389	34	67	624	75	1	33	66	275	524	799
		17%	61%	49%	4%	8%	78%	9%	0%	4%	8%	34%	66%	100%
1953-1965	13	134	225	160	48	17	359	75	3	44	66	275	272	547
		24%	41%	29%	9%	3%	66%	14%	1%	8%	12%	50%	50%	100%
1966-1978	13	168	59	48	9	2	227	94	3	52	83	345	114	459
		37%	13%	10%	2%	0%	49%	20%	1%	11%	18%	75%	25%	100%
1979-1988	10	101	103	66	35	2	204	56	7	64	50	207	174	381
		27%	27%	17%	9%	1%	54%	15%	2%	17%	13%	54%	46%	100%
1989-2000	12	125	328	158	170	0	453	70	17	90	61	256	435	691
		18%	48%	23%	25%	0%	66%	10%	2%	13%	9%	37%	63%	100%
		22%	46%	35%	8%	3%	68%	12%	1%	8%	11%	45%	55%	100%
1921-2000	80	134	273	207	49	17	407	75	6	48	66	275	327	602

Source: GMA 2001

Notes:

-- Background landsliding based on long-term background rate of 275 tons/mi2/yr (see text). After subtraction of creep (75 t/mi2/yr) and fluvial erosion (66 t/mi2/yr), this leaves 134 t/mi2/yr for landsliding. For periods from 1953 to present, rate was adjusted by the ratio of the estimated sediment transport in that period to the long term sediment transport rate to provide an approximation of the hydrology characterizing each period (see text).

-- All landslides mapped were management-related; actual background landslides were assumed to be not mappable (too small, under canopy, etc), so were not visible for mapping.

-- Landsliding values developed from aerial photographs taken at the end of each budget period

-- Harvest related landslides include harvest areas estimated at <20years old, >20years old, and those from clear cut areas, and skid trail sources.

-- Road related landslides include those associated with cut and fill failures, landings, and in the early periods, those associated with railroads

-- Grassland related landslides are those observed in un-forested areas, which may be grazed areas, areas currently maintained as grasslands, or areas cleared during early harvests which have since regrown.

-- Landslide rates for the 1979-1988 and 1989-2000 periods have been adjusted based on data from Mendocino Redwood Company Watershed Analysis that found considerably more slides, and thus more volume than did the GMA mapping in this study. For this reason, the two most recent periods are not strictly comparable to previous periods, as they are based on more complete data (see text).

-- Total management-related sediment for the 1979-1988 period is probably low; some sediment listed in the 1989-2000 period was probably generated in the 1979-1988 period (see text)

-- Background surface rates (comprised of creep, surface erosion by sheetwash and rilling, and deep-seated landslide components) based on work of Roberts and Church (1986, in GMA 2001) and Cafferata/Stillwater Sciences (pers. Comm. 1999, in GMA 2001). Rate used is 75 tons/mi2/yr, but is adjusted in 1953-2000 periods by the hydrologic factor similar to background landslides.

-- Skid road estimates based on measured harvest areas on the 1936, 1952, 1965 & 1978 aerial photographs, delineated into 3 classes of skid road density. Harvest areas after 1988 are computed from CDF GIS coverages.

-- Road erosion computed from measured road miles in 1936, 1952, 1965 and 1978 aerial photographs. Roads after 1988 based on CDF GIS coverage developed from THPs, corrected to GMA 2000 aerial mosaic.

-- Bank erosion is based on a rate of 0.005 tons/ft/yr for Class 1 and Class 2 channels, based on adjustment of average rates developed by MRC (1999) for their lands in the Noyo River watershed. This category includes bank erosion and smaller streamside mass movements under the canopy and generally not visible on aerial photography. Rate used is 66 tons/mi2/yr with adjustments in the 1953-2000 period to reflect period hydrology, similar to background landslides and background surface erosion.

-- Numbers are rounded, so slight discrepancies based on rounding errors may occur.

The sediment source analysis involved three primary components: (1) evaluation of the dominant geomorphic processes that deliver sediment to the various stream channels in the Albion River watershed through limited field reconnaissance, review of existing data, and consultation with those who are familiar with basin conditions; (2) measurement of various parameters, such as landslide size/type/associated land use, road length and harvest areas from sequential aerial photography and existing data bases; and (3) selection of factors to complement or modify the photo-based measurements where other data or information exist, or to estimate conditions where no data exist, thus allowing computation of results. The approach was primarily an indirect, office-based approach.

GMA investigated sources of sediment by this approach for a budget period of 1921 to 2000. This information provides a history of sediment production and delivery to the watercourse during this century, as well as an idea of how the different PW and SW were affected, and which sources have been more or less prevalent.

Use of Mendocino Redwood Company Data. For the most recent periods (1979-1988 and 1989-2000), GMA compared results with data from MRC's sediment source analysis on its land in the Albion watershed, which included landslide and road surface-erosion data. MRC's landslide data were derived from 1987 and 1996 aerial photos (roughly equivalent to GMA's 1988 and 2000 photos and study periods), and the data were compiled only on a Planning Watershed (PW) basis, only for MRC ownership, and were not broken down by Sub-Watershed (SW). In addition, the data did not generally include land use associations. Although the MRC database is more aggregated than GMA data (providing less detail), the MRC data were more complete, using larger-scale aerial photographs (1:12,000, as opposed to GMA's 1:20,000-30,000), and were supplemented with considerable field verification (44% of all landslides), which provided more accurate information. The two data sets (GMA's and MRC's) were considerably different, in part because of the differences in methods. Because GMA considered the MRC data to be better, due to the better analysis and field verification, GMA adjusted his overall landslide estimates by PW for the last two study periods.

For the most part, the adjusted MRC landslide data showed much greater landslide deliveries of sediment than the GMA data. Many of the additional landslides that the MRC data showed were less than 5,000 square feet in area, which are detectable with MRC's larger-scale photographs and field verification, but are smaller than the threshold of detection for the GMA study.

Similarly, GMA adjusted their estimates for road surface erosion based on MRC data collection. In this case, the MRC data again included a greater degree of field verification (approximately 70% of all roads); however, the MRC roads database appeared to exclude roads that the company was no longer using. GMA adjusted the factors for road-related surface erosion, but retained GMA roads coverage, which appeared to be more complete.

GMA's report (GMA 2001) describes in detail the methods used to develop the GMA data as well as the methods used to adjust the figures to reflect the MRC data.

Historic Watershed Activities

As described in Chapter 2, the Albion watershed was heavily logged in the beginning of the century. These early practices were fairly intensive, and produced a considerable amount of sediment. Harvest rates decreased in the 1950s through the 1970s, as the timber stock was fairly well depleted, then increased sharply in the 1980s, accompanied by increased road-building. Methods were unregulated until after 1973, when the California Forest Practices Act was passed. During the most recent period, harvest methods and road construction methods were less destructive and produced less sediment on a unit basis, but the significant increases in harvest rates have resulted in steady increases in sediment, particularly in road-related sediment production.

Time Period of Analysis
Historic aerial photographs were available for 1936 (partial coverage), 1952, 1965, 1978, 1988, and 2000. GMA assumed that features observed in the 1936 photographs covered approximately a 16-year period (i.e., no earlier than 1921), generally similar to the length of the subsequent 1936-1952 period. Thus, the sediment budget covers an 80-year period, extending from 1921 to 2000. Sediment source data were developed for all six of these time intervals, capturing different periods of sediment- producing events, including both the largest storms this century (water years 1938, 1956, 1965, 1974, 1993) and changes in harvest practices and road building techniques.

Hydrology and Geomorphology
GMA analyzed precipitation and streamflow data, extending the relatively short period of record for the Albion River by correlating the existing data with the longer record available for the Noyo River to generate synthetic data. They installed monitoring stations to collect streamflow, turbidity and some suspended sediment data during the 1999-2000 and 2000-2001 winters. GMA also compared 1936 or 1952 aerial photos of a randomly selected location within each PW to 2000 photos of the same location, to generalize about changes over the period.

Streamflow data collected in the basin by the USGS are limited to a single gage: #11468070, located about 12.4 miles upstream from the mouth in the Middle Albion Planning Watershed, a short distance downstream of the confluence with the North Fork. The gage measured streamflow from 14.4 of the 43.0 mi^2 of the watershed, including the wetter upper watershed areas, from October 1961 to September 1969. The gage was operated for annual peak discharges through WY1978.

The 1952 and 1988 air photos reflect periods of relative quiescence related to low water years and, in the case of the 1988 photos, a period of drought. The photo years prior to 1978 reflect intensive timber harvest with no regulation, while 1988 and 2000 reflect timber harvest under the California Forest Practice Act (Z'berg-Nejedly Forest Practice Act of 1973, which established Forest Practice Rules (FPRs) intended to protect resources while allowing for sustainable timber harvest). The effects of precipitation and flood flows were greater prior to the FPRs. Considerable lengths of roads and skid trails had been built, and the railroad had been constructed and was operational. Most of these were adjacent to the stream channels. Effects were less pronounced in the 2000 air photos, probably reflecting both the FPRs and the fact that many of the landslides had already been triggered in earlier years.

During the period of available historic and synthetic streamflow records, 1974 stands out well above other years, not only because of its high peak flow, but also the duration of these flows. This is similar to the Noyo and Caspar Creek watersheds, but considerably different from the Ten Mile watershed and most coastal watersheds further north, where the December 1964 flood was generally the greatest. In the Albion River watershed, the January 1974 event appears to have been the most significant in the past 50, and perhaps 100, years.

Lack of Flows. Flows in the Albion watershed are sometimes surprisingly low. Almost 30% of the time, flow at the USGS gage site during the period of record was below 1 cfs, while about 5% of the time there was zero flow. Thus, for 3-4 months of the year, on average, flows are less than 1 cfs in the upper portions of the Albion watershed. A brief review of water rights permits indicates that diversions are currently permitted for at least 0.5 cfs in areas upstream of the site of the former USGS gage, mostly in the vicinity of Comptche and with a few diversions in the North Fork SW. While most of these diversions are permitted for winter months only, and may not affect low-flow periods, they may be sufficient to negatively influence salmonid habitat and sediment transport (EPA, unpublished, 2001). This could potentially be a reason for the lack of gravels and excessive embeddedness (see Chapter 3). The absence of gravel combined with quite low summer flows, rather than the presence of fine sediment in existing gravels, could well be a limiting factor for salmonid production in the watershed. Many of the channel reaches are incised to bedrock along much of their length and suitable spawning gravels are frequently quite limited (GMA 2001). Diversion purposes include irrigation and domestic uses. Low-flows may be a limiting factor in salmonid production in this upper portion of the watershed. Most of the diversions are near Comptche, on Marsh Creek (EPA, unpublished 2001), serving subdivision and winery uses.

Mass Wasting

Mass wasting sources were determined by sequentially analyzing aerial photographs for each of the six periods, classifying the landslides into harvest-related, road-related, grassland-related and background categories, categorizing the landslides by type, estimating the proportion of the features that delivered sediment to streams, and estimating the volume of sediment delivered for each feature. As previously noted, GMA also compared the results with those from MRC's sediment source analysis portion of their watershed analysis (MRC 1999, in GMA 2001), and adjusted their data to reflect MRC's more detailed data set. Because no background landslides were detected in the aerial photograph analysis, possibly due to a combination of widespread harvest activity beginning earlier than photographs are available for and the inability to detect small landslides at the photo scale, background landsliding rates were estimated based on a review of other studies (see next section).

Determination of Background Loading

As with many other watersheds in the North Coast, determination of a background landsliding rate was difficult. No information on background landsliding rates could be developed from GMA's investigation of aerial photographs, because the earliest aerial photography is from 1936, and intensive human disturbance in the watershed significantly pre-dates those photographs. Thus, no landslides were mapped that were clearly associated with background conditions. However, GMA reviewed various studies of the Caspar Creek watershed as well as long-term sediment yield within the Albion watershed. Data from the South Fork Caspar Creek during 1968-1998 and the North Fork Caspar Creek during 1978-1989 are most representative of unmanaged sediment yields. Depending upon the bulk density factor selected to convert available volume data (in cubic yards) to mass (in tons), the range is from 239-411 t/mi^2/yr.

GMA also examined regional sediment transport relationships to determine a likely transport rate for the Albion watershed, which could also reflect background conditions. These suggest a range of 74-327 t/mi^2/yr, with the higher values being more likely. Thus, the most likely range of values are between about 250 to 325 t/mi^2/yr. Given that the estimates are all fairly similar, the values are probably reasonable. Based on the information available regionally and specifically for the watershed, GMA estimated long-term background sediment yield at 275 t/mi^2/yr. GMA attributed approximately 66 t/mi^2/yr of this to fluvial erosion and 75 t/mi^2/yr to hillslope creep, based on literature values. The remainder, 134 t/mi^2/yr, GMA attributed to background landsliding. For Table 9, GMA adjusted the rates for each period using sediment yield estimates for the period, to reflect whether the periods were relatively wet or dry periods.

Surface Erosion
Surface erosion estimates were categorized as background creep, skid trail/harvest related, and road/railroad related. Background creep was estimated from literature values (see section above).

Skid Trails and Harvest. Surface erosion estimates from skid trails and harvest were developed by estimating the aerial extent and type of harvest for each time period. There is considerable variation in estimates from the literature on sediment production and delivery to stream channels from skid trails. Since skid trails are generally not linked as directly to stream channels as roads typically are, drainage practices (proper installation of water bars, etc.) are of primary importance in determining whether significant sediment production and delivery will occur. Since extensive field surveys to determine these site-specific characteristics were not possible, harvest areas were identified on the historic aerial photographs and assigned a high, medium, or low rating regarding the density of skid trails. Erosion factors were assigned by time period of construction, as well as by density, with the earlier periods assumed to produce more sediment relative to newer construction due to better construction practices, and the amount of erosion to be highest during the period immediately following construction.

Harvest rates were very high in the watershed in the early part of the century. Even before the study period, 56% of the watershed had been harvested. Harvest rates dropped to less than 5% of the watershed between 1928 and 1978, then increased dramatically in the last two decades, with 16% of the watershed harvested during 1979-1988 and 47% of the watershed harvested in the most recent decade. During that period, approximately 3,000-3,500 acres were harvested in each PW, with the highest number of acres and rate of harvest in the South Fork PW. For the South Fork and Middle Albion PW, 60% of the PW was harvested in 1989-2000. The South Fork PW, and the Upper South Fork SW in particular, have been the most heavily harvested over the entire period: 173% of the entire PW has been harvested, implying that it has been cut over completely once, and almost all of the second growth has been cut as well. This PW was 80% harvested prior to 1921. Within the PW, the Upper South Fork SW has been cut over completely more than twice, and was completely cut over even prior to 1921. Rates of harvest have been nearly as high in the Lower Albion PW, with an average cut rate of 133%. Most of this was concentrated in the Lower Albion SW.

All harvest areas in the 1936 photos were assumed to have a high density of skid trails. In 1952 and 1965 the majority of harvesting still used a high density of skid trails. Harvest rates were very low in 1978 and 1988 (and thus surface erosion related to harvest was very low). By 1988 no harvest areas were mapped as high density, which may reflect changes in the Forest Practice Rules. For 2000, areas that were mapped were all assigned low skid trail density, along with a number of new harvest categories from the CDF database, including clear cuts, narrow clear cuts, and cable cuts. Typically, few if any skid trails were seen on these areas, as much effort was apparently spent to obliterate the skid trails developed during harvest operations.

Throughout the study period, skid trails accounted for 2% or less of all sediment generated. The current load is estimated at 17 $t/mi^2/yr$, which reflects recent increases in timber harvest.

Road Surface Erosion. Surface erosion from roads and railroads was estimated by developing a road construction history and a harvest history, and applying erosion rates based on surface type and estimated use intensity. The method used to estimate sediment production from roads is based on a procedure developed by Reid (1981, in GMA 2001) for industrial timber roads and associated use and sediment production in the Clearwater (Washington) basin. This procedure was also recently undertaken on the Navarro River, Noyo River and Ten Mile River watersheds. Although its use has limitations in that the similarity between the Mendocino watersheds and the Clearwater basin is unknown, it provides the best practical method for this TMDL, because any other method would require more extensive development of site-specific information than could be undertaken in this analysis.

Because of revegetation over time, probably not all haul roads were mapped. Furthermore, their importance could be misinterpreted because of lack of use, being overgrown, or being incorporated into harvest units and lost in a maze of skid trails. Some error also exists in combining the GMA and CDF data bases, because the CDF data base is based on Timber Harvest Plans, which did not always include new roads that were not part of the harvest area. GMA corrected the data base using their GIS coverage from aerial photographs, and adjusted for roads that were only vaguely defined in the CDF database. In addition, road segments that were not coded to a specific year in the CDF data base were assigned by GMA to the 1989-2000 period, which probably resulted in an overestimate of roads constructed in the current period, and an underestimate of roads in the 1979-1988 period.

GMA also compared road erosion estimates with those developed by MRC for their ownership. MRC conducted a more detailed analysis of the roads within their ownership, which included visiting 70% of the roads. Comparing the results from the two studies revealed a number of significant disparities. MRC's data are probably better in terms of having field-verified their estimates; however, they assumed that older roads were abandoned and were not delivering sediment if they were not used. GMA assumed that any road still visible probably still delivered some sediment, particularly because these older, "legacy" roads were built to far different standards than roads constructed recently. In addition, several studies have reported that older roads still produce considerable sediment (Toth 1991, Mills 1991, ODF 1999, in GMA 2001). Accordingly, GMA compared the GMA and MRC results, and adjusted MRC data to include an estimate of sediment produced from older, unused roads. GMA data on non-MRC ownerships were adjusted based on this analysis.

There are currently 362 miles of roads in the Albion watershed, which translates to a basinwide road density of 8.43 mi/mi^2. The highest road densities in the basin are found in the Upper South Fork , North Fork, and Lower Albion SW (10.68, 9.87 and 9.54 mi/mi^2, respectively). Not surprisingly, native surface roads were 75% of the total, followed by rocked roads at 20%, and paved at 5%. The South Fork Albion PW contains a significantly higher percentage of rocked roads (30%) than the other three PW: 20%, 18% and 13% for the Middle, Upper and Lower Albion, respectively. This may reflect higher road use in the South Fork PW.

The road construction and railroad history largely mirrors the history of timber harvest through the watershed. Nearly half of the roads were constructed in the last two time periods, with a third of these built in the most recent decade. About a fifth were constructed by 1936, and the rest added at relatively slow rates from 1937-1978. As noted earlier, some of the road construction in the last decade may have actually occurred in earlier time periods, particularly the 1979-1988 period. However, it is still evident that, even accounting for that potential overestimate, considerable quantities of new roads were constructed recently. The majority were concentrated in the South Fork PW, where 52 miles of roads were constructed from 1978-2000 (two thirds of the total length of roads in that PW). In the Upper Albion, 48 miles of roads were constructed in the last two periods, or approximately one third of the total. In the other two PW, approximately 42 miles of roads were constructed. In the Middle Albion, where road construction was only minimal in the 1937-1978 period, the recent periods represented almost three fourths of the total road mileage in the PW.

Although the roads constructed in the last two periods tend to generate less sediment on a unit basis than those constructed in the earlier part of the century (many of the newer roads are ridgetop roads, and drainage practices have improved significantly since the Forest Practice Rules have been enacted), surface erosion from roads has increased from a low of 22 t/mi^2/yr in the 1921-1936 period, up to 90 t/mi^2/yr during the last decade. In fact, road erosion accounted for only 3% of the total sediment inputs in the earlier period, but accounts for 13% today. Together with increased erosion from skid trails, which also reflects the increased harvest rates, this accounts for 107 t/mi^2/yr in the 1989-2000 period, which is double the long-term average of 54 t/mi^2/yr.

Fluvial Erosion

Numerous studies have indicated that fluvial erosion, whether from road diversions and washouts, road drainage-induced gullies, natural gullies, bank erosion or small streamside landslides, can be a major component of the watershed sediment sources. Unfortunately, quantification of these components requires considerable field investigation, typically as part of a comprehensive road inventory process, in order to develop reliable information. GMA used values from previous work in other coastal watersheds with similar geology to develop estimates for bank erosion/small streamside mass wasting.

This approach involved modification of unit area values of fluvial erosion rates developed for the Noyo River, which had been extrapolated from preliminary data for two analysis units from MRC (C. Surfleet, pers. comm. 1999, in GMA 2001), and bank erosion rates from USDA (1972, in GMA 2001). However, because GMA's limited field observations suggested that most of the channels in the Albion watershed are incised and moderately stable, and the rates would be significantly lower than those in other watersheds, the rate was adjusted downward. Separating fluvial erosion into background and management-related sources is problematic. Since most fluvial erosion is probably due to background sources, GMA assigned fluvial erosion to background.

Planning Watershed and Subwatershed Results

In earlier periods, erosion rates were highest in the Upper Albion PW, particularly in the North Fork, followed by the Middle and South Forks. However, it is clear that the South Fork has produced nearly twice as much on a per-unit basis than any other PW, comprising nearly half the erosion for the watershed in the recent period. Middle and Lower Albion PWs, which have also seen significant increases in the last two periods, comprise about a quarter of the watershed-wide erosion. The Upper Albion, where harvest rates declined significantly, only produces about 5% of the total.

While most of the differences in rates are due to differences in harvest rates and road building, some is due to differences in relief. Compared to the other planning watersheds, the Lower Albion, and to a lesser extent, the Upper Albion PW both contain considerable areas of low relief due to either the marine terraces or the wide valley floors, while only small percentages of the Middle and South Fork Albion PW are in low relief. By far the majority of the small parcels in the watershed are found in the areas of low relief, which almost appear to have been set aside for residential development, while the steeper slopes of the Middle, South Fork, and Lower Albion Planning Watersheds are areas of industrial timberland. However, no sub-watersheds have unusually steep slopes.

CHAPTER 5: TMDL AND ALLOCATIONS

The purpose of this chapter is to determine the total loading of sediment which the Albion River and its tributaries can receive without exceeding water quality standards, and to apportion the total among the sources of sediment.

5.1. TMDL

This TMDL is set equal to the loading capacity of the stream. It is the estimate of the total amount of sediment, from both natural and human-caused sources, that can be delivered to streams in the Albion River watershed without exceeding applicable water quality standards.

For North Coast sediment TMDLs, EPA has used three general approaches for deriving the loading capacity: (1) a comparison with a reference time period; (2) a comparison with a reference stream; and (3) the estimated needed improvement from existing loading rates. The approach used in a particular TMDL depends on the availability of data and the characteristics of the specific watershed.

For the Albion River TMDL, EPA is using a modification of the approach used for the Noyo River TMDL (EPA 1999) and similarly used in the Ten Mile River TMDL (EPA 2000b). For the Noyo River, a reference period was used to determine the loading capacity of 470 tons/mi^2/yr. For the Albion River, as with the Ten Mile River, we are not estimating the loading capacity using a reference period within the watershed because of the lack of fish population data and because the watershed was heavily disturbed prior to any data availability for determining sediment yield. In the Noyo, the background sediment yield was estimated at 370 tons/mi^2/yr, which means that the loading capacity was about 125% of background.

While a loading capacity based on 125% of background loading was used in the Noyo and Ten Mile River TMDLs, we have determined that a loading capacity of 150% is appropriate for use in this TMDL, for several reasons. We qualitatively compared the conditions in the Albion River watershed with target conditions and with those of several other watersheds along the Mendocino Coast, including those for which TMDLs have been developed, and found that sediment conditions in the Albion River, while degraded, are not as severely degraded as in other watersheds. For example, the concentrations of fine sediments <0.85 mm in channel bottom samples are generally well within target ranges (see Chapter 3), and those for sediments <6.4 mm are within or only slightly exceeding targets. In addition, the geology of the watershed is more stable, with virtually none of the more erodible melange terrain found in most watersheds along the North Coast, so conditions are not expected to degrade considerably. Moreover, because the watershed is smaller than many of the other Mendocino coastal watersheds, and does not extend as far inland, and because the channels generally appear to exhibit greater transport capacity than others, it is likely that the Albion stream network has a greater capacity to transport relatively smaller, though more frequent, landslides out of the watershed relatively quickly, and their effects are short-lived. Furthermore, the availability of better data allowed for the quantification of smaller landslides in the Albion than in nearby watersheds. This improves confidence in the source analysis and makes it appropriate to use slightly less conservative assumptions for the determination of the loading capacity.

Using the background rate of 275 t/mi^2/yr as determined in Chapter 4, the modified approach results in a loading capacity for the Albion of 275 t/mi^2/yr x 150%, or 412 t/mi^2/yr, which is relatively conservative for the watershed. The lower estimate of background loading in the Albion is slightly lower than for other nearby watersheds, resulting in a relatively lower loading capacity. The loading capacity for the Albion

River is 14% lower than the loading capacity for the Noyo River (470 t/mi^2/yr), and only 6% higher than the loading capacity for the Ten Mile River (388 t/mi^2/yr). The relative reductions called for by this TMDL are within a similar range as EPA has determined for other TMDLs in nearby watersheds on the Mendocino coast.

The TMDL for the Albion River and its tributaries, which is set equal to loading capacity, is 412 tons/mi^2/yr.

Given the hydrologic variability typical of the Northern California Coast Ranges, EPA expects the TMDL to be evaluated as a ten-year rolling average. Load allocations are expressed as an average over the entire watershed; however, the NCRWQCB may determine in the future that its implementation measures could benefit by a distinction among the different Planning Watersheds.

5.2. Allocations

In accordance with EPA regulations, the loading capacity (i.e., TMDL) is allocated to the various sources of sediment in the watershed, with a margin of safety. That is, the TMDL equals the sum of: all waste load allocations (for point sources), load allocations (for nonpoint sources and background), and a margin of safety.

Table 10 shows the TMDL and allocations for the Albion River watershed. Because there are no significant individual point sources of sediment in the Albion River watershed, the wasteload allocation for point sources is set at zero. The margin of safety is not added as an explicit component of the TMDL, but rather is incorporated implicitly into conservative assumptions used to develop the TMDL, as discussed in Section 5.3. Thus, the TMDL for sediment for the Albion River and its tributaries is apportioned among the categories of background and nonpoint sources of sediment identified in the source analysis (see Chapter 4), as load allocations. In other words:

TMDL = loading capacity = nonpoint sources + background = 412 t/mi^2/yr.

Approximately one-third of the loading (137 t/mi^2/yr) is allocated to management-associated nonpoint sources (management landsliding, skid-trail surface erosion and road surface erosion). Background sources comprise two-thirds of the load allocation (275 t/mi^2/yr), including non-management landsliding, soil creep, and fluvial erosion.

The load allocations are expressed in terms of yearly averages (tons/mi^2/yr). They could be divided by 365 to derive daily loading rates (tons/mi^2/day), but EPA is expressing them as yearly averages, because sediment delivery to streams is naturally highly variable on a daily basis. In fact, EPA expects the load allocations to be evaluated on a ten-year rolling average basis, because of the natural variability in sediment delivery rates. In addition, EPA does not necessarily expect each square mile within a particular source category to meet the load allocation; rather, EPA expects the average for the entire source category to meet the load allocation for that category.

TABLE 10:
TMDL AND LOAD ALLOCATIONS

Source Category	TMDL Load Allocation t/mi^2/yr	Current Load Estimate t/mi^2/yr 1989-2000	% of Current Loading	Loading Reduction Needed	% of TMDL Alloc.
LOAD ALLOCATIONS FOR NONPOINT SOURCES (MANAGEMENT-ASSOCIATED LOADS)	**137**	**435**	**6%**	**69%**	**33%**
TOTAL MANAGEMENT LANDSLIDING	109	328	46%	67%	26%
Harvest	65	158	22%	59%	16%
Roads	44	170	23%	74%	11%
SKID TRAILS SURFACE EROSION	12	17	2%	29%	3%
ROAD SURFACE EROSION	16	90	13%	82%	4%
LOAD ALLOCATIONS FOR BACKGROUND (NON MANAGEMENT-ASSOCIATED LOADS)*	**275**	**275**	**39%**	**0%**	**67%**
NON-MANAGEMENT LANDSLIDING	134	134	19%	0%	33%
SOIL CREEP (Background Surface Erosion)	75	75	11%	0%	18%
FLUVIAL EROSION	66	66	9%	0%	16%
TOTALS	**412**	**710**	**100%**	**42%**	**100%**

*Based on an estimate of background loading rate.

Determination of Allocations

In addition to ensuring that the sum of the load allocations equals the TMDL, EPA considered several factors related to the feasibility and practicability of controlling the various nonpoint source sediment sources. The load allocations for nonpoint sources reflect our best professional judgment of how effective best management practices are in controlling these sources. For example, techniques are available for greatly reducing sediment delivery from roads (Weaver and Hagans 1994); therefore, the load allocation for road-related sediment (landsliding and surface erosion) reflects a reduction of about 77% from the current estimate of the current loading rate. Similarly, conservation and land management measures to control sources associated with mass wasting due to timber harvesting are expected to be moderately effective, so the load allocation for mass wasting from timber harvesting reflects a 59% reduction from the estimate of the current loading. EPA expects that measures to control small landslides will be more effective than those to control larger landslides.

Overall, the allocations are intended to be a guide for the NCRWQCB in implementing the TMDL, and for the landowners in continuing their programs of sediment reduction. Relative to other TMDLs on the Mendocino Coast, this TMDL calls for slightly lower sediment reductions from management sources; for example, the overall reduction needed to meet the Albion River TMDL is 69%, compared with 75% for the Ten Mile River and approximately 75% for the Noyo River TMDLs.

5.3. Margin of Safety

The margin of safety is included to account for uncertainties concerning the relationship between pollutant loads and instream water quality and other uncertainties in the analysis. The margin of safety can be incorporated into conservative assumptions used to develop the TMDL, or added as an explicit separate component of the TMDL (EPA 1991).

Targets
Water quality targets were chosen that consider a range of factors for the protection of water quality related to sediment. These include: selecting a wide range of targets that are both directly descriptive of good water quality conditions (instream targets) and supportive of nondegradation policies (watershed targets); selecting conservative water quality targets where the scientific literature supports them; making conservative assumptions for targets, where data are sparse, regarding which limiting factors are potentially affecting coho salmon; making conservative assumptions with respect to the nature of the relationship between hillslope sediment production and in-stream effects; and including targets for watershed conditions (hillslope and roads) that will hinder additional sediment delivery into the water bodies. Because existing in-stream data are limited, the targets represent the optimal conditions for beneficial use support for salmonids, which are the most sensitive beneficial use.

Source Analysis
Conservative assumptions were made in the source analysis to account for uncertainty, as described by GMA (2001). In general, the assumptions resulted in attributing more of the observed sediment loads to management activities than is actually taking place. This reduces the amount estimated for background sources, and thus, the amount available for load allocations. (The small amount of fluvial erosion that may have been caused by management activity was assigned to background, but was more than adequately compensated for by additional conservative assumptions in the background rate determined in the sediment source analysis). The more accurate data provided from MRC’s database provides a better margin of safety by providing greater certainty.

TMDL and Load Allocations
EPA determined that historical loading rates analyzed for the study period in this basin were not appropriate to use as a reference period within the basin. There was no data that suggested a period during which water quality standards were apparently being met. (Although the loading rates for the 1979-1988 period appear to be meeting the TMDL, this period reflects a period of drought, which naturally produces less sediment. The rate in that period may also be a slight underestimate of the sediment generated during the period, as described in Chapter 4). A loading capacity and TMDL was selected that is lower than the sediment loading rates estimated for most periods within the basin between

1921-1999. Because background loading from fluvial erosion is assigned entirely to non-management causes, no allocation is made for management-caused bank erosion, which essentially functions as a margin of safety for that particular source.

In allocating the TMDL, we used the long-term background loading rate rather than the estimate of current background loading, which is higher than the long-term rate due to the fact that the current period (1989-2000) is wetter than normal. Using the lower background rate to determine loading capacity yields a lower estimate of the loading capacity.

An overall reduction of 69% over current management loading reflects a large sediment reduction, considering that conditions in the watershed are only moderately degraded.

5.4. Seasonal Variation and Critical Conditions

The TMDL must describe how seasonal variations were considered. Sediment delivery in the Albion River watershed inherently has considerable annual and seasonal variability. For this reason, the TMDL and load allocations are designed to apply to the sources of sediment, not the movement of sediment across the landscape, and to be evaluated on a ten-year rolling average basis.

The TMDL must also account for critical conditions for stream flow, loading, and water quality parameters. This TMDL does not explicitly estimate critical flow conditions because sediment impacts may occur long after sediment is discharged, often at locations far downstream of the sediment source. Rather, the approach used in this TMDL is to use indicators which reflect net long term effects of sediment loading and transport. Critical conditions are also influenced by high flow events (i.e., significant floods), which we considered by bracketing our analysis periods to show the effects of major storm periods or droughts.

CHAPTER 6: IMPLEMENTATION AND MONITORING RECOMMENDATIONS

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

The State implementation measures should contain provisions for ensuring that the load allocations in the TMDL (see Chapter 5) will in fact be achieved. These provisions may be non-regulatory, regulatory, or incentive-based, consistent with applicable laws and programs, including the State's recently-upgraded nonpoint source control program.

Furthermore, the State implementation and monitoring plans should be designed to determine if, in fact, the TMDL is successful in attaining water quality standards. To assist in this effort, the Albion River TMDL contains water quality indicators (see Chapter 3) as well as load allocations. Both the indicators and load allocations can assist in interpreting water quality standards, but they were developed using independent approaches, because the relationship between land management practices and the effects on water quality related to sediment is highly complex. Given the complexities, EPA recommends that the State consider both approaches to implement and evaluate the success of the TMDL in attaining water quality standards.

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

It is clear from the available data that reducing sediment from roads should be the highest priority in terms of sediment reduction. This will be the most cost-effective means of achieving the TMDL. This could include reducing the overall mileage of roads through decommissioning unused roads and upgrading existing roads to reduce sediment delivery to streams. Correction of small landslides to prevent delivery will also assist in efforts to achieve the TMDL.

The data base of information describing the watershed could also be increased through additional monitoring. EPA encourages the State and landowners to work together to fully implement the implementation and monitoring measures, as specified by the State.

CHAPTER 7: PUBLIC PARTICIPATION

EPA regulations require that TMDLs be subject to public review (40 CFR 130.7). EPA provided public notice of the draft Albion River sediment TMDL by placing a notice in the Mendocino Beacon and Santa Rosa Press-Democrat, newspapers of general circulation in the Albion River watershed. EPA has prepared a written summary of responses to all written comments on the draft TMDL received by EPA through the close of the comment period, September 17, 2001.

EPA maintained an email mailing list of interested persons to provide notification of issues relating to the Albion River TMDL. Occasionally, this included items of interest on the watershed not directly related to the TMDL. EPA also responded to comments and concerns that we received during the development process. EPA provided notification of its meetings and activities also to local radio stations and newspapers.

EPA and its consultant, Graham Matthews and Associates, met with MRC, Campbell Timberland Management, Inc., and members of the Albion River Watershed Protection Association and the Big River Watershed Alliance.

EPA held an informational meeting on the development of Albion River and Big River TMDLs at the Mendocino Community Center on February 15, 2001. This was also coordinated with the Albion River Watershed Protection Association and the Big River Watershed Alliance.

EPA also participated in the Mendocino County Board of Supervisors/Joint Planning Commission meeting on March 15, 2001, to present information on TMDLs generally, and the Big and Albion Rivers particularly.

An informal meeting to discuss the Public Review Draft TMDL was held on August 30, 2001, at the new Albion School. Formal written comments were received until October 1, 2001. The original public comment period was scheduled to end September 17, 2001. However, EPA extended the original comment period by two weeks.

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Glossary

Active channel	The area of the stream channel that is usually wetted.
Aggradation	Elevated stream channel bed resulting from deposition of sediment.
Anadromous	Refers to aquatic species which migrate up rivers from the sea to breed in fresh water, undergoing a physiological change to allow them to adjust from freshwater to saltwater to freshwater conditions.
Bankfull	The average annual flood , generally with a frequency interval of once every 1.5-2.3 years. Also, the channel form that accommodates the bankfull flow.
Bankfull channel	The area of the stream channel that contains the bankfull flow. Also, the area of the channel that appears to hold an average annual flood.
Basin Plan	The Water Quality Control Plan, North Coast Region-- Region 1.
Beneficial Use	Uses of waters of the state designated in the Basin Plan as being beneficial. Beneficial uses that may be protected against quality degradation include, but are not limited to: domestic, municipal, agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and the preservation and enhancement of fish, wildlife and other aquatic resources or preserves.
Cable Yarding	Yarding of cut timber accomplished by dragging cut timber up a hillslope from the cut area to a ridgetop landing.
CDF	California Department of Forestry and Fire Protection.
CDFG	California Department of Fish and Game.
CDWR	California Department of Water Resources.
cfs	Cubic feet per second: a measure of water flow.
Debris torrents	Long stretches of bare, generally unstable land areas or stream channel banks scoured and eroded by the extremely rapid movement of water-laden debris, commonly caused by debris sliding or road stream crossing failure in the upper part of a drainage during a high intensity storm.
Decommission	Closing and obliterating all traces of a road and restoring the land to its natural contours and drainage patterns.
Deep-seated landslide	Landslides involving deep regolith, weathered rock, and/or bedrock, as well as surficial soil. Deep seated landslides commonly include large (acres to hundreds of acres) slope features and are associated with geologic materials and structures.
Degradation	Lowering of the channel bed resulting from scour during flood flows.
Diversion potential	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
Drainage structure	A structure or facility constructed to control road runoff, including (but not limited to) fords, inside ditches, water bars, outsloping, rolling dips, culverts or ditch drains.
Dolbeer Donkey	The first machine used to haul cut timber to a landing area. It replaced animal hauling teams.

Embeddedness	The degree that larger stream bed sediment particles (boulders, rubble or gravel) are surrounded or covered by fine sediment. It is usually visually estimated in classes (<25%, 25-50%, 50-75%, and >75%) according to percentage of random large particles that are covered by fine sediment.
EPA	The United States Environmental Protection Agency.
Erosion	The group of processes whereby sediment (earthen or rock material) is loosened, dissolved, or removed from the landscape surface. It includes weathering, solubilization, and transportation.
ESU	Evolutionarily Significant Unit, used by NMFS to identify a distinctive group of Pacific salmon or steelhead for purposes of the federal Endangered Species Act.
Flooding	The overflowing of water onto land that is normally dry.
FPR	Forest Practice Rules, defined by the Z'berg Nejedly Forest Practice Act of 1973, as amended.
FWS	The United States Fish and Wildlife Service
Fry	A young juvenile salmon after it has absorbed its egg sac and emerged from the redd.
GIS	Geographic Information System.
Hydrologically closed road	Generally referring to roads that are closed to further use, with natural flow conditions restored (e.g., removing stream crossing fill), though the road itself may not be revegetated or obliterated.
Hydrologically connected road	A road with drainage that is directed toward a watercourse.
Hydrologically maintenance-free road	A road constructed so that there is no possibility of connecting the road drainage to the watercourse with the potential of failure, such as stream crossing failure.
Inner gorge	A geomorphic feature generally identified as the area of stream bank immediately adjacent to the stream, having a slope generally over 65% and being situated below the first break in slope above the channel.
Inside ditch	The ditch on the inside of the road, usually at the foot of the cutbank.
Landslide	Any mass movement process characterized by downslope transport of soil and rock, under gravitational stress by sliding over a discrete failure surface-- or the resultant landform.
Large woody debris	A piece of woody material generally having a diameter greater than 30 cm (12 inches) and a length greater than 2 m (6 feet) located in a position where it may enter the watercourse channel.
Low-Flow Channel	The part of the stream that is occupied by water during the periods of lowest flow, generally in late summer or early fall.
Mass wasting	Downslope movement of soil mass under force of gravity-- often used synonymously with "landslide." Common types if mass soil movement include rock falls, soil creep, slumps, earthflows, debris avalanches, debris slides and debris torrents.
MRC	Mendocino Redwood Company.
NCRWQCB	North Coast Regional Water Quality Control Board.
NMFS	The United State National Marine Fisheries Service.

NTU	Nephelometric Turbidity Units, a standard measure of turbidity.
Pool Tail-out	The downstream end of a pool, where the main current narrows, forming a "tail." AKA riffle head
Primary Pool	A pool that is at least as long as the low-flow channel width, and occupies at least half the width of the low-flow channel and, for 1st and 2nd order streams, is at least 2 ft or more in depth; and for 3rd order and higher streams, is at least 3 ft or more in depth. (Flosi et al. 1998)
Reach	The stretch of water visible between bends in a river or channel.
Redd	A gravel nest or depression in the stream substrate formed by a female salmonid in which eggs are laid, fertilized and covered with gravel for a period of incubation.
Refugia	Habitat areas that are of best quality and can contribute to full support of the species.
Regional Water Board	The California Regional Water Quality Control Board, North Coast Region.
Riffle	A gravelly or rocky shoal or sandbar lying just below the surface of a stream, or the stretch of choppy water caused by such a shoal or sandbar.
Riffle Head	The beginning (i.e., upstream end) of a riffle (aka pool tail-out).
Sediment	Fragmented material that originates from weathering of rocks and decomposed organic material that is transported by, suspended in, and eventually deposited by water or air.
Sediment delivery	Sediment delivered to a watercourse channel by wind, water or direct placement.
Sediment discharge	The mass or volume of sediment (usually mass) passing a watercourse transect in a unit of time.
Sediment source	The physical location on the landscape where earthen material resides which has or may have the ability to discharge into a watercourse.
Sediment yield	The total amount of sediment (dissolved, suspended, and bed load) passing through a given cross section of a watercourse channel in a given period of time.
Shallow -seated landslide	A landslide produced by failure of the soil mantle on a steep slope (typically to a depth of one or two meters; sometimes includes some weathered bedrock). It includes debris slides, soil slips and failure of road cut-slopes and sidecast. The debris moves quickly (commonly breaking up and developing into a debris flow) leaving an elongated, concave scar.
Sidecast	Fill from road construction cuts that is deposited to the side of the road.
Skid trail	Constructed trails or established paths used by tractors or other vehicles for skidding logs. Also known as tractor roads.
Steep slope	A hillslope, generally with a gradient greater than 50%, that leads without a significant break in slope to a watercourse.
Stream	See watercourse.
Stream order	The designation (1,2,3, etc.) of the relative position of stream segments in the drainage basin network. For example, a first order stream is the smallest, unbranched, perennial tributary which terminates at the upper point. A second order stream is formed when two first order streams join. A third order stream is designated when two 2nd- order streams join.

Tail-out	The lower end of a pool where flow from the pool, in low flow conditions, discharges into the next habitat unit, usually a riffle. Location where spawning generally occurs.
Thalweg	The deepest part of a stream channel at any given cross section.
Thalweg profile	Change in elevation of the thalweg as surveyed in an upstream-downstream direction against a fixed elevation.
THP	Timber Harvest Plan
TMDL	Total Maximum Daily Load, as defined under section 303(d) of the Clean Water Act, and regulations at 40 CFR Section 130.
Tractor Yarding	Yarding of cut timber using a tractor.
TSD	Technical Support Document.
Turbidity	A measure of the degree of light that can pass through water. High turbidity (low light transmissivity) can be caused by suspended fine sediments or organic material.
Unstable areas	Locations on the landscape which have a higher than average potential to erode and discharge sediment to a watercourse, including slide areas, gullies, eroding stream banks, or unstable soils. Slide areas include shallow and deep seated landslides, debris flows, debris slides, debris torrents, earthflows, inner gorges, and hummocky ground. Unstable soils include unconsolidated, non-cohesive soils and colluvial debris.
V*	A numerical value which represents the proportion of fine sediment that occupies the scoured residual volume of a pool, as described by Lisle and Hilton (1992). Pronounced "V-star."
Watercourse	Any well-defined channel with a distinguishable bed and bank showing evidence of having contained flowing water indicated by deposit of rock, sand, gravel, or soil.
Waters of the state	Any ground or surface water, including saline water, within the boundaries of the state.
Watershed	Total land area draining to any point in a watercourse, as measured on a map, aerial photo or other horizontal plane. Also called a basin, drainage area, or catchment area.
Water quality criteria	Numeric or narrative criteria established under the Clean Water Act to protect the designated uses of a water.
Water Quality Indicator	An expression of the desired instream or watershed environment. For each pollutant or stressor addressed in the problem statement, an indicator and target value is developed.
Water quality objective	A State Basin Plan term equivalent to the Clean Water Act's water quality criteria. Water quality criteria are limits or levels of water quality constituents or characteristics established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area.
Water quality standard	A Clean Water Act term which includes the designated uses of a water, the water quality criteria established to protect the designated uses, and an antidegradation policy.
Yarding	Collection of cut timber at a landing area.
Yearlings	Fish that hatched in the previous year (i.e., one-year-olds).
Young-of-Year	Fish that hatched in the current season.
WY	Water Year. October 1 - September 30. E.g., WY1999 = October 1, 1998 through September 30, 1999.