U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IX

GARCIA RIVER SEDIMENT
TOTAL MAXIMUM DAILY LOAD

MARCH 16, 1998

APPROVED BY:

ORIGINAL SIGNED

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EXECUTIVE SUMMARY

The Garcia River watershed is a forested watershed located in northern California. The purpose of the Garcia River Total Maximum Daily Load (TMDL) is to identify loading allocations that, when implemented, are expected to result in the attainment of the applicable water quality standards for sediment. The Garcia River watershed was listed on California's 1996 Clean Water Act (CWA) Section 303(d) list as water quality limited due to sedimentation. The level of sedimentation in the Garcia River watershed was judged to exceed the existing Water Quality Standards (WQS) necessary to protect the beneficial uses of the basin, particularly the cold water fishery. Accelerated erosion from land use practices and other causes is impacting the migration, spawning, reproduction, and early development of cold water fish such as coho salmon and steelhead trout.

The TMDL includes: a problem assessment, which includes an assessment of existing instream and upslope conditions; identification of instream numeric targets, which are intended to interpret and apply the narrative water quality standards and also represent the optimum instream conditions for cold water fish; an assessment of significant sediment sources that have in the past or are presently impacting the stream system; a linkage analysis to determine the magnitude of reductions necessary to attain the numeric targets; an allocation of loads section, which identifies the loading capacity of the stream and individual load allocations for land use activities; and several other sections designed to address considerations set forth in Section 303(d) of the Clean Water Act or the implementing regulations at 40 CFR 130.7.

The EPA has relied on the Garcia River Watershed Water Quality Attainment Strategy developed by the North Coast Regional Water Quality Control Board (December, 1997) for much of the information and analysis contained in this TMDL.

INTRODUCTION

The Garcia River watershed is a forested watershed located in northern California. The purpose of the Garcia River Total Maximum Daily Load (TMDL) is to identify the necessary reductions of human-related delivery of sediment to the river system which will result in the improvement of channel conditions necessary to efficiently reduce existing instream sediment sources and provide adequate salmonid habitat. Protection of water quality will be achieved when the water quality standards (WQS) adopted to protect the beneficial uses of the Garcia River watershed and contained in the *Water Quality Control Plan for the North Coast Region* (the Basin Plan) are met. The TMDL identifies loading allocations that, when implemented, are expected to result in the attainment of the applicable water quality standards for sediment. The Garcia River watershed was listed on California's 1996 Clean Water Act (CWA) Section 303(d) list as water quality limited due to sedimentation. The level of sedimentation in the Garcia River watershed was judged to exceed the existing WQS necessary to protect the beneficial uses of the basin, particularly the cold water fishery.

Section 303(d)(1)(A) of the Clean Water Act requires that "Each State shall identify those waters within its boundaries for which the effluent limitations...are not stringent enough to implement any water quality standard applicable to such waters." The CWA also requires states to establish a priority ranking for waters on the 303(d) list of impaired waters and establish TMDLs for such waters. As part of the 1996 303(d) list submittal, the State identified the Garcia River as high priority for TMDL development and began work on the TMDL in 1996.

The requirements of a TMDL are described in 40 CFR 130.2 and 130.7 and Section 303(d) of the CWA, as well as in various guidance documents (e.g., U.S. EPA, 1991). A TMDL is defined as "the sum of the individual wasteload allocations for point sources and load allocations for nonpoint sources and natural background" (40 CFR 130.2) such that the capacity of the waterbody to assimilate pollutant loadings (the Loading Capacity) is not exceeded. That is,

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

where Σ = the sum, WLAs = waste load allocations and LAs= load allocations (including natural background). A TMDL is also required to be developed with seasonal variations and include a margin of safety to address uncertainty in the analysis. In addition, pursuant to the regulations at 40 CFR 130.6, states are required to develop water quality management plans to implement water quality control measures including TMDLs.

This TMDL incorporates elements which address the statutory and regulatory requirements for a TMDL along with needed documentation of the basis for the TMDL. These elements include an assessment of the pollutant problems and impacts on the beneficial uses, development of instream numeric targets that interpret and apply the WQS, an assessment of the sources of the pollutant, and estimation of loading capacity and associated load allocations to meet WQS.

The Environmental Protection Agency (EPA) has oversight authority for the 303(d) program and is required to review and either approve or disapprove the TMDLs submitted by states. If the EPA disapproves a TMDL submitted by a state, the EPA is required to establish a TMDL for that waterbody. Pursuant to a consent decree entered in the United States District Court, Northern District of California, (*Pacific Coast Federation of Fishermen's Associations, et al. v. Marcus*, No. 95-4474 MHP, March 11, 1997) EPA committed to assuring that TMDLs would be established for 18 rivers by December 31, 2007. Pursuant to the consent decree, EPA developed a Supplemental TMDL Establishment Schedule which set December 31, 1997, as the deadline for the establishment of a TMDL for the Garcia River. In October 1997, the State of California's North Coast Regional Water Quality Control Board (Regional Board) released for public comment a preliminary draft TMDL for the Garcia River. Due to the large number of comments received from the public, the Regional Board delayed its submission of the Garcia River TMDL to EPA for evaluation, and postponed its scheduled hearing on the draft TMDL until January 22, 1998. In order to grant the Regional Board additional time to hold the hearing and continue development of the TMDL, the parties to the lawsuit agreed that the deadline for establishment of a TMDL for the Garcia River would be extended to March 16, 1998.

Under the consent decree, if the State of California fails to establish a TMDL by the deadline in the Supplemental TMDL Establishment Schedule, EPA must establish a TMDL for that waterbody by the deadline in the Schedule. Since the State did not submit the TMDL to EPA in time to meet the March 16, 1998 deadline, EPA is establishing the Garcia River TMDL.

Upon establishment of the TMDL by EPA, the State is required to incorporate the TMDL, along with appropriate implementation measures, into the State Water Quality Management Plan (40 CFR 130.6(c)(1), 130.7). The Regional Board Basin Plan, and applicable state-wide plans, serve as California's Water Quality Management Plan governing the Garcia River watershed. If the State subsequently adopts and submits for EPA approval a TMDL which is different from the TMDL established by EPA, EPA will review the State-submitted TMDL to determine if it meets all TMDL requirements. If EPA approves the State-established TMDL, EPA expects the State-established TMDL would be the TMDL for the Garcia River.

This TMDL does not apply to portions of the watershed in Indian Country because State WQS do not apply to Indian Country. Only a very small portion of the watershed is considered to be in Indian Country.

Differences Between the EPA TMDL vs. the Regional Board Strategy

As noted above, the Regional Board issued a preliminary draft TMDL for the Garcia River in October, 1997. On December 9, 1997, the Regional Board issued for public comment the official draft TMDL as part of the Regional Board's proposed Garcia River Watershed Water Quality Attainment Strategy (Strategy). Much of the information in EPA's Garcia River TMDL is derived directly from the Strategy. However, the EPA TMDL differs from the Regional Board Strategy in certain respects, including the following:

- Certain aspects of the EPA TMDL report provide less detailed background and explanatory information, referring the reader instead to the Regional Board's Strategy for more in-depth discussions.

- Unlike the State's draft Strategy, the EPA TMDL does not included interim targets and is not a phased TMDL. Nevertheless, EPA endorses the phased approach to the Garcia River TMDL proposed by the Regional Board in the Strategy. The Regional Board developed a phased approach strategy which includes interim and final targets, a monitoring plan, and an adaptive management approach including schedules for reviewing the TMDL. Both the follow-up monitoring and review schedule are key elements of TMDLs done through the phased approach (U.S. EPA 1991). EPA will encourage the State to carry out the phased adaptive management approach proposed in the Strategy for the Garcia River.

- The number of indicators for numeric targets has been reduced in response to comments and in an effort to simplify the TMDL. The indicators and targets selected by EPA are those which EPA believes most closely correlate with increased sedimentation and are most supported with information specific to the Garcia River.

- The allocations have been changed to account for linkages with instream targets and are presented in single numbers as opposed to ranges identified in the Strategy.

- The margin of safety section has been expanded to provide more specific examples of the type of implicit assumptions that were made throughout development of the TMDL and an explicit margin of safety was added to account for unassessed sediment sources.

- There are no Implementation and Monitoring plans included as part of this document because they are not required components of a TMDL. However, the State is required to identify implementation measures needed to implement the TMDL, and to incorporate the TMDL itself in the Basin Plan (40 CFR 130.6). In addition, the State has proposed its TMDL as a phased TMDL which includes follow-up monitoring to evaluate TMDL effectiveness and the need for revisions. This is appropriate for TMDLs, such as the Garcia River TMDL, which involve substantial uncertainty in the analysis. EPA endorses the implementation and monitoring plans proposed in the Strategy, and expects the State to incorporate them in Basin Plan along with the TMDL as part of a reasonable approach to water quality management planning and implementation.

PROBLEM STATEMENT

An assessment of the water quality problems is necessary to clearly identify the water quality standards which are not being met or which are threatened and to identify the pollutant(s) for which the TMDL is being developed. The Regional Board summarized existing information in the Strategy which provides a general understanding of the watershed and condition of the fishery. It does not specifically or comprehensively describe the conditions in individual tributaries. Based on this information, the Regional Board developed general and specific problem statements which reflect how the beneficial uses are impacted based on the limited existing information. EPA relied on this information for the Problem Statement. The EPA TMDL is developed at the whole basin scale because inadequate information was available at the tributary level to develop TMDLs at a finer geographic scale.

In general, the Garcia River watershed is a forested watershed in Mendocino County, California. It is impacted by elevated sedimentation due to inherent geologic instabilities, past and present land use practices, and other factors. Figure 1 depicts the location of the Garcia River watershed in northern California. The cold water fishery is identified by the Regional Board as a beneficial use of the Garcia River watershed. Coho salmon, a species native to the Garcia River, has been listed by the National Marine Fisheries Service as a threatened species. In addition, steelhead populations have declined significantly in the watershed. Sedimentation has contributed to the reduction and loss of habitat necessary to support cold water fish such as these salmonids.

Water Quality Standards (WQS)

Water quality standards (WQS) adopted for the Garcia River basin are contained in the Basin Plan. The WQS for the Garcia River are comprised of the beneficial uses of water and the water quality objectives designed to protect those beneficial uses. The beneficial uses of water are described as either existing or potential. The water quality objectives are designed to protect the most sensitive of the beneficial uses.

In the Garcia River, the beneficial uses addressed in the TMDL include: cold freshwater habitat (COLD); migration of aquatic organisms (MIGR); estuarine habitat (EST); and spawning, reproduction, and/or early development (SPAWN). The water quality objectives addressed include settleable material and sediment.

Table 1: Summary of Beneficial Uses Addressed in the Garcia River TMDL (Regional Board, 1994)

Beneficial Water Uses	Potential or Existing	Description
Cold Freshwater Habitat (COLD)	Existing	Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitat, vegetation, fish, or wildlife, including invertebrates.
Migration of Aquatic Organisms (MIGR)	Existing	Uses of water that support habitat necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish.

Estuarine Habitat (EST)	Existing	Uses of water that support estuarine ecosystems including, but not limited to, preservation or enhancement of estuarine habitat, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds).
Spawning, Reproduction, and/or Early Development (SPAWN)	Existing	Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.

Table 2: Summary of Water Quality Objectives Addressed in the Garcia River TMDL (Regional Board, 1994)

Water Quality Objective	Description
NARRATIVE OBJECTIVES	
Settleable Material	Water shall not contain substances 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.

Beneficial Use Issues

Salmonids are born in fresh water streams where they spend one to several years of their lives feeding, growing, and hiding from predators. Once they are large enough, fresh water salmonids undergo a physiological change which allows them to swim out to the ocean where they then spend the next one to several years. Salmonids return to the streams in which they were born to lay eggs and begin the life cycle again. They require gravels free from excessive fine sediment to lay their eggs and for the eggs to develop into free-swimming fish. They also require deep pools for the young fish to feed and grow while protected from predators.

Land management activities can serve to increase erosion beyond natural rates through mass wasting (landsliding), fluvial erosion (gullying and stream bank erosion), and surface erosion (sheetwash). Such increased erosion can cause coarse and fine sediment to enter the stream, filling in deep pools and silting in potential spawning gravels to the detriment of salmonids. Many stream systems on the north coast, including the Garcia River watershed, are composed of Franciscan complex geology and are prone to storm-induced erosional events. Land management activities can accelerate this natural process, overwhelming the stream channel's ability to efficiently move the delivered sediment. Historic land use practices, in particular, appear to have had a major impact.

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

Figure 1.

As noted in the Strategy, the California Department of Fish and Game (DFG) estimated that in 1960 there were 2000 coho spawning in the Garcia River watershed. By the 1970s, DFG's creel census data indicated that between 0-20 coho were being caught each year (DFG, 1975). The State indicated in the Strategy that Craig Bell, a professional fishing guide on the Garcia River (public testimony, 1997) estimated that there are fewer than 200 wild coho in the Garcia River today. The reduction in coho populations, he states, follows the loss of pink salmon in the 1950s and chinook salmon in the 1970s.

Summary of Existing Conditions

In support of the Strategy, the Regional Board prepared an *Assessment of Aquatic Conditions in the Garcia River Watershed* (1997) (Assessment) which reviewed all available information to develop an assessment of the overall condition of the watershed. Information from this was summarized in the Problem Statement and Source Analysis sections of the Strategy. This summary is based on information from both of those sections in the Strategy. In general, stream channels in the Garcia River basin are wider, shallower, and more homogeneous than is desirable or were historically present.

1. Substrate Composition

According to the Strategy, contractors to the Mendocino County Resource Conservation District through the *Garcia River Watershed Enhancement Plan* (1992) found that data in several sub-basins indicated that spawning gravels were more than 50% embedded. The lower Garcia River lacks potential spawning gravels altogether. Monitoring data from timber landowners reviewed by the State indicated that in only two of the four planning watersheds monitored were the distributions of channel bed fine sediments optimum for salmonid development and in none of the four planning watersheds sampled were fines optimum for successful incubation.

2. Aquatic Habitat

The State noted that data from the *Garcia River Watershed Enhancement Plan* (1992) and from the DFG indicates that pool depth and pool/riffle ratio is adequate for salmonid rearing in the lower reaches of the watershed and significant spawning has been observed in the lower Garcia River. Adequate pool habitat is not adequate in any of the other surveyed sub-basins. The occurrence of large woody debris was rated quite low in each of the surveyed reaches, with the possible exception of one sub-basin. Large woody debris is an important structural element of North Coast streams, providing channel stability, as well as salmonid habitat. Pacific Watersheds Associates (PWA) (1997) data indicates that streambanks may not be optimally vegetated with tree and shrub species and, as a result, banks may not be adequately protected from stream erosion. Barriers to fish migration, including sediment deltas and aggraded reaches which dewater in the summer, were found in several sub-basins as well as the mainstem. The Strategy noted that the DFG fish population data generally indicates that coho populations have dramatically declined since 1960. The coho remaining appear to favor the same tributaries of the lower watershed. Steelhead populations appear to have declined as well, but range more broadly throughout the basin.

3. Upslope Conditions

The Source Analysis developed by PWA (1997) indicates that overall sediment production rates have decreased throughout most of the Garcia River basin, especially between 1978 to 1997. The greatest rate reductions appear to be associated with landslide processes and surface erosion occurring on skid trails. The data suggests that only modest gains have been made in reducing fluvial, mass movement and surface erosion from roads. PWA also noted that during the past 10 years, approximately 43% of the Garcia River watershed has experienced a renewed period of timber harvesting and road reconstruction which may cause an increase in sediment production that has not been assessed given drought conditions over this same time period. Data also indicates that higher order, lower gradient tributary streams still contain appreciable quantities of stored sediment. It may take decades to remobilize and route currently stored sediments in the active channel of tributaries and, as a consequence, significant improvements in channel stability and habitat quality may be delayed in many portions of the Garcia River. In addition, an analysis of the road density indicates that road densities in the Garcia River watershed are well above the desired density to protect instream habitat, also indicating that erosion from roads is a probable source of concern.

GENERAL PROBLEM STATEMENT

The Garcia River watershed has experienced a reduction in the quality and quantity of instream habitat which is capable of supporting the cold water fishery, particularly that of coho salmon and steelhead. Controllable factors contributing to this habitat loss include the acceleration of sediment production and delivery due to land management activities and the loss of instream channel structure necessary to maintain the system's capacity to efficiently store, sort, and transport delivered sediment.

Three factors are important in describing the issue of sedimentation: sediment production, sediment delivery, and sediment transport. Water quality concerns arise when sediment is delivered to the stream in amounts or to locations that overwhelm the stream's capacity to transport it. Such is the case in the Garcia River watershed. Habitat niches are filled by sediment and the stream channel is aggraded, in some places. It is important to note, though, that the filling once noted in the estuary and lower mainstem appears to be reversing-- an indication that the process of recovery has begun. Deep holes and other habitat niches, however, are still absent in the estuary and lower mainstem.

For gravel-bed streams, such as the Garcia River, the presence of channel structure plays a crucial role in the efficient storage, sorting, and transport of sediment through the river system (Keller et al. 1995). Channel structure takes the form of large woody debris, boulders, armored stream banks, and other structural elements. For streams in the Pacific Northwest, including northern California, large woody debris has been identified as a particularly important structural element (Keller et al. 1995). Thus, sediment delivery and instream channel structure, particularly large woody debris, are integral companions in the problems (and solutions) related to sedimentation and the reduction in the quality and quantity of instream habitat.

1. Instream Problem Statements

1. Physical Barriers to Migration

The migration of anadromous fish in the Garcia River watershed from the ocean, within the basin, and back to the ocean is impacted by the presence of migration barriers such as: 1) shallow or dewatered stream segments due to aggradation (rising stream bed elevation) and 2) improperly installed culverts which provide either a poor starting location, require too high a jump for anadromous fish to successfully navigate, or reduce the depth of the water. This statement relates to the MIGR beneficial use and the potential for sediment in the form of aggradation or road fill to prevent the migration of salmonids. (Natural barriers, such as bedrock falls, are not addressed here since they were not created by land management activities and hence are not controllable. Moreover, the sediment TMDL does not address anthropogenic barriers associated with culverts).

2. Fine Sediment in Spawning Gravels

Spawning gravels of the Garcia River watershed are impacted and likely to suffer additional impacts by the delivery of fine sediment to the stream which fills the interstices of the framework particles: 1) cementing them in place and reducing their viability as spawning substrate, 2) reducing the oxygen available to fish embryos, 3) reducing intragravel water velocities and the delivery of nutrients to and waste material from the interior of the redd (salmon nest), 4) and impairing the ability of fry (young salmon) to emerge as free-swimming fish. This statement relates to the SPAWN beneficial use and the potential for settleable material to impact spawning substrate or redds.

3. Aggradation of Sediment In Spawning Gravels

Spawning gravels of the Garcia River watershed are impacted by the delivery of fine and coarse sediment to the stream which causes aggradation, the burial of large woody debris and other structural elements, a loss of the stream's ability to effectively sort gravel, and a potential reduction in the dominant particle sizes. This statement relates to the SPAWN beneficial use and the potential for sediment and settleable material to impact spawning substrate.

4. Lack of pools for Rearing Habitat

Pools of the Garcia River watershed potentially suitable as rearing habitat are impacted by the delivery of fine and coarse sediment to the stream which: 1) reduces the volume of available rearing habitat by filling in pools and burying pool-forming structural elements such as large woody debris, 2) reduces pool depth and therefore the cool water refuge associated with temperature stratification, 3) reduces the availability of fish cover as a result of decreased depths and the burial of large woody debris and other structural elements, and 4) causes loss of surface flow as pools are filled in resulting in less available habitat and protection from predators. This statement relates to the SPAWN beneficial use and the potential for sediment and settleable material to impact rearing habitat.

5. Stream Channel Instability

Increased sediment delivery to the Garcia River watershed impacts stream channel stability by causing: 1) aggradation, stream channel widening, greater flood potential, and greater stream bank erosion, 2) the burial of channel structural elements such as large woody debris with a reduction in sediment transport efficiency, and 3) loss of wetlands and increased flooding in the estuary. This statement relates to the COLD and EST beneficial uses and the potential for sediment to impact stream channel stability and habitat niches.

2. Upslope Problem Statements

1. Loss of Large Woody Debris

The removal of vegetation (particularly large conifers) from the riparian zone of the Garcia River watershed causes: 1) a loss of stream bank stability and increased stream bank erosion, 2) a loss of sediment filtering capacity and increases in sediment delivery, and 3) a reduction in the potential for large woody debris recruitment to the stream and in the stream's sediment transport efficiency. This statement relates to the COLD beneficial use and the potential for sediment and settleable matter to impact stream channel stability and habitat niches.

2. Road Density

The density and use of roads, landings, skid trails, and agricultural facilities in the Garcia River watershed causes: 1) increased surface erosion and fine sediment production and delivery and 2) an increased potential for stream diversions (stream channel capture), rill and gully erosion, and shallow-seated landslides with corresponding increases in sediment production and delivery. This statement relates to the COLD beneficial use and the potential for sediment and settleable matter to impact stream channel stability and habitat niches.

3. Sediment from Unstable Areas

Operations on unstable slopes (e.g., inner gorges, headwall swales, active or potentially active landslides, or steep slopes) in the Garcia River watershed cause increased landsliding and the production and delivery of fine and coarse sediment. This statement relates to the COLD beneficial use and the potential for sediment and settleable matter to impact stream channel stability and habitat niches.

NUMERIC TARGETS

Section 303(d)(1)(C) of the Clean Water Act states that TMDLs "shall be established at a level necessary to implement the applicable water quality standards...." The numeric targets developed for the Garcia River TMDL are intended to interpret the narrative water quality standards adopted in the Basin Plan (1994). This TMDL uses a subset of the targets identified by the Regional Board in its proposed TMDL (Strategy, 1997). The numeric targets represent the optimal conditions for salmonid reproductive success. The Regional Board based the numeric targets on scientific literature, available monitoring data for the basin and best professional judgement. The literature supports these targets and, when implemented, the TMDL should fully meet these targets and, as a result, the WQS. Table 3 depicts the EPA numeric targets.

While EPA agrees that all of the indicators proposed by the Regional Board serve as useful TMDL monitoring and evaluation indicators and are supported by the literature as referenced in the Strategy, EPA established a smaller number of indicators for TMDL target establishment. This is in response to comments and to simplify the TMDL. EPA encourages the State to work with landowners to use the broader set of indicators developed by the Regional Board as part of a comprehensive monitoring plan.

The indicators for which EPA established numeric targets include percent fines <0.85 mm, percent fines <6.5 mm, V*, d_{50} and pool frequency. Scientific literature suggests that these indicators are the most easily linked to fish habitat conditions which support salmonids and can be used to evaluate the long term impacts of upslope activities and erosion reduction efforts (Knopp, 1993, Chapman, 1988). Existing information on present and historical conditions, although not extensive, is more comprehensive for these indicators than for the others proposed in the Strategy. The scientific basis for the EPA targets is discussed in more detail in pages 35-45 in the Regional Board Strategy.

Table 3: Summary of EPA Instream Numeric Targets for the Garcia River Watershed

Life Stage & Channel Stability	Parameter	Associated Water Quality Standard	Monitoring Location*	Numeric Targets
Embryo Development	Percent fines<0.85 mm	SPAWN, COLD, EST, settleable material, sediment	Class I streams and restorable Class I streams	14%
Emergence	Percent fines <6.5 mm	SPAWN, COLD, EST, settleable material, sediment	Class I streams and restorable Class I streams	30%
Rearing	Pool frequency	SPAWN, settleable material	Class I streams	Primary pools** covering 40% of the total habitat length
Channel Structure/Stability	V*	COLD, MIGR, settleable material, sediment	3rd order streams with slopes 1-4%	$\leq$0.21 (mean) $\leq$0.45 (max)
Channel Structure/Stability	Median particle size diameter (d_{50})	COLD, settleable material, sediment	3rd order streams with slopes 1-4%	$\geq$69 mm (mean) >37 mm (min)

* Other monitoring protocols (where, when, how) should be identified in the State's or landowners monitoring plans
** Primary pools are defined by the Regional Board for Class I streams as having a pool dimension of a low flow depth of at least three feet, a length equal to or greater than the low-flow channel width, and a width at least one-

half the width of the low flow channel.

1. <u>Percent Fines <0.85 mm</u>

Once the eggs are laid and fertilized, the spawners cover the redds with material from upstream, including clean gravels and cobbles. The interstitial spaces between the particles allow for water to flow into the interior cavity where dissolved oxygen, needed by the growing embryos, is replenished. Similarly, the interstitial spaces allow water to flow out of the interior cavity carrying away metabolic wastes. However, fine particles either delivered to the stream or mobilized by storm flow can intrude into those interstitial spaces, blocking the flow of oxygen into the redd and the metabolic wastes out of it. The reduced permeability into and out of the redd results in a reduction in the rate of embryo survival.

Research on this subject has concluded that as the percentage of fines increases as a proportion of the total bulk core sample, the survival to emergence (i.e., out of the gravel) decreases. Fines that impact embryo development are generally defined as particles which pass through a 0.85 mm sieve. The 0.85 mm cut off is based on the available sieve sizes at the time of the initial studies in this area.

a. Numeric Target

<u>The percent fines target to be applied in Class I and restorable Class I streams is 14% fines <0.85 mm.</u> Class I streams are defined by the California Department of Forestry and Fire Protection as watercourses which contain domestic water supplies, including springs, on site and/or within 100 feet downstream of the operation areas and/or have fish always or seasonally present onsite, including habitat to sustain fish migration and spawning. Class I streams include historically fish-bearing streams. This target is selected as the midpoint between the percentages of fines reported in unmanaged streams in the Peterson and Burns studies. The target takes into account that the 11% fines <0.85 mm which was observed in unmanaged streams in the Pacific Northwest (Peterson et al., 1992) is probably too low for the highly erosive Franciscan geology found on the north coast of California. It takes into account that the 17% fines <0.85 mm which was seen in unmanaged California streams beginning in 1967 (Burns, 1970) is probably too high given the tremendous sediment loads which were discharged to streams as a result of the 1964 storms. And, it takes into account the range of fines <1.0 mm (15-35%) which are already seen in impacted, managed streams in the Garcia River basin. In addition, this target takes into account the lack of uniformity among the data and the fines levels seen in managed streams in the Garcia River basin. This target is intended to be consistent with the water quality objective for settleable matter and sediment and protect the spawning life stage of cold water fish and their associated habitat as described in the EST, SPAWN and COLD beneficial uses.

b. Existing Conditions

Table 4 is a summary of monitoring data collected by three industrial timber companies and one non-industrial timber owner. Several sampling locations have been monitored once per year for several years. Of the stream segments sampled, the data indicates that only in Inman Creek and two locations in the North Fork Garcia River sub-basin are the percent fines <0.85

mm optimum for salmonid embryo development.

Table 4: Summary of Existing McNeil Data

Planning Watershed	Stream Name	Year	<0.85 mm (%)	<6.5 mm (%)
113.70010	Upper Redwood Creek	1994	32.2	57.9[1]
	Lower Redwood Creek	1994	19.4	53.5[1]
113.70011	No Data			
113.70012	No Data			
113.70013	Mainstem Garcia @ Blue Waterhole Creek	1995	18.2	46.7[1]
113.70014	Mainstem Garcia @ Inman Creek	1994	15.8	51.0[1]
	Inman Creek	1995	12.8	36.7[1]
113.70020	No Data			
113.70021	No Data			
113.70022	No Data			
113.70023	No Data			
113.70024	No Data			
113.70025	North Fork Garcia #1 (lower)	1989	17.3[2]	40.5[3]
		1990	20.9[2]	47.8[3]
		1991	14.1[2]	30.3[3]
	North Fork Garcia #2 (mid-lower)	1989	13.3[2]	26.9[3]
		1990	15.4[2]	39.1[3]
		1991	15.1[2]	35.8[3]
	North Fork Garcia #3 (mid)	1989	25.3[2]	35.8[3]
		1990	17.7[2]	31.2[3]
		1991	20.6[2]	42.0[3]
	North Fork Garcia #4 (mid-upper)	1989	25.9[2]	43.9[3]
		1990	25.7[2]	48.3[3]
		1991	27.0[2]	46.5[3]
	North Fork Garcia #5 (upper)	1989	26.3[2]	46.7[3]
		1990	27.1[2]	46.7[3]
		1991	31.3[2]	52.2[3]
113.70026	No Data			

[1] Actual measurement was for particles less than or equal to 4 mm.

[2] Actual measurement was for particles less than 1 mm.

[3] Actual measurement was for particles less than 4.75 mm.

c. Comparison of Numeric Target and Existing Conditions

A comparison of target and existing information helps provide information on the extent of the problem as well as the sediment reduction needed to meet water quality standards. For percent fines data was available at 10 sites (See Table 4). For sites where multiple data values from different years were available, the values for each individual site were averaged. Then, the values for all sites were averaged (Table 5).

Table 5: Comparison of existing fine sediment data for % fines <0.85 mm with instream numeric target

Indicator	Existing Data (n=20) (Average Value)	Numeric Target
% fines <0.85 mm	20.6%	14%

2. <u>Percent fines <6.5 mm</u>

After 4 to 6 weeks, the embryos are ready to emerge from the gravel as fry (young swimming fish.) The presence of fine sediment in the gravel interstices can impede fry emergence. However, the size of fine particles likely to fill the interstices of redds sufficient to block passage of fry are larger than those likely to suffocate embryos. That is, particles ranging from 0.85 mm to 9.5 mm are capable of blocking fry emergence, depending on the sizes and angularity of the framework particles, while still allowing sufficient waterflow through the gravels to support embryo development. Besides a correlation between percent fines and the rate of survival to emergence, there is also a correlation between percent fines and the length of incubation; i.e., the amount of time it takes for the fry to emerge from the egg. Percent fines is also inversely related to the size of emergents (Chapman, 1988). Each of these factors impact the ultimate survivability of the embryos and fry.

a. Numeric Target

<u>The numeric target for fines <6.5 mm is 30% to be applied in Class I and restorable Class I streams</u>. This target is based on the literature review performed by the Regional Board (Strategy, pages 38-40). Though much of the laboratory data suggest that 25% fines <6.5 mm may be more appropriate for coho salmon, these data are moderated by the fact that data from unlogged coho streams showed that the amount of fines <6.4mm varied between 27 to 55% (Chapman, 1988). In addition, the State noted that Kondolf, in unpublished data, found that fines should not comprise more that 30% of the overall particle size distribution. This target is intended to be consistent with the water quality objective for settleable matter and sediment and

protect the spawning life stage of cold water fish and their associated habitat as described in the EST, SPAWN and COLD beneficial uses.

b. Existing Conditions

Table 4 provides existing data for percent fines <6.5 mm. In none of the streams surveyed were fines <6.5 mm optimum for successful incubation.

c. Comparison of Numeric Target and Existing Conditions

Like the comparison above for percent fines <0.85 mm, EPA compared the existing data by averaging the values from the different sites. Again, for those sites which had multiple data for different years these values were averaged to provide a single value for each site (Table 6).

Table 6: Comparison of existing fine sediment data for % fines <6.5 mm with instream numeric target

Indicator	Existing Data (n=20) (Average Value)	Numeric Target
% fines <6.5 mm	45.0%	30%

3. V*

V* provides a measurement of the fraction of a pool's volume which is filled with fine sediment. This is a measure of the in-channel supply of mobile bedload sediment. It is affected by sediment inputs and is related to the quality of fish habitat since salmonids prefer deep, cool pools. It is an unbiased measurement and its variance in a reach of stream has been shown to be low enough to provide precise estimates of mean values with a reasonable amount of effort. (Lisle, 1993).

a. Numeric Target

The numeric targets for V* are a mean of less than or equal to 0.21 and a maximum of less than or equal to 0.45. These targets are based on Knopp's findings (1993). The V* indicator has two targets associated with it. The lower number ≤ 0.21 represents the optimum target, while the higher number ≤0.45 represents the maximum number that should be found. By setting two numbers, the EPA recognizes that there may be annual variability in this target.

Knopp measured a range of habitat variables in 60 streams on the north coast, including the Garcia River. The 60 streams in the Knopp study were all of similar geologic and climatic conditions to the Garcia River, making them reasonable comparisons to the Garcia River. The study included stream reaches which were moderately and highly disturbed as well as what were called index reaches, which were defined as drainages with no human disturbance history or little disturbance within the past 40 years and no evidence of residual erosion or instability due to past human activity. The index reaches act as reference reaches. Knopp found that in the index reaches, the V* mean measured 0.21 or less and the maximum measured 0.45 or less. The V* values identified by Knopp represent the average of six separate pools. V* measurements exhibited a trend of increasing accumulations of fine sediments with increasing upslope disturbance, indicating that V* results were affected by upslope disturbance. The combined index reaches were significantly different from the moderate and highly disturbed reaches. But, the moderately disturbed reaches were not statistically different from the highly disturbed reaches. This indicates that V* results may take upwards of 40 years before mitigation of current disturbance is positively reflected. These targets are intended to be consistent with the water quality objectives for settleable material and sediment and protect the habitat of cold water fish as described in the COLD beneficial use. It is also assumed that the MIGR beneficial use will be addressed by these targets. This TMDL is only addressing migration barriers caused by sediment aggradation since EPA guidance (August 27, 1997) specifies that "in the specific case of a physical barrier to fish migration such as a culvert,... there is no pollutant to allocate and the TMDL process is not appropriate." Since V* reflects sediment aggradation of pools, it is presumed that as sediments are reduced in pools, other migration areas within the stream channel will improve.

b. Existing Conditions

Knopp measured one data point for V* in the Garcia Basin. The V* value measured in Blue Waterhole Creek was 0.40.

c. Comparison of Numeric Target and Existing Conditions

EPA compared the existing data with the numeric targets (Table 7). EPA recognizes that since the data set for this target is very limited (i.e., 1 data point), drawing definitive conclusions regarding where the data point falls in comparison to the targets may not be as meaningful as in places where more data is available.

Table 7: Comparison of existing V* data with instream numeric targets

Indicator	Existing Data (n=1)	Numeric Targets
V*	.40	$\leq$0.21 (mean) $\leq$0.45 (max)

4. Mean Particle Size Diameter (d_{50})

The d_{50} is the median value of the size distribution in a sample. It is a measure of the central tendency of the whole sample, and thus is one of several indicators of how "fine" or "coarse" the sample is overall. As discussed in the discussion for the percent fines targets, both amount and size of fine and coarse sediments can impact salmonid lifestages. The d_{50} values identified by Knopp (1993) represent three 200-count riffles using the pebble count method. A clear trend of decreasing particle sizes in the riffles was evident with increasing upslope disturbance. The combined index reaches were significantly different from the moderately and highly disturbed reaches. But, the moderately disturbed reaches were not statistically different from the highly disturbed reaches. This indicates that d_{50} results may take upwards of 40 years before mitigation of current disturbance is positively reflected.

a. Numeric Targets

The targets for d_{50} are greater than or equal to 69 mm and a minimum of greater than or equal to 37 mm. These values are from Knopp's findings (1993). The d_{50} indicator has two targets associated with it. The higher number $\geq$69 mm represents the optimum target, while the lower number $\geq$37 mm represents the mimnimum number that should be found. By setting two numbers, the EPA recognizes that there may be annual variability in this target. These targets are intended to be consistent with the water quality objectives for settleable material and sediment and protect the habitat of cold water fish as described in the COLD beneficial use.

b. Existing Conditions

Knopp measured one data point for d_{50} in the Garcia Basin. The d_{50} value measured in Blue Waterhole Creek was 55.3 mm.

c. Comparison of Numeric Targets and Existing Conditions

EPA compared the existing data with the numeric targets (Table 8). EPA recognizes that since the data set for this target is very limited (i.e., 1 data point), drawing definitive conclusions regarding where the data point falls in comparison to the targets may not be as meaningful as in places where more data is available.

Table 8: Comparison of existing d_{50} data with instream numeric targets

Indicator	Existing Data (n=1)	Numeric Targets
d_{50}	55.3 mm	$\geq$69 mm $\geq$37 mm (min)

5. Pool Frequency[1]

Juvenile coho require pools for both summer and overwintering rearing. In the summer, pools provide cool, quiet habitat where coho feed and hide from predators. During the winter, off-channel pools provide habitat in which coho and steelhead both can get out of flood flows to avoid being swept downriver and out to sea. Steelhead prefer riffles for rearing during their first summer, but make more regular summer uses of pool habitat as they grow in size. The *Garcia River Watershed Assessment* (1997) concludes that the availability of pools is one of the factors limiting the productivity of coho salmon in the basin. Similarly, while young of the year steelhead appear to be abundant, the availability of pools is a factor which is also limiting the production of larger-sized steelhead.

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[1]The pool frequency target was not included in EPA's proposed TMDL. However, it is included in the State's draft Strategy. EPA has added this target to the TMDL after consideration of numerous comments because EPA believes this target is a good indicator of the adequacy of rearing habitat.

Pools are formed by a stream's hydrologic power in combination with the resistance of pool-forming elements, such as well-armored banks, boulders, and large woody debris. Pool volumes are reduced either when a stream's hydrologic power is reduced (e.g., by increased sediment loading) or by the reduction of pool-forming elements. The number of pool-forming elements can be reduced by modification of the channel morphology (e.g., burial), physical removal (e.g., log-jam removal), reduction in supply (e.g., logging of near stream trees), or a combination of all three causes.

a. Numeric Target

The target for pool frequency is to have 40% of the total habitat length composed of primary pools, as described below. The State noted that Flosi and Reynolds (1994) concluded from the Department of Fish and Game's habitat typing data that California coastal coho streams in relatively better condition have as much as 50% of their total habitat length in primary pools. According to the Strategy, however, Flosi has revised this figure to 40% based upon review of additional data (personal communication between Flosi and the State).

A primary pool is defined for first and second order streams to have a maximum depth of at least two feet, occupying at least half the width of the low-flow channel, and be as long as the low-flow channel width. In third and fourth order streams, primary pools are defined in the same way except the maximum depth must be at least three feet. This target is intended to be consistent with the water quality objectives for settleable matter and sediment and protect the rearing life stage of cold water fish and their associated habitat as described in the SPAWN and COLD beneficial uses.

b. Existing Conditions

The California Department of Fish and Game, as part of its fish population surveying in the Garcia basin, estimated the percent of the study area in pools, riffles and runs (Table 9). The data indicates that in a number of basins, the ratio of pools to riffles is less than optimum for salmonid rearing.

Table 9: Summary of estimates of the percentage of pools, riffles and runs from Department of Fish and Game Stream Surveys

Planning Watershed	Stream	Date	Pools (%)	Riffles (%)	Runs (%)
113.70010	Mill	06/24/94	40	20	40
	Pardaloe	06/24/94	0	100	0
113.70011	None				
113.70012	None				
113.70013	Blue Waterhole	08/20/87	30	40	30
113.70014	None				
113.70020	Signal	08/19/87	30	60	10
		11/06/95	70	15	15
113.70021	None				
113.70022	None				
113.70023	South Fork	08/17/87	40	50	10
		10/13/88	40	50	10

		10/19/89	25	65	10
		10/08/91	25	65	10
		10/06/92	20	80	0
	Fleming	08/17/87	50	30	20
		10/13/88	30	50	20
		10/19/89	15	75	10
		11/09/90	20	60	20
		10/08/91	50	40	10
113.70024	Rolling Brook	08/18/87	15	65	20
	Lee	10/19/89	15	84	1
113.70025	North Fork	10/27/83	60	0	40
113.70026	Hathaway	09/25/86	75	5	20
	Garcia	08/18/87	30	20	50
		08/20/87	30	20	30
		11/11/87	5	2	93

c. Comparison of Numeric Targets and Existing Conditions

EPA compared the existing information to the instream target (Table 10).

Table 10: Comparison of existing pool data with instream numeric target

Indicator	Existing Data	Numeric Targets
Pool Frequency	32.5% (n=22)*	Primary pools covering 40% of the total habitat length

*The data as presented does not indicate the percentage of identified pools which represent primary pools

Conclusion

The numeric targets are intended to interpret and apply the narrative WQS. They were developed for optimal salmonid success which is a conservative approach.

SOURCE ANALYSIS

The purpose of the Source Analysis is to demonstrate that all pollutant sources have been considered, and significant sources estimated, in order to help determine the degree of loading reductions needed to meet numeric targets and allocation of loading allowances among sources. 40 CFR 130.2 defines a TMDL as the sum of individual wasteload allocations, load allocations and natural background. In order to develop individual load allocations, existing and potential sources must be first be characterized.

Typically, a sediment budget quantifies sediment sources (inputs), by each erosional process, as well as changes in the amount of channel stored sediment, and sediment outputs as measured at gauging stations over a designated time frame (Reid and Dunne, 1996). Quantifying sediment sources involves determining the volume of sediment delivered to stream channels by the variety of erosional processes operating within the watershed. For the Garcia River watershed, these can be divided into 4 primary processes or sediment delivery mechanisms: 1) mass movement (landslides), 2) fluvial erosion (gullies, road and skid trail crossing failures, and stream bank erosion), 3) surface erosion (rills and sheetwash) and 4) land management activities which directly place sediment in stream channels.

The development of a sediment budget for a large watershed area, such as the Garcia River watershed, can best be accomplished by dividing or stratifying the area into sub-units of similar characteristics, such as soil, bedrock, vegetation, topography, and land use. Each sub-unit is then characterized by constructing budgets for representative areas within it. These can then be confidently extrapolated throughout each sub-unit to arrive at an estimate of the overall sediment budget for the watershed. This is the approach used by Pacific Watershed Associates (PWA) in their analysis.

The Source Analysis for the Garcia River watershed relies primarily on the work of PWA, *Sediment Production and Delivery in the Garcia River Watershed, Mendocino County, California: An Analysis of Existing Published and Unpublished Data* (1997). Their analysis involved reviewing several studies and reports prepared over the last 10 years documenting watershed conditions and changes which have occurred in the watershed over the last 100 years. The primary sources of published and unpublished data from the Garcia River watershed reviewed in the work of PWA include that of: 1) O'Connor Environmental, Inc. (OCEI) conducted under contract to Forest, Soil and Water and the California Department of Forestry and Fire Protection (CDF) through the Mendocino County Resource Conservation District (Forest, Soil and Water, 1997); 2) Louisiana-Pacific Corporation Sustained Yield Plan for Coastal Mendocino County, 1997; 3) Coastal Forestlands, Ltd, Watershed and Aquatic Wildlife Assessment, 1997; and 4) Philip Williams and Associates conducted under contract to the Mendocino County Water Agency (Garcia River Gravel Management Plan, 1996).

The PWA analysis relied most heavily on the OCEI report (1997) since it is the only basin wide analysis which utilizes a single methodology for determining sediment sources. Thus, it provides the framework for the sediment budget presented by PWA and is augmented by the information provided for individual sub-basins by other researchers. The work of OCEI was conducted using aerial photographs from 1966, 1978, and 1996 and is discussed in *The Garcia River: Watershed Assessment and Instream Monitoring* Plan (1997). OCEI assessed the number of sources and volume of sediment delivered through mass wasting and surface erosion over a 40 year period via the aerial photographs and general statistics provided by CDF from its Geographic Information System (GIS) for the basin.

Louisiana-Pacific Corporation (L-P) conducted field work in several of the tributary basins under its control in the Garcia River watershed to increase the reliability of the work presented in its draft *Sustained Yield Plan for Coastal Mendocino County* (1997). Preliminary findings were submitted in September 1997 as comments to OCEI's draft "Mass Wasting and Surface Erosion Modules." The L-P Level II analysis significantly modified the OCEI and PWA preliminary estimates, resulting in an increased estimate of sediment production. The L-P analysis covered a 45-year period, from 1952-1997.

Coastal Forestlands, Ltd. (CFL) submitted a draft *Watershed and Aquatic Wildlife Assessment* in July 1997 and a final in September 1997. CFL's work, like L-P's addresses the conditions in the sub-basins predominantly under their ownership. CFL, like OCEI, conducted a review of the 1996 aerial photographs to identify sites of mass wasting. Though historic photos were not reviewed, CFL did conduct field work to confirm their aerial photo work. The *Watershed and Aquatic Wildlife Assessment* provides CFL's assessment of the mass wasting data.

Philip Williams & Associates conducted an assessment of the Garcia River watershed relative to the issue of gravel mining and gravel management. The *Garcia River Gravel Management Plan* (1996) provides an assessment of sediment production and movement in the lower watershed, including an assessment of suspended sediment and bedload data collected by USGS at the Eureka Hill bridge in the lower river.

Although the existing information is relatively voluminous, it does not specifically and comprehensively describe the conditions in the basin, as data exists in some planning watersheds but not in others. A general understanding of the condition of the Garcia River basin, however, can be ascertained by viewing in total the information which exists. The assessment of additional site specific information collected in the future will assist in developing a more comprehensive understanding of the basin and allow for future revisions to the TMDL.

1. Sediment Inputs

Mass Wasting

The OCEI aerial photo analysis estimated annual and total sediment delivery to stream channels within the Garcia Basin from all mass movement processes covering the time period from 1957-1996 - a 40-year period. OCEI then modified the photo-based estimates to include field data collected by L-P. (See Table 12). PWA concluded from their analysis that 40-60% of the overall average annual sediment production in the Garcia River watershed was from mass movement and stream bank erosional processes. OCEI concluded that of the 40-60% mass movement component over 80% is associated with land management activities (>60% from roads and skid trails and approximately 20% from timber harvest activities). The sediment yield not associated with land management activities (20% of the total based on the OCEI analysis) is estimated to be natural background. The OCEI analysis indicates that rates of sediment delivery throughout the Garcia River basin vary greatly. One half of the sub-basins delivered sediment to stream channels at a considerably higher rate than the basin average. To what degree differences in land management practices within different sub-basin areas influenced higher volumes and/or rates of sediment yield is not discernable from existing data.

Fluvial Erosion

PWA defines fluvial erosion to include gullies, road and skid trail crossing failures, and stream bank erosion caused by stream flows and concentrated runoff. Inventories in northern California show significant past and potential future fluvial erosion and sediment yield from roaded and managed slopes. There is no basin-wide data in the Garcia River watershed which quantifies the volume or rate of sediment delivery due to fluvial erosion processes. Thus, PWA compared the available sediment delivery data for the Garcia River watershed to sediment budgets developed for other similar watersheds and concluded that 26-45% of the overall sediment budget is attributable to fluvial erosion from roads and skid trails. PWA did not estimate sediment production due to fluvial erosion associated with stream banks.

Surface Erosion

According to PWA, surface erosion includes rill and sheetwash erosion. The stability of the soil surface, rainfall intensity, slope, etc. are factors which influence the amount of surface erosion which occurs and is delivered to a stream. Estimates of sediment delivery for surface erosion are derived from an assessment of road density statistics from 1987-1997 and measurements of skid trail densities in sample areas in the basin. PWA estimated that approximately 10-21% of the overall sediment budget is from surface erosion.

Sediment Production Associated with Agricultural Activities

Sediment from agricultural roads is accounted for in the PWA source analysis. PWA does not account for streambank and gullying sediment sources contributed by agricultural activities. Both PWA and the Regional Board conclude that the contributions from these sources are relatively small compared to other sources (Strategy, 1997).

Total Sediment Inputs

PWA concluded that over a 45 year period (1952-1997) the best available data for the Garcia River watershed (L-P, 1997) indicates the long term sediment production rate averages, at a minimum, 1,380 tons/mi^2/yr. In other words, this is the amount of sediment going into stream channel in the Garcia River watershed.

2. Instream Stored Sediment

PWA evaluated data collected by L-P during the summer of 1997 to obtain an indication of the degree to which sediment stored in the stream system is available as a source of future sediment delivery. They found that the higher order stream channels currently contain the majority of remaining stored sediment in both the terrace/flood plain setting and the active channel compartment. PWA concluded that a small percentage of the terrace/floodplain stored sediment will be remobilized, largely through bank erosion processes, and be delivered to downstream reaches over the next several decades. However, stored sediment in the active channel compartment generally has a shorter residence time, and remobilization of active channel-stored sediment could serve as a measurable contributor to sediment yield which can continue to delay full aquatic recovery.

3. Sediment Outputs

The USGS conducted a bedload and suspended sediment load analysis in water year 1992-1993. Based on this Philip Williams and Associates (1996) estimated that the average annual sediment output is 2,160 tons/mi^2/yr.

Overall Sediment Budget

The assessments conducted by PWA (1997), Philip Williams & Associates (1996) and L-P (1997) indicate that, at a minimum, an average of 1,380 tons/mi^2/year of sediment are entering the Garcia River watershed while 2,160 tons/mi^2/year are exiting it. According to Philip Williams & Associates (1996) historic gravel mining extraction rates for the Garcia River watershed were 67,078 tons/year for the period from 1966 to 1993 (Mendocino County, 1995). This accounts for 586 tons/mi^2/year of material leaving the stream system above that which is entering it. The remaining 194 ton/mi^2/year may be associated with:

- Sediment input estimates which are too low
- Sediment output estimates which are too high
- Movement of instream stored sediment by natural processes

The total sediment budget supports the conclusions of Philip Williams & Associates (1996) and others that the current channel morphology in the lower Garcia River appears to be relatively stable and that the channel is in a state of “dynamic equilibrium.” The lack of major aggradation and thalweg incision in the lower Garcia River main stem during the last few years suggests either that stored sediment in tributary streams was insignificantly mobilized to the lower river reaches as a result of the big storms over these years and/or that sediment production through the watershed from upstream hillslope areas was not severe.

Table 11: Summary of Sediment Budget for the Garcia River Watershed

Sediment Movement Mechanism	Percentage of overall budget	Estimated average annual sediment yield (tons/mi²/yr)
SEDIMENT INPUTS		
Mass wasting	40 to 60%	560 to 840
Fluvial erosion	26 to 45%	364 to 630
Surface erosion	10 to 21%	140 to 294
Total		1,380*
MOVEMENT OF STORED SEDIMENT		
Gravel extraction	77%	586
Background erosion	23%	194*
SEDIMENT OUTPUTS		
Bedload and suspended sediment	100%	2,160*

Source: Strategy, 1997

* 194 tons/mi²/year have not been specifically accounted for in the sediment budget. They may be part of the natural erosion of instream stored sediment as depicted here or represent inaccuracies in the sediment input or output estimates.

Explanation of Sediment Budget

PWA estimated that between 40-60% of the overall budget was from mass wasting and that between 40-60% from fluvial and surface erosion. Of the mass wasting component, OCEI estimated that 60% was associated with roads which equals between 336-504 tons/mi²/yr; 20% was associated with timber harvesting or 112-168 tons/mi²/yr; and 20% was natural background or 112-168 tons/mi²/yr.

Mass Wasting

Roads - 60%	336-504
Timber - 20%	112-168
Background - 20%	112-168
Total Mass Wasting	560-840

Of the fluvial and surface erosion component, it was estimated that between 65-75% was fluvial erosion or 364-630 tons/mi²/yr and between 25-35% was from surface erosion or 140-294 tons/mi²/yr.

Comparison with Other Sediment Budgets

As a means of grounding the various sources of existing data for the Garcia River, PWA compared their results with sediment production values determined for the Redwood Creek watershed in coastal Humboldt County and from the nearby Navarro River and Caspar Creek watersheds. These north coast basins provide the best estimates for comparison because of their proximity to the Garcia River watershed. The comparison is summarized in Table 12.

While each of the estimates of sediment production for the Garcia and Navarro Rivers and Caspar Creek has utilized different approaches and methods, as well as measured different sediment sources, there is general agreement in the total estimate of sediment yield rates between the watersheds. Because the Louisiana Pacific data for certain planning watersheds in the Garcia River involved the greatest amount of field measurements to quantify a wide variety of sediment sources, PWA believed that the estimated long term average annual sediment yield rates are a more accurate prediction of the basin's erosion history than the revised OCEI data. While the Redwood Creek sediment rates are higher than what is realistically expected to be occurring in most northern California watersheds over the last two decades since the data reflects poor logging practices from the past, the percentages from the various sources may be a fair representation of where and how sediment is being produced today.

Conclusion

PWA concluded that over a 45 year period (1952-1997) the best available data for a portion of the lower Garcia River watershed (L-P, 1997) indicates the long term sediment production rate for the entire basin averages, at a minimum, 1,380 tons/mi^2/yr. Approximately half is from mass wasting, approximately 35% is from fluvial erosion and approximately 15% from surface erosion. Of the mass wasting component, 60% is from roads, 20% is due to timber harvest activities and 20% is assumed to be natural background. PWA looked at a long timeframe (45 years) to provide a better understanding of the sediment dynamics in the Garcia River watershed. Looking at data over a shorter timeframe may not fully represent the actual sediment that has entered and may still be present in the system.

PWA concluded from reviewing relevant information that the Garcia River sediment transport regime, as a whole, is recovering from the widespread erosion and sediment delivery which occurred between the late 1950's and the mid-1970's. In addition, Philip Williams and Associates noted that the current channel morphology in the lower Garcia River appears to be relatively stable and that the channel is in a state of "dynamic equilibrium." Also, the OCEI analysis found that landsliding caused from timber activities has gone down since the late seventies.

However, instream data still indicate that the stream is not supporting the beneficial uses. Therefore, although the lower Garcia is in a state of dynamic equilibrium, the total amount of sediment in the stream is still too high. This may be due to a number of reasons such as a lag time between when the sediment is delivered to the system and when that sediment is moved through the system. Given that the stream is still not supporting beneficial uses, sediment inputs need to be decreased, such that the instream sediment component can begin to move out of the system. By reducing the ratio of sediment delivery to flow (i.e., the concentration of sediment in the streams), the dominant physical process will change from one of net deposition of fines to net entrainment of fines. In other words, the sediment carrying capacity of runoff from the land surface will be greater if the initial concentration of the sediment is lower.

Finally, the PWA analysis repeatedly notes that the sediment budget and its component parts may actually be underestimating the actual loading. Although there are a number of uncertainties in the available information, given that the overall sediment yield budget is in line with sediment budgets for other nearby streams and that the critical issue is recovery of the stream system, EPA considers this the best available analysis and information available for use in this TMDL.

Table 12: Comparison of Sediment Production, by process, for the Garcia River, Navarro River, Caspar Creek and Redwood Creek Watersheds
Sediment Yield Rate (t/mi^2/yr) & (% of total budget)

Sediment Source Mechanism	Garcia River minus Hathaway (OCEI)	Rolling Brook & So. Fk. Garcia River L-P Level II analysis	Navarro River	Redwood Creek	South Fork Caspar Creek (big storms, poor logging)	North Fork Caspar Creek (big storms, no recent logging)
Landslides	462 t/mi^2/yr (41%)	810 t/mi^2/yr (59%)	566 t/mi^2/yr (51%)	2400 t/mi^2/yr (44%)		
Road Surface	268 t/mi^2/yr (24%)	38 t/mi^2/yr (3%)	545 t/mi^2/yr (49%)	167 t/mi^2/yr (3%)		
Road Cutbanks and Ditches	--	--	--	100 t/mi^2/yr (2%)		
Haul Road & Skid Trail Crossing	--	532 t/mi^2/yr (38%)	--	223 t/mi^2/yr (4%)		
Gullies from Diversions on Roads and Skids	--		--	1125 t/mi^2/yr (21%)		
Skid Trail Surface Erosion	400 t/mi^2/yr (35%)	--	--	780 t/mi^2/yr (14%)		
Streambank Erosion	--	Included in landslides	--	690 t/mi^2/yr (13%)		
TOTALS	1130 t/mi^2/yr (100%)	1380 t/mi^2/yr (100%)	1111 t/mi^2/yr (100%)	5485 t/mi^2/yr (101%)	1420 t/mi^2/yr (100%)	680 t/mi^2/yr (100%)

Source: (PWA, 1997)

LINKAGE ANALYSIS

In order to determine the TMDL, it is important to assess the magnitude of instream sediment problems and the associated levels of sediment source reductions needed to address instream problems. This section assesses the degree to which sediment reductions are needed from sources in the Garcia watershed to alleviate the instream sediment problems discussed in the Problem Statement section. The analysis is based on three methods of comparing existing and desired conditions for the watershed:

1. comparison of average sediment loading rates per square mile in highly impacted and relatively unimpaired basins in the North Coast Region, and applying these comparisons in the Garcia setting,
2. qualitative analysis of the linkages between sources and instream conditions, and
3. comparison of existing and historical conditions with target levels for the instream indicators selected in the numeric targets section.

1. Comparison of Sediment Loads in the Garcia to Reference Streams

In comparing the source estimates, PWA found that the average sediment delivery estimate for the Garcia River (1380 tons/mi^2/yr) is consistent with the estimates from the Navarro River (1111 tons/mi^2/yr), and South Fork Caspar Creek (1420 tons/mi^2/yr) data (See Table 12). These north coast basins provide the best estimates for comparison because of their proximity to the Garcia River watershed. In estimating the loading capacity and associated load allocations necessary to meet WQS, a comparison of the current sediment estimates with a relatively unimpaired reference watershed is an appropriate comparison. The Caspar Creek data provides a good comparison since the North Fork Casper Creek sub-basin was relatively unimpaired. In contrast, South Fork Casper Creek has had recent land use activities closer to those found in the Garcia River. In the North Fork of Caspar Creek, which has had no recent logging, sediment yield was estimated at 680 t/mi^2/yr, compared to 1,420 t/mi^2/yr in the heavily logged South Fork of Caspar Creek or approximately a 52% difference. The South Fork Caspar Creek has a sediment yield estimate on the same order of magnitude as the Garcia River, which suggests that an <u>overall reduction target of 52%</u> may be appropriate for the Garcia River in order to attain sediment loading rates associated with a reasonably unimpaired watershed.

2. Qualitative Analysis of Linkage between Upslope Activities and Instream Conditions

Another comparison to link sediment source reductions to instream conditions, is to look at the difference between existing instream conditions and the numeric targets. The Regional Board provided a thorough qualitative analysis of the linkage between the sources of sediment and the instream conditions (Strategy, pages 95-100). The Regional Board developed a set of hypotheses regarding linkages between specific upland activities and conditions to instream habitat conditions. In reviewing existing data for sub-basins they found that a general picture of impacts and likely causes emerges. The Regional Board found that sediment delivery from human-caused mass wasting, fluvial erosion and surface erosion has an impact on instream conditions including pool and spawning gravel characteristics to such an extent that substantial sediment reductions are likely to be necessary in order to remedy the habitat problems.

3. Quantitative Analysis of Linkage between Upslope Activities and Instream Conditions

Linkages between sediment sources in the watershed and instream conditions are generally indirect and highly variable. However, over the long term, reductions in sediment inputs to the stream system are expected to result in reduction in sediment distributions in the channel. Assuming that these reductions will be roughly proportional to the instream conditions, source reductions in Table 13 have been developed as part of this analysis. The comparative analyses are based on a very limited set of data (Strategy, 1997). Table 13 provides a comparison of the instream numeric targets with existing instream conditions and the corresponding amount of sediment reductions necessary to achieve the instream targets.

This analysis assumes a one-to-one correspondence between sediment source reductions needed and reductions in stream sediment levels as measured by these indicators. Although the actual relationship between sediment delivery and instream conditions influenced by sediment dynamics is poorly understood, this one-to-one correspondence is considered a reasonable and conservative approximation. Moreover, what is most important is not the specific quantified results, but rather the general conclusion that substantial sediment loading reductions appear to be necessary to address the instream problems associated with sediment.

Table 13: Linkage of Instream Conditions to Sediment Reductions*

Indicator	Existing Conditions Average Value	Numeric Targets	% Reduction in Sediment Delivery Needed to Attain Numeric Target
% fines <0.85 mm	20.6% (n=20)	14%	32%
% fines < 6.5 mm	45.5% (n=20)	30%	33%
V*	0.40 (n=1)	≤0.21(mean) ≤0.45 (max)	49%
d_{50}	55.3 mm (n=1)	≥69 mm ≥37 mm (min)	20%

* The pool frequency target is not included in this linkage analysis since EPA recognizes that pool frequency is influenced by many factors, therefore making a direct correlation between the target and sediment reductions not as clear.

This comparison indicates that the minimum amount of sediment reduction needed to attain WQS ranges between 20%-49%. These figures suggest an overall percent reduction goal of 33% to be appropriate, as it reflects the greatest number of data points, and is also a mid-range between 20-49%. However, the overall 33% percentage reduction goal needs to be adjusted because the data were collected in 1989-1995, reflecting current conditions as opposed to overall historic conditions. As noted in the Source Analysis section, EPA belives the longer term sediment production estimate provides a more comprehensive picture of actual sediment loading in the system. Therefore, the instream data is adjusted to reflect this longer term analysis.

Production of sediment from forestry-related activities is likely to have declined sharply in most sub-watersheds from 1978 to 1997 due to improvements in forestry practices over this timeframe and possibly also due to drought conditions during this period. Thus, EPA adjusted the reductions derived from the 1989-1995 instream data to reflect those probable differences in sediment production over the two time periods, using differences in the sediment production estimates from the two time periods, as explained below.

Adjustment of reductions derived from instream monitoring data

Estimates of sediment production from mass wasting were developed by PWA (1997) for both the 1952-1996 period (overall period), and for the period from 1978-1996 (recent period). According to PWA's estimates, mass wasting for the 1978-1996 period was about 43% of the amount produced for the 1952-1996 period.

Table 12 illustrated that mass wasting produced 810 tons/mi^2/yr, based on L-P 45-year data (PWA, 1997), and roads and skid trails produced 570 tons/mi^2/yr, for an overall estimate sediment production of 1380 tons/mi^2/yr during the 1952-1996 period. Applying the factor of 43% of the overall period for mass wasting to L-P's sediment production data, EPA determined that approximately 348 tons/mi^2/yr was produced for the recent period (1978-1996). EPA assumed that surface erosion production from roads and skid trails for the recent period is unchanged from the overall period.[2] Thus, overall sediment production for the more recent period is estimated at 918 tons/mi^2/yr (See Table 14 below).

Table 14: Sediment Production Estimates for Historical and Recent Period

Source Mechanisms	Historical Sediment Load Estimate (1952-1996)*	Recent Sediment Load Estimate (1978-1996)	Notes
Mass Wasting	810 tons/mi^2/yr	348 tons/mi^2/yr	Recent is 43% of historic period, based on PWA comparison of the two periods
Road Surface, Road and Skid Trail Crossings and Gullies from Diversion on Roads and Skid Trails	570 tons/mi^2/yr	570 tons/mi^2/yr	Assumed unchanged in recent period
Total	1380 tons/mi^2/yr	918 tons/mi^2/yr	

* Based on L-P-based Sediment Budget data in PWA (See Table 12)

Estimated Source Reduction From Historic Sediment Production Levels

A 33% reduction (from current instream indicator data) from 918 tons/mi^2/yr (the current sediment production) would suggest a preliminary determination that overall sediment production should be reduced to 615 tons/mi^2/yr.[3] Defined in terms of a reduction from historic sediment production (1952-1997), the 1380 tons/mi^2/yr must be reduced by 55% to obtain 615 tons/mi^2/yr.

Conclusion

Table 15 below illustrates that the two quantitative methods of estimating needed source reductions suggest that historic production levels of 1380 tons/mi^2/yr should be reduced by 52-55%, to approximately between 615 and 649 tons/mi^2/yr. Because these two analysis methods reveal similar results, and because this estimate is consistent with the load estimate for North Fork Caspar Creek, which is relatively unimpaired (680 tons/mi^2/yr), it appears to be a reasonable source reduction estimation to meet overall target conditions in the future. As discussed below under "Loading Capacity and Allocation of Loads," EPA has increased the estimated reduction and reduced the allowable sediment production calculated in this section to provide a margin of safety.

Table 15: Results of the Three Methods to Determine Necessary Sediment Reductions

Method	Estimated Reduction	Allowable Sediment Production	Notes
1. Reference Stream Comparison	52%	649 tons/mi^2/yr	
2. Qualitative Analysis	"Substantial sediment reductions"		
3. Comparisons of existing and target conditions	55%	615 tons/mi^2/yr	33% reduction from 1978-1996 production rates, equivalent to 55% reduction from 1952-1997 production rates

2. No data on changes in fluvial and surface sediment production from roads and skid trails was available. However, it is probable that the overall sediment production from these sources did not change as substantially as for mass wasting. This is our best assumption given that, although the Forest Practice Rules may have improved road management during this most recent time period (1978-1997), the number of roads and skids trails has increased during this time frame and PWA indicates that the data show that only modest gains have been made in reducing the rate of fluvial, mass movements and surface erosion occurring along roads.

3. This assumes that conditions in the 1989-1995 period (when the substrate data were collected) adequately reflect conditions in the 1978-1996 period (recent sediment production period.)

LOADING CAPACITY AND ALLOCATION OF LOADS

The requirements of a TMDL are described in 40 CFR 130.2 and 130.7 and Section 303(d) of the Clean Water Act, as well as in various guidance documents. A TMDL is defined as the sum of the individual wasteload allocations for point sources, and load allocations for nonpoint sources and natural background pollutants. The allocations indicate the amount of pollutant reduction that is required to attain WQS. Allocations may be assigned based on land use, land area, or erosional process. In addition, the regulations at 40 CFR 130.2(g) state that "Load allocations are best estimates of the loading, which may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading." The Garcia River allocations have been developed for land use activities based on the source analysis of the various erosional processes. The load allocations have been developed as annual average loads at the basin-wide scale.

Load Allocations

The following are the load allocations. Explanation is provided below.

Table 16: TMDL Load Allocations

	a	b	c	d	e	f	g
Source Mechanism	1952-97 Sediment Load Estimate ($t/mi^2/yr$)	Controllable Percent	Control. Load ($t/mi^2/yr$)	Uncontrol. Load ($t/mi^2/yr$)	Remaining Controllable Load ($t/mi^2/yr$) (20% of c)	**Load Allocation ($t/mi^2/yr$) (d + e)**	Total % Reduction
Mass Wasting (Natural Background)	162	0%	0	162	0	**162**	0
Mass Wasting (Roads)	486	90%	437	48	87	**135**	72%
Mass Wasting (Timber Harvesting)	162	50%	81	81	16	**97**	40%
Road Surface	38	90%	34	4	6	**10**	73%
Road and Skid Trail Crossings and Gullies from Diversions on Roads and Skid Trails	532	90%	478	53	95	**148**	72%
TOTAL	1380	75%	1030	348	204	**552**	**60%**

Explanation of Load Allocations

The Allocations are based on the source analysis developed by PWA, based on L-P data, since their estimate is based on field work and is considered the most accurate. Theses numbers also fall within the ranges developed by the Regional Board in Table 11. Since the L-P-based numbers developed by PWA were used, the sediment load estimates and allocations were developed based on single numbers rather than the ranges developed by the Regional Board.

The total Load Allocation is based on an average annual load reduction of 60%. This comes from the weight of evidence from both the analysis of the relative sediment yield in the North versus South Fork Caspar Creeks and analysis of the instream data, both of which estimated that between a 52-55% reduction is needed. EPA chose 60% to account for unquantified sources including agricultural sources and road cutbanks and ditches and to provide an additional margin of safety as required by the CWA. This is discussed more fully under Margin of Safety below.

The load allocations were based on the percentages of controllable sources developed by the Regional Board. This is a conservative approach which is based on the assumption that if all "controllable" sources are mitigated or reduced, then the instream environment will recover its natural condition. "Controllable" sources of sediment are defined as those which are associated with human activity *and* will respond to mitigation, altered land management, or restoration. The percentages are based on an understanding of the available mitigation, land management and/or restoration measures which have been developed for a variety of situations. The percentages reflect a professional judgment of how successful the various best management practices (BMPs) generally are in controlling these sources. For example, BMPs to control sources associated with roads are very well known (see *Handbook for Forest and Ranch Roads*, Weaver and Hagans 1994) and are expected to be highly successful. Therefore, 90% is assigned to the reduction of road-related sources. Similarly, the conservation and land management measures to control sources associated with mass wasting due to timber harvest units are expected to be only moderately successful, so a 50% sediment reduction goal is assigned to the reduction of timber harvest-related sources.

The natural background estimate comes from the OCEI analysis, which estimated that 20% of the mass wasting is natural.

The PWA analysis estimated that 60% of the mass wasting component is associated with roads and that 20% is associated with timber harvesting activities.

Allocations for road-related sediment applies to all land use activities including roads for timber and agricultural activities and county roads.

Calculations

- It was determined that a 60% overall reduction is required. 60% of 1380 tons/mi^2/yr = 828 t/mi^2/yr. The total loading capacity then equals 552 tons/mi^2/yr (1380 - 828 = 552).

- The total controllable load is 1030 tons/mi^2/yr. This is calculated by applying the 90% and 50% controllable percentages discussed above to the applicable categories in the overall sediment load estimate (see column c).

- 828 t/mi^2/yr (the amount that must be reduced) is approximately 80% of the total controllable load of 1030 t/mi^2/yr (the maximum amount which realistically can be reduced).

- Therefore, EPA has determined that there needs to be a reduction of 80% of each category of "controllable load." To derive the load allocations, EPA determined the amount remaining after controlling 80% of the total controllable sediment load. This is equal to the other 20% of the controllable load (which totals 204 tons/mi^2/yr) plus the remaining uncontrollable load (totaling 348 tons/mi^2/yr), which equals 552 t/mi^2/yr.

- Individual load allocations:

	(col. e)	(col. d)	(col. f)
Mass wasting (roads)	437 X 20% = 87	+ 486 X 10% = 48	= 135
Mass Wasting (timber)	81 X 20% = 16	+ 162 X 50% = 81	= 97
Road Surface	34 X 20% = 6	+ 38 X 10% = 4	= 10
Crossings and gullies	479 X 20% = 95	+ 532 X 10% = 53	= 148
Total			552 tons/mi^2/yr

Agriculture

As noted above, the allocation for road related sediment applies to all land use activities including agriculture. The source analysis developed by PWA does not account for streambank and gullying sediment sources contributed by agricultural activities. It is the understanding of both PWA and the Regional Board that the contributions from these sources are relatively small compared to other sources. Therefore, there are no specific load allocations for agriculture-related sediment from streambank and gully erosion. The explicit Margin of Safety does account for these unquantified sources (see below). Based on the Regional Board Strategy, it is also assumed that these sources will be addressed and significant reductions are expected as part of the implementation plan in the Strategy.

Conclusion

The Loading Capacity and Allocations of Loads are developed for all major sources of sediment in the Garcia River. As part of the supporting documentation, all sources were considered. Certain sources were not quantified including sediment related to certain agricultural activities, road cutbanks and ditches and surface erosion on skid trails. These were accounted for in the margin of safety. The sum of the load allocations plus the natural background is less than or equal to the estimated loading capacity. The Loading Capacity meets the regulatory definition at 40 CFR 130.2(f) which states that the loading capacity is “[t]he greatest amount of loading that a water can receive without violating water quality standards.” In addition, the Load Allocations meet the regulatory requirements at 40 CFR 130.2(g) in that they are “best estimates of the loading, which may range from reasonably accurate estimates to gross allotments...”

This TMDL applies as average annual mass loads per square mile. This meets the regulatory definition that “TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure.” (40 CFR 130.2) This annual TMDL could be converted into daily loads, but expressing the TMDL as an annual average yield better reflects the dynamic nature of sediment movement throughout a watershed over time.

For the Garcia River the TMDL = ΣWLA = 0 (there are no point sources in the watershed)

ΣLA = 135 (mass wasting from roads)
97 (mass wasting from timbering)
10 (road surface)
148 (skid trails, etc.)
162(natural background from mass wasting)

TMDL = 552 tons/mi^2/year

MARGIN OF SAFETY

Section 303(d) of the Clean Water Act and the regulations at 40 CFR 130.7 require that TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality. The margin of safety can either be incorporated into conservative assumptions used to develop the TMDL or added as a separate component of the TMDL (EPA, 1991). In the Strategy, the Regional Board noted that in every one of the components used to develop the TMDL, assumptions were made where sufficient data was lacking. Conservative assumptions have been made in each case as a way of addressing the uncertainty associated with the data.

EPA has identified these conservative assumptions more specifically to fully account for the implicit margin of safety. In addition, EPA has included an explicit margin of safety by increasing the overall percent reduction needed from between 52-55% up to 60% to account for unquantified sources including agricultural sources and road cutbanks and ditches.[4]

Table 17: Supporting Information For Margin of Safety

UNCERTAINTIES in TMDL SUPPORTING DOCUMENTATION	EFFECTS/NEEDED ADJUSTMENTS
1. Existing instream data was limited.	To account for this uncertainty, the targets represent the optimal conditions for salmonid success.
2. The 1380 tons/mi^2/year developed by PWA is considered a minimum value because several categories of sediment production have not been quantified by existing studies	To account for this, the percent reduction is increased to 60%.

[4]EPA has determined that it would not be appropriate to establish an allocation and a corresponding percent reduction for agricultural activities other than roads because (1) allocations are required only for "significant" sources, (2) sufficient data are not available to set an allocation for agricultural activities other than roads, and (3) both the Regional Board and PWA conclude that contributions from these sources are relatively small compared to those from other sources.

However, EPA has determined that it is appropriate to increase the margin of safety used to calculate this TMDL in order to essentially establish a "reserve" for these unassessed sources. As noted in the linkage section (Table 15), EPA preliminarily determined that the total allowable annual sediment production should be approximately 615 tons/mi^2/year. Of this, a portion should be set aside as a "reserve" for unquantified sources such as agricultural activities other than roads. Rather than specifying an explicit resource in tons/yr, EPA has increased the margin of safety and is requiring a 60% reduction, which results in a total annual allocation of 552 tons/mi^2/year, rather than the approximately 55% reduction which would yield an allocation of 615 tons/mi^2/year, for those sources for which allocations are established. EPA's intent is that as more information is developed for the Garcia watershed, it may be possible to revise this TMDL to more explicitly provide a load allocation for what are currently unassessed sources, and if necessary, to revise the allocations set forth in this TMDL.

3. The long-term erosion rate is based on the L-P Level II analysis which was done in just portions of the entire basin.	Since extrapolating could underestimate the total loading amount, the allocations were set at a more conservative level.
4. Each of the estimates (Garcia River, Redwood Creek and Navarro River) of sediment production are believed to be under-estimating the actual extent of each category of erosion and sediment yield. For example, the Redwood Creek analysis, which has more extensive gauging information, still does not account for 14% of the total past sediment yield.	Conservative allocations were established.
5. The Natural Background estimate is based only on mass wasting, so it is viewed as a minimum volume.	This was accounted for by the 60% reduction and through conservative allocations for other sources.
6. Higher order, lower gradient tributary streams still contain appreciable quantities of stored sediment both in the active channel and on adjacent terraces/flood plains. It may take decades to remobilize and route currently stored sediments in the active channel of tributaries and as a consequence significant improvements in channel stability and habitat quality may be delayed in many portions of the Garcia.	To account for this, more conservative allocations from upslope sources were developed.
7. The magnitude and extent to which channel stored sediments are present in tributaries throughout the remainder of the Garcia River watershed is unknown at this time.	To account for this, more conservative allocations from upslope sources were developed.
8. Recognizing and estimating attainable reduction in the risk of sediment delivery from non-road related hillslope mass movement processes was more difficult than for road-related mass movement.	Higher reductions from road-related mass movement sources were developed.
9. The data suggests that only modest gains in reducing the rate of fluvial, mass movement and surface erosion along roads has occurred.	Conservative allocations for road related sediment were developed.
10. Hillslope sources identified as "associated" with land management activities as discussed in the Source Analysis section are assumed to be *caused* by the associated land management activities.	Allocations for land use activities based on this assumption were developed.
11. The loading reductions are partly based on an assumed success rate likely to be associated with the various conservation measures and/or altered land management activities.	Conservative percent reductions were maintained to account for the uncertainty in the effectiveness.

Conclusion

As the Table 13 points out, there are a number of uncertainties associated with the supporting documentation, most notably in the source analysis. Given these uncertainties, conservative assumptions have been made regarding the amount of loading reductions that are needed to attain WQS. This approach is warranted and meets the statutory requirements that a margin of safety take into account any lack of knowledge concerning the relationship between the effluent limitations and water quality.

As is repeated throughout the Regional Board Strategy, the submittal of site-specific data in the future will help to reduce the uncertainty associated with the current assessment and will therefore allow for a reduction in the degree of conservatism associated with the current assumptions. Thus, it is likely, depending on the quality and quantity of the site-specific data which is submitted over time, that adjustments to the TMDL in the future will result in less stringent allocations as the margin of safety is reduced.

SEASONAL VARIATION

There is inherent annual and seasonal variation in the delivery of sediment to stream systems. As reported by PWA (1997), surface erosion occurs on an annual basis, but primarily as a result of winter rains. Fluvial erosion and mass wasting, on the other hand, occur as a result of big storms and thus may not be significantly active processes every year. For this reason, the allocations are designed to apply to the sources of sediment, themselves, not the movement of sediment across the landscape or delivery of sediment directly to the stream channel. If implemented as envisioned, potential and existing sediment delivery sites will be identified and the quantity of sediment associated with each site measured or estimated. Then, as a result of mitigation or altered land management, the amount of potential sediment saved from delivery to a water of the State will be measured or estimated. The relationship between the original measurement or estimate of potential sediment delivery and the amount saved by mitigation will indicate the degree to which the allocation has been achieved.

It is difficult to accurately predict specific impacts of sediment loading at particular times and places on particular salmonid life stages given spatial and temporal lag time between sediment delivery and the occurrence of sediment related impacts on beneficial uses. In addition, it is infeasible to predict or control sources at fine spatial and temporal scales in many cases. Therefore, the approach in this TMDL is to select indicators to interpret narrative WQS which are believed to provide a good composite picture of instream sediment-related conditions and changes over time. Then, targets and associated TMDLs are set at levels believed to be protective of beneficial uses at key life stages taking into account the lag time effects. In addition, the numeric targets generally represent summer flow conditions. This TMDL accounts for seasonal variation through the careful articulation of likely cause and effect relationships between sediment loadings and effects on salmonid habitat at different key life stages, and its consideration of lag time effects.

Normal winter rains and larger storms will nonetheless have an effect on the assessment of allocations. Storm events which occur after mitigations have been achieved will provide a test of the success of the mitigation. For this reason, the State has suggested in the Strategy that follow-up inventories be required and storm-related hillslope targets are proposed which will help assess post-mitigation success. EPA endorses the State's approach to follow-up monitoring.

CRITICAL CONDITIONS

The regulations at 40 CFR 130.7 state that TMDLs shall take into account critical conditions for stream flow, loading and water quality parameters. This TMDL does not explicitly estimate critical flow conditions for several reasons. First, unlike many pollutants (e.g. acutely toxic chemicals) sediment impacts on beneficial uses may occur long after sediment is discharged, often at locations far downstream from the point of discharge. Second, sediment impacts are rarely correlated closely with flow over short time periods. Third, it is impractical to accurately measure sediment loading, transport, and short term effects during high magnitude flow events which usually produce most sediment loading and channel modification in systems such as the Garcia. Therefore, the approach used in this TMDL to account for critical conditions is to use indicators which are reflective of the net long term effects of sediment loading, transport, deposition, and associated receiving water flows. These indicators may be effectively measured at lower flow conditions at roughly annual intervals. Inclusion of a large margin of safety helps to ensure that the TMDL will result in beneficial use protection during and after critical flow periods associated with maximum sedimentation events.

IMPLEMENTATION AND MONITORING

The main responsibility for water quality management and monitoring resides with the States. Thus, the Regional Board's Strategy included an implementation plan, and the TMDL portion of the Strategy was designed as a phased TMDL which included a monitoring strategy. Because these are state responsibilities, EPA did not include implementation and monitoring plans in this draft TMDL.

However, pursuant to EPA policy (August 8, 1997) and federal regulations 40 CFR 130.6, the EPA fully expects the State to develop and submit an implementation plan to EPA as part of revisions to the State water quality management plan coupled with the proposed TMDL. The State implementation plan should include reasonable assurances that the nonpoint source load allocations established in the TMDL (for waters impaired solely or primarily by nonpoint sources) will in fact be achieved. These assurances may be non-regulatory, regulatory, or incentive-based, consistent with applicable laws and programs. In addition, the plan should include a public participation process and appropriate recognition of other relevant watershed management processes, such as local source water protection programs, state section 319 management programs or state section 303(e) continuing planning.

The Regional Board's detailed implementation strategy provides a good framework for ensuring that the load allocations will be achieved. The source control actions identified by the Regional Board, therefore, should be adequate to result in attainment of water quality standards.

EPA encourages the State and landowners to work together to fully implement the implementation strategy. EPA also supports the Regional Board's phased approach, attainment schedule, monitoring plan, and overall adaptive management approach, which allows opportunities for refinement of the TMDL and accompanying implementation strategy. In addition, EPA intends to continue to review the implementation and monitoring measures identified in the Strategy, and to play an active role in assessing whether the measures will reasonably assure that the load allocations are met.

TIMEFRAME

The Regional Board laid out an attainment schedule for the allocations and targets. The Schedule includes interim compliance dates with allocations being met by 2018 (except for timber-related mass wasting which will be met by 2038). The final targets in the Strategy are to be attained by 2048. EPA believes the State's judgement is reasonable regarding an appropriate timeframe for meeting the allocations and targets. As EPA recognized in 1995 in establishing the Great Lakes Water Quality Guidance, "Determining the reasonable period of time in which water quality standards will be met is a case-by-case specific determination considering a number of factors including, but not limited to: behavior and ubiquity of pollutants of concern; type of remediation activities necessary; available regulatory and non-regulatory controls; and individual State or Tribal requirements for attainment of water quality standards." [Appendix F to 40 CFR part 132 (60 Federal Register p. 15416, March 23, 1995)] The river systems on the north coast are known to be highly dynamic systems where recovery from sediment inputs may take decades. The Regional Board Strategy recognizes this by setting final target attainment over a reasonable timeframe, while also identifying interim targets and review schedules to assure that TMDL implementation is ongoing.

That said, EPA also believes that even though there is uncertainty regarding how long this river system may take to fully recover and how much past practices may be influencing current conditions, given the current conditions of the stream there is a need to speed up recovery to the extent practicable. Focussing on controllable sources of sediment is an appropriate approach for achieving a speedier recovery. The Regional Board's adaptive management approach for phasing the TMDL and including interim targets will also provide appropriate check points to assure the TMDL is being fully implemented.

PUBLIC PARTICIPATION

40 CFR 130.7 requires that TMDLs be subject to public review. The State and EPA have provided for public participation through several mechanisms. Regional Board staff obtained input regarding the Strategy from the Garcia River Watershed Advisory Group (WAG). The WAG is a stakeholders group consisting of representatives of landowners; land managers; conservation groups; local, state, and federal agencies; and other interested members of the public. In addition, Regional Board staff presented the ideas contained in the Strategy to the public and North Coast Regional Water Quality Control Board in a workshop held on October 22, 1997 in Santa Rosa, California. Prior to the workshop, a draft Strategy was available for public review and comment. The final proposed Strategy was available for public review and

comment beginning on December 9, 1997. The Regional Water Quality Control Board held a hearing on the final Strategy on January 22, 1998 which provided the public an opportunity to testify. Finally, EPA provided for public comment on this document through a 30-day comment period. EPA considered all comments on the draft TMDL in establishing this TMDL, and prepared a responsiveness summary explaining EPA's responses to comments received.

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GLOSSARY

Aggradation	To fill and raise the elevation of the stream channel by deposition of sediment.
Agricultural facility	Any building, corral, pen, pasture, field, trail, or other feature on the landscape which is attributable to or associated with agricultural operations
Anadromous	Refers to aquatic species which migrate up rivers from the sea to breed in fresh water.
Areas of instability	Locations on the landscape where land forms are present which have the ability to discharge sediment to a watercourse.
Baseline data	Data derived from field based monitoring or inventories used to characterize existing conditions and used to establish a database for planning or future comparisons.
Beneficial Use	Uses of waters of the state that may be protected against quality degradation including, but not limited to, domestic, municipal, agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and the preservation and enhancement of fish, wildlife and other aquatic resources or preserves.
Class I	Watercourses which contain domestic water supplies, including springs, on site and/or within 100 feet downstream of the operation area and/or have fish always or seasonally present onsite, including habitat to sustain fish migration and spawning. Class I streams include historically fish-bearing streams.
Class II	Watercourses which have fish always or seasonally present offsite within 1000 feet downstream; and/or contain aquatic habitat for non-fish aquatic species. Class II waters do not include Class III waters that are directly tributary to Class I waters.
Class III	Watercourses which do not have aquatic life present, but show evidence of being capable of sediment transport to Class I and II waters under normal high flow conditions during and after completion of land management activities.
Class IV	Human-made watercourses, which usually supply downstream established domestic, agricultural, hydroelectric supply or other beneficial uses.
Controllable source	Any source of sediment with the potential to enter a water of the State which is caused by human activity and will respond to mitigation, restoration, or altered land management.
Debris torrents	Long stretches of bare, generally unstable stream channel banks scoured and eroded by the extremely rapid movement of water-ladened debris, commonly caused by debris sliding or road stream crossing failure in the upper part of a drainage during a high intensity storm.
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.
Drainage structure	A structure or facility constructed to control road runoff. These structures include but are not limited to fords, inside ditches, water bars, outsloping, rolling dips, culverts or ditch drains.
Flooding	The overflowing of water onto land that is normally dry.

Fry	A young juvenile salmon after it has absorbed its egg sac and emerged from the redd.
Headwater swale	The swale or dip in the natural topography that is upslope from a stream, at its headwater. There may or may not be evidence of overland or surface flow of water in the headwater swale.
Interstices	The space between particles (e.g. space between sand grains).
Inner gorge	A geomorphic feature formed by coalescing scars originating from mass wasting and erosional process caused by active stream erosion. The feature is identified as that area of stream bank situated immediately adjacent to the stream, having a slope generally over 65% and being situated below the first break in slope above the channel.
Inside ditch	The ditch on the inside of the road, usually at the foot of the cutbank.
Landslide	Any mass movement process characterized by downslope transport of soil and rock, under gravitational stress by sliding over a discrete failure surface-- or the resultant landform.
Large woody debris	A piece of woody material having a diameter greater than 30 cm (12 inches) and a length greater than 2 m (6 feet) that is located in a position where it may enter the watercourse channel.
Mass wasting	Downslope movement of soil mass under 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.
Numeric targets	A numerical expression of the desired instream environment. For each stressor or pollutant addressed in the problem statement of the Strategy , a numeric target is developed based on the numeric or narrative State water quality standards which are needed to recovered the impaired beneficial use.
Permanent drainage structure	A road drainage structure designed and constructed to remain in place following active land management activities while allowing year round access on a road.
Planning Watershed	The uniform designation and boundaries of sub basins within a larger watershed. These Watersheds are described by the California Department of Forestry as Cal Water Watersheds.
Redd	A gravel nest or depression in the stream substrate formed by a female salmonid in which eggs are laid, fertilized and incubated.
Sediment	Fragmented material that originates from weathering of rocks and decomposed organic material that is transported by, suspended in, and eventually deposited by water or air.
Sediment budget	An accounting of the sources, movement, storage and deposition of sediment produced by a variety of erosional processes, from its origin to its exit from a basin.
Sediment delivery	Material (usually referring to sediment) which is 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 erosion	The group of processes whereby sediment (earthen or rock material) is loosened, dissolved and removed from the landscape surface. It includes weathering, solubilization and transportation.
Sediment source	The physical location on the landscape where earthen material resides which has or may have the ability to discharge into a watercourse.
Sediment yield	The sediment yield consists of dissolved, suspended and bed loads of a watercouse channel through a given cross-section in a given period of time.
Shallow seated landslide	A landslide produced by the failure of the soil mantle (typically to a depth of one or two meters, sometimes includes some weathered bedrock), on a steep slope. It includes debris slides, soil slips and failure of road cut-slopes and sidecast. The debris moves quickly (commonly breaking up and developing into a debris flow) leaving an elongated, concave scar.
Skid trail	Constructed trails or established paths used by tractors or other vehicles for skidding logs. Also known as tractor roads.
Smolt	A young salmon at the stage at which it migrates from fresh water to the sea.
Steep slope	A hillslope, generally greater than 50% that leads without a significant break in slope to a watercourse. A significant break in slope is one that is wide enough to allow the deposition of sediment carried by runoff prior to reaching the downslope watercourse.
Stream	See watercourse.
Stream class	The classification of waters of the state, based on beneficial uses, as required by the Department of Forestry in Timber Harvest Plan development. See definitions for Class I, Class II, Class III, and Class IV for more specific definitions.
Stream order	The designation (1,2,3, etc.) of the relative position of stream segments in the drainage basin network. For example, a first order stream is the smallest, unbranched, perennial tributary which terminates at the upper point. A second order stream is formed when two first order streams join. Etc.
Sub basin	A subset or division of a watershed into smaller hydrologically meaningful Watersheds. For example, the North Fork Garcia River is a sub basin of the larger Garcia River watershed.
Swale	A channel-like linear depression or low spot on a hillslope which rarely carries runoff except during extreme rainfall events. Some swales may no longer carry surface flow under the present climatic conditions.
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.
Unstable areas	Characterized by slide areas, gullies, eroding stream banks, or unstable soils. Slide areas include shallow and deep seated landslides, debris flows, debris slides, debris torrents, earthflows and inner gorges and hummocky ground. Unstable soils include

unconsolidated, non-cohesive soils and colluvial debris.

V*	A numerical value which represents the proportion of fine sediment that occupies the scoured residual volume of a pool.
Watercourse	Any well-defined channel with a distinguishable bed and bank showing evidence of having contained flowing water indicated by deposit of rock, sand, gravel, or soil.
Waters of the state	Any surface water or groundwater, including saline water, within the boundaries of the state.
Watershed	Total land area draining to any point in a watercourse, as measured on a map, aerial photo or other horizontal plane. Also called a basin, drainage area, or catchment area.
Water quality objective	Limits or level of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area.
Water quality standard	Consist of the beneficial uses of water and the water quality objectives as described in the Water Quality Control Plan for the North Coast Region.