Reference Document for the Garcia River Watershed Water Quality Attainment Action Plan for Sediment

prepared by staff of the

California Regional Water Quality Control Board
North Coast Region
5550 Skylane Boulevard, Suite A
Santa Rosa, California 95403

September 21, 2000

(Revision to 12/09/97
Garcia River Watershed
Water Quality Attainment Strategy
for Sediment)

PREFACE

The *Reference Document for the Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Reference Document) is a revised version of the *Garcia River Watershed Water Quality Attainment Strategy for Sediment* (Strategy) dated December 9, 1997. The title has been modified in order to clarify the relationship between the Reference Document and the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan) and to avoid confusion between the two documents. The Action Plan consists of the portions of the Strategy that were modified and adopted by the Regional Water Quality Control Board as an amendment to the Water Quality Control Plan in December, 1998. This clarification also required all references to the "Strategy" be modified to refer to the either the "Reference Document" or the Action Plan."

Other clarifications to the Reference Document include the addition of several sections into the Load Allocation chapter of the Reference Document. These sections include the General Discussion, Technical Rational for the Load Allocations, Analysis of the Load Allocation Contained in the Proposed Action Plan, and the Margin of Safety sections. These sections were produced for the December 1998 Regional Water Board Hearing and are now included in the Reference Document for ease of reference and technical support.

Revisions were also made to the Reference Document so as to obtain complete consistency between the Reference Document and the Action Plan. All regulatory provisions were deleted from the Reference Document, including detailed descriptions of the Implementation Plan. All regulatory provisions are contained in the Basin Plan amendment entitled the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan).

EXECUTIVE SUMMARY

The *Reference Document for the Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Reference Document) is a non-regulatory, staff-level tool for landowners; land managers; interested public; and state, local, and federal resource protection agency personnel to use as an aid for developing and implementing plans to reduce sediment delivery to the Garcia River and its tributaries. It is a planning document that will be revised or updated over time as factors affecting sediment conditions are better understood.

The Reference Document directly supports the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan). The Action Plan contains all regulatory provisions and serves as a phased Total Maximum Daily Load (TMDL), implementation plan, and monitoring plan for the Garcia River watershed. This Reference Document is intended to be a useful reference for providing additional background for the concepts contained in the Action Plan.

The Garcia River watershed has been listed as water quality-limited (impaired) due to sedimentation on the 303(d) list as required by Section 303(d) of the Clean Water Act. Sedimentation is impacting the cold water fishery, a beneficial use of the Garcia River watershed, including the migration, spawning, reproduction, and early development of cold water fish such as coho salmon and steelhead. Cold freshwater and estuarine habitats are also impacted by sedimentation. Accelerated erosion due to land use practices and other causes is impacting migration corridors, spawning gravels and rearing pools, as well as impacting the overall channel stability.

The Reference Document provides an assessment of the current instream conditions which is contained in the Problem Statement section. Also, a description of the desired future instream conditions for cold water fish is followed in the Numeric Targets section. This description is primarily in the form of numeric targets for instream parameters such as the percentage of fine sediment which composes riffles, and the depth, width, and frequency of pools. The numeric targets are not established as enforceable standards. Instead, they provide guideposts identifying the desired future condition of the instream environment.

Following the description of the desired future conditions is an assessment of the current upslope conditions which is contained in the Source Analysis section. And, a synthesis of the instream and upslope data is provided in the Load Capacity Calculation section of the Reference Document.

This is followed by the Load Allocations section which describes the sediment delivery reductions which should occur to achieve the desired future instream conditions. The technical rationale for these load allocations and the margin of safety is also included in the Load Allocations section of the Reference Document. The Load Allocations are established for roads, timber operations, agricultural activities, and gravel mining operations. The Load Allocations are based on Best Management Practices (BMPs) and reflect the predicted success of the practices for each land use.

Next, the Implementation Plan section of the Reference Document provides the overview and background information for the Implementation Plan found in the Action Plan. The Implementation Plan section of the Reference Document includes the request of landowners in the Garcia River watershed that they develop and submit Site-Specific Management Plans. The development and submittal of Site-Specific Management Plans is entirely voluntary. However, it is judged as the best mechanism for ensuring fair, reasonable, and effective sediment delivery reduction. The Garcia River Management Plan is contained in the Action Plan's Implementation Plan, and describes management practices to be applied to those properties for which no Site-Specific Management Plan has been submitted.

Lastly, the Monitoring Plan section of the Reference Document is also included which provides background information for the Monitoring Plan found in the Action Plan. The Monitoring Plan section of the Reference Document also identifies parameters and protocols for instream and hillslope monitoring. Landowners are encouraged to develop their own monitoring proposals as part of the Site-Specific Management Plan. Through individual discussions between landowners and Regional Water Board staff, a basin-wide monitoring plan will emerge. The collection and review of monitoring data is critical to the success of the Reference Document. It will allow landowners and the public to identify those stream reaches where progress is being made and those which still require effort. Further, it will allow for an assessment of the accuracy of the Reference Document, providing information for future revisions.

Information regarding landowner assistance is provided in the Education and Assistance section. A schedule for the review and potential revision of the Reference Document is provided in the Review and Revision section.

Regional Water Board staff have attempted in the Reference Document to thoroughly and comprehensively address each of the subject areas identified above. All of the relevant existing data for the watershed is either contained or summarized in the Reference Document. The *Assessment of Aquatic Conditions in the Garcia River Watershed* (1997), also prepared by Regional Water Board staff, provides the full collection of source material for the Reference Document. It too contains all of the relevant existing information for the watershed, as well as numerous maps and summaries of the condition of individual tributary basins. It can be reviewed at the offices of the North Coast Regional Water Quality Control Board beginning December 16, 1997, or ordered for purchase by calling (707) 576-2220.

TABLE OF CONTENTS

A. INTRODUCTION **1**
Components of a TMDL 4
Developing the Reference Document 7
Summary 8

B. REGULATORY FRAMEWORK **10**
Clean Water Act Requirements 10
1988 Non-Point Source Management Plan 14
Proposed Action Plan 15
Summary 16

C. PUBLIC PARTICIPATION **17**
Garcia River Watershed Advisory Group 17
Future Opportunities for Public Participation 18
Recommendations of the Garcia River Watershed Advisory Group 18

D. GENERAL DESCRIPTION OF THE WATERSHED **19**
Introduction 19
Land Use 19
Geology 22
Soil/Vegetation Regions 23
Hydrology 24
Summary 29

E. ACTION PLAN

I. PROBLEM STATEMENT **30**
Introduction 30
Channel Morphology 30
Aquatic Habitat 34
Limiting Factors 41
Problem Statements 45

II. NUMERIC TARGETS **48**
Introduction 48
Overview of the Numeric Targets 48
Migration-related Targets 49
Spawning-related Targets 49
Embryo Development-related Targets 50
Fry Emergence-related Targets 53
Rearing-related Targets 55
Channel Structure/Stability-Related Targets 58

Summary 64
Attainment Schedule 65
Annual and Seasonal Variation 65

III. SOURCE ANALYSIS 66
Introduction 66
Geomorphology 67
Riparian Functioning 69
Erosional Processes Active in the Basin 72
Preliminary Sediment Budget 83
Summary of Upland Data 86
Problem Statements 86

IV. LOAD CAPACITY CALCULATION 89
Introduction 89
Summary of the Existing Data 89
Synthesis 89
Summary 93

V. LOAD ALLOCATIONS 62
Introduction 62
General Discussion 62
Technical Rationale for the Load Allocation 63
Analysis of the Load Allocation Contained in the Action Plan 64
Sediment Delivery Reductions and Load Management Measures 65
Sediment Reduction Requirements and Schedule 66
Cost-Effectiveness 72
Margin of Safety 73
Annual and Seasonal Variation 74

VI. IMPLEMENTATION PLAN 76
Overview 76
Background 77
Implementation Enforcement 77

VII. MONITORING PLAN 79
Overview 79
Parameters 79
Sampling Locations 79
Sampling Schedule 80

VIII. ESTIMATED TOTAL COST AND POTENTIAL SOURCES OF FUNDING (EDUCATION AND ASSISTANCE OPPORTUNITIES) 83
Funding Programs 83
Information Technical Assistance 86

IX. PLAN FOR FUTURE REVIEW AND REVISION OF THE REFERENCE DOCUMENT AND ACTION PLAN........ 88

F. REFERENCES........ 90

G. GLOSSARY........ 97

Figures

1. Map of the Garcia River Watershed in Northern California
2. Summary of Beneficial Water Uses of the Garcia River (NCRWQCB 1994)
3. Summary of Water Quality Objectives and Prohibitions for the Garcia River (NCRWQCB 1994)
4. Map of the Garcia River Watershed and Land Ownership Boundaries
5. Ownership Statistics by Planning Watershed: Land Holdings Greater than 1000 Acres in the Garcia River Watershed
6. Summary of the total miles of stream in each Planning Watershed
7. Summary of estimated bankfull flows associated with each Planning Watershed
8. Map of the annual average precipitation in the Garcia River watershed, including Planning Watershed boundaries
9. Average annual rainfall distribution in the vicinity of the Garcia River estuary
10. Flood frequencies at the USGS gaging station in the Garcia River at Connor Hole
11. Summary of peak flow discharges in the Garcia River watershed at the USGS gaging station at Connor hole
12. Estimates of substrate composition from Department of Fish and Game Stream Surveys
13. Summary of Existing McNeil Data
14. Summary of substrate data collected as part of the habitat typing conducted by the Mendocino County Resource Conservation District
15. Summary of fish habitat data collected as part of the habitat typing conducted by the Mendocino County Resource Conservation District
16. Summary of estimate of the percentage of pools, riffles and runs from the Department of Fish and Game Stream Surveys
17. Summary of instream cover ratings from the Department of Fish and Game Stream Surveys
18. Summary of fish population data from the Department of Fish and Game Stream Surveys
19. Summary of redd density data collected by the Salmon Trollers Association
20. Summary of water quality data collected at Buckridge Road and the Highway 1 bridge, Garcia River watershed
21. Comparison of existing instream data with instream numeric targets
22. Summary of stream channel openings measured from 1952 through 1996
23. Summary of canopy-related data collected as part of the habitat typing conducted by the Mendocino County Resource Conservation District
24. Estimated total sediment delivery and average sediment delivery rates from mass wasting

25. Estimate of the miles of stream affected by stream channel opening
26. Summary of sediment delivery associated with surface erosion
27. Summary of road density statistics for the Garcia River watershed
28. Summary of instream stored sediment data collected by LP as presented by PWA 1997
29. Summary of all relevant upland data
30. Summary of all relevant instream and upland data and information
31. Summary of monitoring parameters and protocols
32. Schedule for review and potential revision of the Reference Document and Action Plan

A. INTRODUCTION

The *Reference Document for the Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Reference Document) is a non-regulatory, staff-level tool for landowners; land managers; interested public; and state, local, and federal resource protection agency personnel to use as an aid for developing and implementing plans to reduce sediment delivery to the Garcia River and its tributaries. It is a planning document that will be revised or updated over time as factors affecting sediment conditions are better understood.

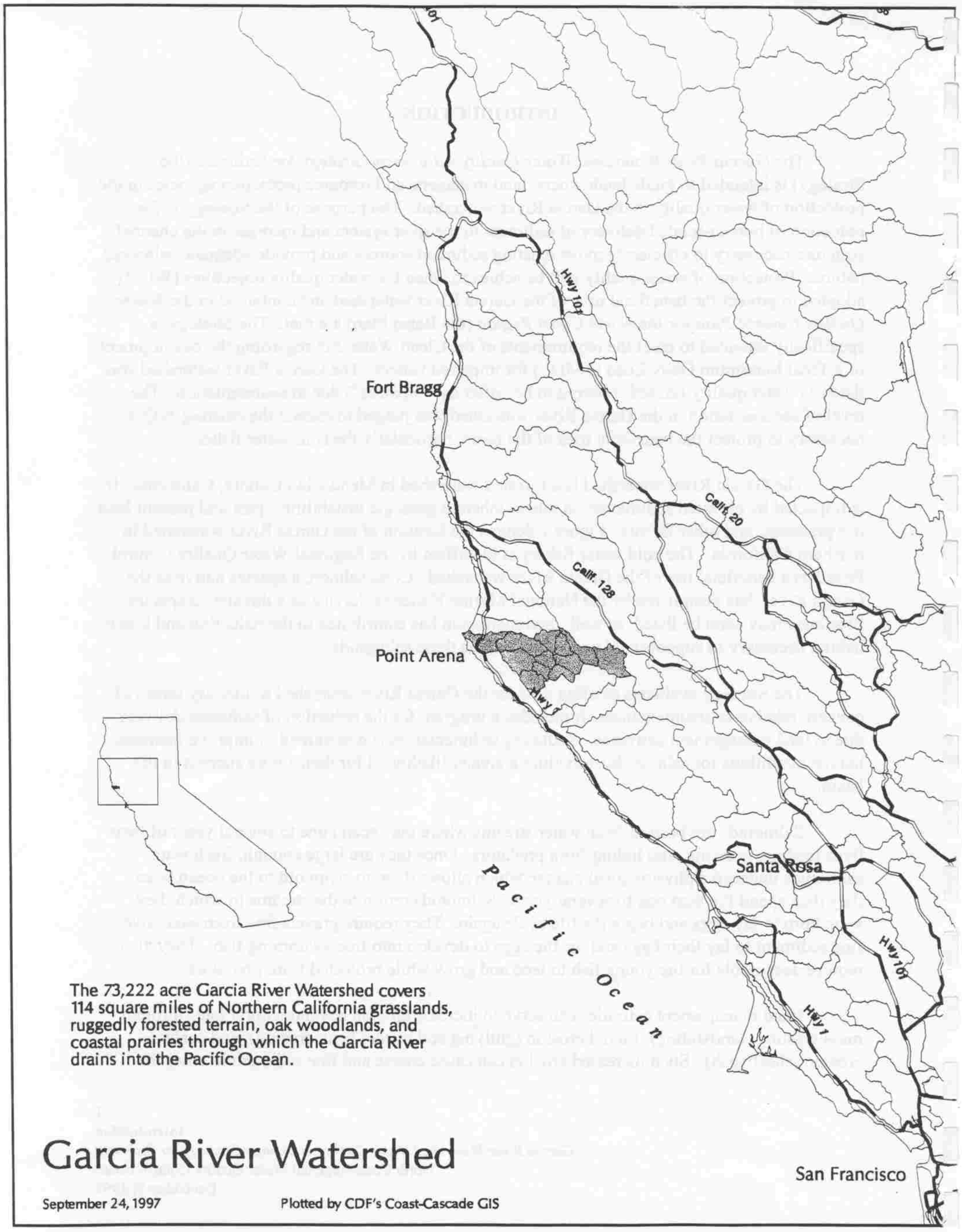
The Reference Document directly supports the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan). The Action Plan contains all regulatory provisions and serves as a phased TMDL, implementation plan, and monitoring plan for the Garcia River watershed. This Reference Document is intended to be a useful reference for providing additional background for the concepts that follow.

The purpose of the Action Plan is the reduction of human-related delivery of sediment to the river system and increase in the channel structure necessary to efficiently move existing sediment sources and provide adequate salmonid habitat. Protection of water quality will be achieved when the water quality objectives (WQO) 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 Action Plan is specifically intended to meet the requirements of the Clean Water Act regarding the development of a Total Maximum Daily Load (TMDL) for impaired waters. The Garcia River watershed was listed as water quality impaired due to sedimentation. The level of sedimentation in the Garcia River watershed was judged to exceed the existing WQO necessary to protect the beneficial uses of the basin, particularly the cold water fishery.

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 Water Quality Control Board as a beneficial use of the Garcia River watershed. The National Marine Fisheries Service (NMFS) listed coho salmon, a species native to the Garcia River Watershed, in 1996, as a threatened species under the federal Endangered Species Act. On June 7, 2000, NMFS also listed steelhead trout in the Northern California Evolutionarily Significant Unit (ESU), encompassing coastal river basins from Redwood Creek in Humboldt County south to the Gualala River, as a threatened species. Sedimentation has contributed to the reduction and loss of habitat necessary to support cold water fish such as these salmonids.

The Reference Document evaluates existing data for the Garcia River watershed to identify issues of concern relative to sedimentation. It includes a program for the reduction of sediment delivery due to land management activities. Reducing sedimentation is determined to improve instream habitat conditions for salmonids, providing a greater likelihood for their future success in the basin.


Fort Bragg
Hwy 101
Calif. 20
Calif. 128
Point Arena
Hwy 1
Santa Rosa
Pacific Ocean
Hwy 101
Hwy 1
The 73,222 acre Garcia River Watershed covers 114 square miles of Northern California grasslands, ruggedly forested terrain, oak woodlands, and coastal prairies through which the Garcia River drains into the Pacific Ocean.
Garcia River Watershed
San Francisco
September 24, 1997
Plotted by CDF's Coast-Cascade GIS

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 while still providing salmonid habitat. Historic land use practices, in particular, appear to have had a major impact. The Reference Document attempts to identify ways of reducing current loads of sediment to the watershed and improving the stream channels' ability to efficiently move the existing sediment while re-creating deep pools and clean gravels for spawning.

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.

The Department of Fish and Game estimated that in 1960 there were 2000 coho spawning in the Garcia River watershed. By the 1970s, the Department of Fish and Game's creel census data indicated that between 0-20 coho were being caught each year. Craig Bell, a professional fishing guide on the Garcia River (public testimony) estimates 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.

Regional Water Board staff proposed a phased approach to the Action Plan which allows landowners time to evaluate the site-specific conditions on their own property and develop Site-Specific Management Plans designed to reduce sedimentation in a manner appropriate to their site-specific conditions. The Action Plan provides:

- A gross assessment of conditions in the basin;

- A framework for evaluating site-specific conditions, controlling existing and potential human-caused erosional sources, and improving the ability of the stream channel to efficiently move existing sediment;

- Flexibility to revise the Action Plan as site-specific information is developed which better describes the condition of the basin than does the current, gross assessment.

The development of the Reference Document and Action Plan follows a year and a half of public meetings of the Garcia River Watershed Advisory Group (WAG). The WAG is a stakeholder group consisting of representatives of: land owners; land managers; environmentalists; local, state and federal agencies; and other interested members of the public. The group provided data, data interpretation, and suggestions in the formulation of the Reference Document.

Components of a TMDL

A Total Maximum Daily Load (TMDL) is required for waters which are listed as impaired on the 303(d) list. The Garcia River is listed as impaired due to sedimentation. This Reference Document is intended to support the Action Plan which meets the requirements of a TMDL and provides a program for the implementation and revision of the TMDL over time. The Action Plan is considered a phased TMDL.

The requirements of a Total Maximum Daily Load (TMDL) are described in Title 40 of the Code of Federal Regulations, Section 130.2 (40 CFR 130.2), 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 waste load allocations for point sources, load allocations for nonpoint sources, and natural background pollutants. That is:

$$TMDL = WLA + LA + NB$$

where: WLA = waste load allocation, LA= load allocation, and NB = natural background. In addition, a TMDL is required to account for seasonal variations and includes a Margin of Safety (MOS) to address uncertainty in the analysis.

The Action Plan includes individual load allocations for all significant sources in the watershed. The load allocations are expressed as a percent load reduction from controllable sources where controllable sources are defined as those sources of sediment which are associated with human activity and respond to mitigation, restoration or altered land management. The Action Plan also includes a prediction of the sediment delivery which will occur as a result of the load reductions. The Action Plan, therefore, satisfies the requirement for a load allocation formulation but not on a daily time step basis. Sediment is not discharged, like other pollutants, on a daily basis via a discharge pipe or other similar controlled mechanisms such as through a storm drain. Therefore, the TMDL is expressed in average tons/mi^2/year to better address seasonal and geographic variation. In addition, the predictions associated with the TMDL are expressed in ranges to account for inter-annual variation and the uncertainty associated with the sediment budget figures.

Finally, unlike chromium, selenium, or other similar pollutants, sediment generally impacts salmonids indirectly rather than causing a direct assault on the organism. In general, sedimentation impacts the *habitat* required by the species rather than the direct physical health of the organism. While the biology of salmonids is certainly complex, their ecology is generally even more so. Laboratory experiments in which organisms are exposed to various levels of pollutants that have direct effects can reliably identify the amount of a pollutant which causes death or chronic effects. No such direct experiment can determine how much sediment can enter a complex instream ecosystem before altering the available salmonid habitat in such a way as to significantly reduce a population's likelihood of reproductive success.

Therefore, the Action Plan relies on the TMDL *process* as suggested in the Total Maximum Daily Load Fact Sheet (See Appendix A) as a way of systematically evaluating the identified problems; identifying mechanisms for reducing the sources of the problems to a level which will meet the water quality standards; and developing a framework for testing, over time, the efficacy of the Action Plan.

Components of a TMDL:

- A *Problem Statement* provides a description of the waterbody/watershed setting, the beneficial use impairments of concern, and the pollutants or stressors causing the impairment. The Problem Statement section of the Reference Document describes the problems associated with sedimentation in the Garcia River watershed in terms of its impact on the various life cycle stages of salmonids and on the overall stability of the stream channel. The *Assessment of Aquatic Conditions in the Garcia River Watershed, Prepared for the North Coast Regional Water Quality Control Board* (Manglesdorf, A.T. 1997) identifies instream temperatures as a stressor relevant to the production of salmonids, particularly coho salmon. However, due to concerns expressed by some members of the Garcia River Watershed Advisory Group, instream temperature will be addressed in a separate document. Channel structure, another identified stressor, is included in the Reference Document because of its role in combination with sediment delivery in determining the degree to which instream salmonid habitat is impacted by sedimentation.

- *Numeric Target(s)* are based on and implement the numeric or narrative water quality objectives adopted in the *Water Quality Control Plan for the North Coast Region* (the Basin Plan) and express the desired future condition for each stressor addressed in the TMDL. The Numeric Targets section of the Reference Document provides a review of the scientific literature upon which the proposed numeric targets are based. Numeric targets are proposed which protect each of the various salmonid life stages and provide greater channel stability. As additional data is developed for the Garcia River watershed itself, these targets can be refined to better reflect the site-specific conditions of the watershed. Further, the numeric targets must be understood as *goals,* not *requirements*. They provide a guidepost to landowners, resource managers and the public by which to determine how close the Reference Document and Action Plan is to recreating an instream environment suitable to support sustainable populations of salmonids. Numeric targets are not intended to be attained immediately, nor are they directly enforceable against landowners.

- The *Source Analysis* provides an assessment of the relative contributions of sources to the beneficial use impairment and the extent of needed discharge reductions or controls. The Source Analysis section of the Reference Document provides a general assessment of the sources of sediment to the Garcia River based on a sediment budget produced by Pacific Watershed Associates under contract to the U.S. Environmental Protection Agency. The Source Analysis section concludes that mass wasting produces the greatest volume of sediment in the basin followed by fluvial erosion and surface erosion. Mass wasting and fluvial erosion are generally initiated by storm events and deliver both coarse and fine sediment to the stream system. Surface erosion occurs annually and delivers fine sediment to the watershed. Roads, in particular, are identified as a primary source of human-caused sediment delivery.

- The *Load Capacity Calculation* uses the average annual sediment load derived from the Source Analysis to calculate a load capacity reduction in order to achieve the desired future condition in the watershed.

- The *Load Allocation* results in the assignment of sediment load reduction and/or restoration responsibility among the various landowners. The Load Allocation section of the Reference Document proposes a program of source reductions by which to control "controllable" sources of sediment. "Controllable" sources are defined as those which are human-caused and are likely to respond to mitigation or altered land management practices. Landowners are not responsible for reducing sources of sediment that are not controllable. The Load Allocation section of the Reference Document identifies roads as the most controllable source of mass wasting, fluvial, and surface erosion-related sediment delivery. Roads are also a universal source of sediment amongst all the land uses found in the basin. As such, roads are given a high priority for sediment delivery reduction. Load Allocation requirements are also developed for landings, skid trails, timber harvest units and agricultural activities, and gravel mining operations.

In addition, the Water Quality Management Planning process (40 CFR 130.6) requires States to include TMDLs and associated implementation measures and monitoring in the State Water Quality Management Plans. The TMDL and Implementation and Monitoring Plans are found in the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan).

- The *Implementation Plan* provides a plan of action which is expected to result in the required source reductions and attainment of the numeric targets. The Implementation Plan section of the Action Plan encourages individual landowners and a consortia of landowners to assess the specific conditions of their own property(s) and develop Site-Specific Management Plans designed to address the specific sediment-related problems they identify. Many landowners have already volunteered to submit resource planning documents as Site-Specific Management Plans, including two of the industrial timber companies and several of the agricultural landowners. In addition, many landowners have already been implementing conservation measures designed to reduce sediment delivery, though perhaps have not formally identified their activities and successes to the Regional Water Board.

For landowners who choose not to develop their own Site-Specific Management Plan, the Implementation Plan section of the Action Plan provides a Garcia River Management Plan that includes management practices designed to address the general problems identified in the basin. Not all of the management practices identified will be applicable to individual properties, and thus a Site-Specific Management Plan is a far preferable tool for sediment delivery reduction. The goals of Site-Specific Management Plans and of the Garcia River Management Plan are to identify management practices which will attain the Load Allocation requirements identified in the Load Allocation section of the Action Plan and move towards attainment of the numeric targets.

- The *Monitoring Plan* identifies the techniques, locations, and schedule for collecting data sufficient to determine the effectiveness of the Implementation Plan and to test the assumptions made in the assessment. The Monitoring Plan section of the Action Plan describes the monitoring and reporting program necessary to: a) develop a greater understanding of conditions in the Garcia River basin, b) assess the progress in attaining the desired future conditions as described by the numeric targets, and c) assess compliance with the Load Allocation requirements. Most importantly, monitoring data will allow for adaptation of the Action Plan as a better understanding of the watershed and its hydrologic-biologic dynamic is achieved.

- The development and adoption of a TMDL requires adequate *Public Participation* to ensure that all relevant issues are considered and incorporated, where applicable. The Public Participation section of the Reference Document describes the opportunities for public participation which have been a part of the development of the Reference Document. The Reference Document was developed after nearly one and a half years of meetings with the Garcia River Watershed Advisory Group (WAG) and its several subcommittees. The WAG is a consortium of landowners; resource managers; environmentalists; and local, state and federal agency representatives. Because the WAG was unable to develop a comprehensive strategy of its own, Regional Water Board staff took elements of the many WAG and subcommittee discussions from 1996-97 and developed the Action Plan for consideration by the Regional Water Board.

Developing the Reference Document and Action Plan

A watershed assessment of the Garcia River basin was conducted to provide the basis for the Action Plan and is contained in the *Assessment of Aquatic Conditions in the Garcia River Watershed* (1997). The watershed assessment provides a review of the existing information for the basin divided by sub-basin in combination with a desktop analysis primarily consisting of aerial photo review. The goal of the watershed assessment was to provide an understanding of the factors in each sub-basin that are limiting the success of salmonids and to identify the controllable causes of those factors based on existing information. Conducting additional field-work was not envisioned in the development of this first version of the Reference Document. The subjects which were reviewed in the watershed assessment include: landslides, surface erosion, riparian functioning, hydrology, stream channel conditions, fish habitat, water quality, and water supply. The data and information relevant to each of these subjects were combined for each sub-basin to develop an understanding of how material is routed through the watershed.

The existing information was collected from various sources including published reports, individual interviews, inter-agency discussions, and discussions of the Garcia WAG. Desktop analyses were conducted primarily by consultants to the California Department of Forestry and Fire Protection through the Mendocino County Resource Conservation District and to the North Coast Regional Water Quality Control Board through the U.S. Environmental Protection Agency. These analyses were supplemented with data analyses conducted by Regional Water Quality Control Board staff with the assistance of staff at the U.S. Environmental Protection Agency and the California Department of Forestry and Fire Protection. In addition, the watershed assessment was developed with considerable input from the Garcia WAG.

Summary

The *Reference Document for the Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Reference Document) is a non-regulatory document intended to guide landowners, land managers, and resource protection agencies in the protection of water quality in the Garcia River watershed. The Reference Document directly supports the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan).

The purpose of the Reference Document is the reduction of human-related delivery of sediment to the river system and increase in the channel structure necessary to efficiently move existing sediment sources and provide adequate salmonid habitat. Because the watershed has been listed on the 303(d) list as impaired due to sedimentation, this Reference Document is intended to support the Action Plan in meeting the requirements for a Total Maximum Daily Load (TMDL) as required under Section 303(d) of the Clean Water Act. The analysis contained in the Reference Document indicates that implementation of the Action Plan will result in attainment of the water quality standards. This Reference Document includes further background for each of the following recommended elements:

- Problem Statement
- Numeric Targets
- Source Assessment
- Load Capacity Calculation
- Load Allocation (Allocation of Responsibility)
- Implementation Plan
- Monitoring Plan
- Public Participation

This version of the Reference Document is generally based on discussions of the Garcia River Watershed Advisory Group, the *Assessment of Aquatic Conditions in the Garcia River Watershed* (1997), and a review of scientific literature. It is based on existing information, only, as expected by the U.S. Environmental Protection Agency, Region 9.

B. REGULATORY FRAMEWORK

Clean Water Act Requirements

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." Water quality standards (WQS) adopted for the Garcia River basin are contained in the *Water Quality Control Plan for the North Coast Region* (the Basin Plan).

On December 9, 1993, the North Coast Regional Water Quality Control Board (Regional Water Board) adopted a major revision to the Basin Plan. It was approved by the State Water Resources Control Board (State Water Board) on March 21, 1994, and approved by the Office of Administrative Law (OAL) on August 18, 1994. The Regional Water Board amended the Basin Plan on March 24, 1994, June 22, 1995, and May 23, 1996; the State Water Board approved the amendments on June 16, 1994, November 16, 1995, and on August 15, 1996; the Office of Administrative Law approved the amendments on June 30, 1994, February 21, 1996, and on November 20, 1996, respectively.

Among other things, the Basin Plan for the Garcia River identifies: the beneficial uses of water; water quality objectives; a policy for agricultural wastewater management; an action plan for logging, construction, and associated activities; guidelines for implementation and enforcement of discharge prohibitions relating to logging, construction, or associated activities; and a policy and action plan for the control of discharges of herbicide wastes from silvicultural applications. Figure 2 summarizes the beneficial uses identified in the Basin Plan for the Garcia River. Figure 3 summarizes the water quality objectives and prohibitions identified in the Basin Plan for the Garcia River. And, Appendix B contains, from the Basin Plan, the Policy for Agricultural Wastewater Management; the Action Plan for Logging, Construction, and Associated Activities; the Guidelines for Implementation and Enforcement of Discharge Prohibitions Relating to Logging, Construction, or Associated Activities; and the Policy and Action Plan for Control of Discharges of Herbicide Wastes from Silvicultural Applications.

The Water Quality Standards (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 case of the Garcia River, the beneficial uses of most concern to the development of the Action Plan include: cold freshwater habitat (COLD); migration of aquatic organisms (MIGR); spawning, reproduction, and/or early development (SPAWN); and estuarine habitat (EST). Municipal and Domestic Supply (MUN) was initially identified as a potential beneficial use of concern. No data, however, was submitted to the Regional Water Board which suggests that the potential MUN beneficial use is impacted by sedimentation at this time. The water

Figure 2: Summary of Beneficial Water Uses of the Garcia River (NCRWQCB 1994)

Beneficial Water Uses	**Potential or Existing**	**Description**
Municipal and Domestic Supply (MUN)	Potential*	Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.
Agricultural Supply (AGR)	Existing	Use of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.
Industrial Service Supply (IND)	Existing	Use of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well repressurization.
Water Contact Recreation (REC-1)	Existing	Use of water for recreation activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white-water activities, fishing, or use of natural hot springs.
Non-Contact Water Recreation (REC-2)	Existing	Uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beach combing, camping, boating, tide-pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.
Commercial and Sport Fishing (COMM)	Existing	Uses of water for commercial or recreational collection of fish, shellfish, or other organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes.
Cold Freshwater Habitat (COLD)	Existing	Use of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitat, vegetation, fish, or wildlife, including invertebrates.
Wildlife Habitat (WILD)	Existing	Uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitat, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.
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.
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.

Beneficial Water Uses	Potential or Existing	Description
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).
Aquaculture (AQUA)	Potential	Uses of water for aquaculture or mariculture operations including, but not limited to, propagation, cultivation, maintenance, or harvesting or aquatic plants, and animals for human consumption or bait purposes.

* Though the MUN designation is listed as "potential" in the Basin Plan, the Garcia River watershed comes under the State Water Resources Control Board's Sources of Drinking Water Policy as a drinking water source, regardless of existing use.

Figure 3: Summary of Water Quality Objectives and Prohibitions for the Garcia River (NCRWQCB 1994)

Water Quality Objective	Description
NARRATIVE OBJECTIVES	
Color	Waters shall be free of coloration that causes nuisance or adversely affects beneficial uses.
Tastes and Odors	Waters shall not contain taste- or odor-producing substances in concentrations that impart undesirable tastes or odors to fish flesh or other edible products of aquatic origin, or that cause nuisance or adversely affect beneficial uses.
Floating Material	Water shall not contain floating material, including solids, liquids, foams, and scum, in concentrations that cause nuisance or adversely affect beneficial uses.
Suspended Material	Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.
Settleable Material	Water shall not contain substances that result in deposition of material that causes nuisance or adversely affect beneficial uses.
Oil and Grease	Waters shall not contain oils, greases, waxes, or other materials in concentrations that result in a visible film or coating on the surface of the water or on objects in the water, that cause nuisance, or that otherwise adversely affect beneficial uses.
Biostimulatory Substance	Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses.
Sediment	The suspended sediment load and suspended sediment discharge rate of surface water shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.
Temperature	The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the Region Water Board that such alteration in temperature does not adversely affect beneficial uses. At no time or place shall the temperature of any COLD water be increased by more than 5^{o}F above natural receiving water temperature.
Toxicity	All waters shall be maintained free of toxic substances in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life.

Water Quality Objective	Description
Pesticides	No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses. There shall be no bioaccumulation of pesticide concentrations found in bottom sediments or aquatic life.
Chemical Constituents	Waters designated for use as domestic or municipal supply (MUN) shall not contain concentrations of chemical constituents in excess of the limits specified in California Code of Regulations, Title 22, Chapter 15, Division 4, Article 4, Section 64435 and Section 64444.5.
NUMERIC OBJECTIVES	
Turbidity	Turbidity shall not be increased more than 20 percent above naturally occurring background levels.
Dissolved Oxygen	At a minimum, waters will contain 7.0 mg/L at all times. Ninety percent of the samples collected in any year must contain at least 7.5 mg/L. Fifty percent of the monthly means in any calendar year shall contain at least 10.0 mg/L.
pH	The pH of waters will always fall within the range of 6.5 to 8.5.
2,4-D PGBE ester	No sample shall exceed 40 parts per billion acid equivalent. No series of samples averaged over a 24-hour period shall exceed 2 parts per billion acid equivalent.
PROHIBITIONS	
The discharge of soil, silt, bark, slash, sawdust, or other organic and earthen material from any logging, construction, or associated activity of whatever nature into any stream or watercourse in the basin in quantities deleterious to fish, wildlife, or other beneficial uses is prohibited.	
The placing or disposal of soil, silt, bark, slash, sawdust, or other organic and earthen material from any logging, construction, or associated activity of whatever nature at locations where such material could pass into any stream or watercourse in the basin in quantities which could be deleterious to fish, wildlife, or other beneficial uses is prohibited.	
There shall be no discharge of 2,4,5-T or 2,4,5- TP herbicides to waters of the State within the North Coast Region.	

quality objectives of most concern to the development of the Action Plan include those for: settleable material and sediment. Water quality objectives for suspended material and turbidity are also considered. The actions described in the Implementation Plan are designed to implement the settleable matter and sediment water quality objectives and are predicted to result in the attainment of the turbidity and suspended material water quality objectives, as well. The numeric targets proposed in the Numeric Targets section of the Action Plan provide goals which are intended to be consistent with the goals of the water quality standards. The numeric targets particularly focus on the impacts to the habitat necessary for the successful migration, spawning, reproduction, and early development of salmonids caused by the delivery of coarse and fine sediment to the stream system.

Section 303(d)(1)(A) of the Clean Water Act also requires that the State "Establish a priority ranking for such waters, taking into account the severity of the pollution and the uses to be made of such waters." In accordance with section 303(d)(1)(A), the North Coast Regional Water Quality Control Board (NCRWQCB) adopted, through Resolution No. 94-36 on February 24, 1994, a priority list of waters within the North Coast Region in which water quality standards were not being met. The Garcia River was included on that list based on the finding that the sedimentation was, in part, responsible for the impairment of the cold water fishery. Section 303(d)(1)(C) of the Clean Water Act requires that "Each State shall establish for the waters identified in the paragraph (1)(A) of this subsection, and in accordance with the priority ranking, the total maximum daily load..." In addition, the Porter-Cologne Water Quality Control Act requires the State to include TMDLs and associated implementation measures into the Basin Plan. The *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan) was developed to meet the requirements of the TMDL and incorporated as an amendment to the Basin Plan. The Reference Document is a non-regulatory, reference and planning document that supports the Action Plan.

1988 Non-Point Source Management Plan

In 1988, the State Water Resources Control Board adopted Resolution No. 88-123 which, among other things, adopted a *Non Point Source Management Plan* (Management Plan) for the State. The Management Plan identifies three options to be used to address any given nonpoint source problem. It is left to the Regional Water Quality Control Boards to decide which, or what mix of the options, will be applied in any given situation. The three identified options are as follows:

1. <u>Voluntary Implementation of Conservation Measures</u>

Property owners or managers may voluntarily implement management practices. Implementation could occur for economic reasons and/or through awareness of environmental benefits. Voluntary implementation can be encouraged through education, training, financial assistance, technical assistance, and demonstration projects. A voluntary approach would take advantage of the expertise and incentives offered by a variety of existing State and Federal programs which are geared towards promoting private actions which could have water quality benefits. Lead agencies for these programs include the U.S. Natural Resource Conservation Service, Resource Conservation Districts, and the U.C. Cooperative Extension Service.

2. <u>Regulatory-Based Encouragement of Conservation Measures</u>

Although the Porter-Cologne Act constrains Regional Boards from specifying the manner of compliance with water quality standards, there are two ways in which Regional Boards can use their regulatory authorities to encourage implementation of conservation measures.

First, Regional Water Boards may encourage the implementation of Best Management Practices (BMPs) by waiving adoption of waste discharge requirements on condition that dischargers implement BMPs. Another variation of this concept is to waive enforcement of prohibitions against discharge on condition that BMPs are implemented.

Alternatively, the State Board and the Regional Water Boards may enforce the implementation of BMPs indirectly by entering into Management Agency Agreements (MAAs) with other agencies which have the authority to enforce. Such authority derives either from the agency's regulatory authority or its management responsibility for publicly owned or controlled land. Such an MAA exists between the Regional Water Quality Control Board and the California Department of Forestry and Fire Protection for the protection of water quality on private forest lands.

3. Effluent Limitations

Regional Water Boards can adopt and enforce requirements on the nature of any proposed or existing waste discharge, including discharges from nonpoint sources. Although Regional Boards are precluded from specifying the manner of compliance with waste discharge limitations, in appropriate cases limitations may be set at a level which, in practice, requires implementation of BMPs.

The 1995 *California Rangeland Water Quality Management Plan* (Rangeland Management Plan) was developed by the Range Management Advisory Committee, in cooperation with the State Water Resources Control Board, the California Association of Resource Conservation Districts and other appropriate agencies, and landowner as well as conservation organizations. The Rangeland Management Plan draws upon the *Nonpoint Source Management Plan*, including the three options identified above, to provide a specific course of action for rangeland property owners.

Proposed Action Plan

This Action Plan intends to follow the guidelines established in the *Nonpoint Source Management Plan* for all land uses and the Rangeland Management Plan for agricultural uses, in particular. Many landowners in the Garcia River watershed have already proposed that they voluntarily develop and implement BMPs. The Action Plan sets forth information and mechanisms by which landowners can tailor their own management strategies to better ensure water quality and beneficial use protection. The Regional Water Board has strongly encouraged this continued and growing voluntary implementation from the basin's landowners, as per option one of the *Nonpoint Source Management Plan*.

Because a sufficient number of landowners have not committed to implement best management measures and it is necessary to provide reasonable assurances that the beneficial uses of the Garcia River watershed will be restored, the Action Plan has elements from both options one and two of the *Nonpoint Source Management Plan*. In accordance with option one of the *Nonpoint Source Management Plan*, the Regional Water Board will continue to encourage all landowners to either voluntarily develop and implement a Site-Specific Management Plan or implement the Garcia River Management Plan. Descriptions of the Site-Specific Management Plan and the Garcia River Management Plan are found in the Implementation Plan section of the Action Plan.

There are 10 landowners in the Garcia River watershed who each own more than 1000 acres of property in the basin. Their total land holdings cover 81% of the watershed. In order to work efficiently, Regional Water Board staff proposes that those landowners be the staff's highest priority for encouragement and assistance in developing and reviewing proposed Site-Specific Management Plans.

Summary

The Clean Water Act requires the development of water quality standards which includes the beneficial uses of waters of the State and the water quality objectives necessary to protect them. It further requires that the State periodically review the condition of water quality to determine if the water quality standards are being met. For those waters which are not supporting beneficial uses or are otherwise not meeting the water quality standards, the Clean Water Act requires that the State identify those waters and develop a Total Maximum Daily Load (TMDL) by which to restore beneficial uses. Moreover, state law requires the inclusion of TMDLs and associated implementation measures in the Water Quality Management Plan. The Garcia River has been identified as impaired due to sedimentation and the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan) is intended to meet the requirements for a TMDL and be adopted as an amendment to the Basin Plan.

The State Water Resources Control Board has adopted a state-wide policy for the control of non-point sources of pollution such as sedimentation. The *Non Point Source Management Plan* (1988) describes a three tiered process in which voluntary efforts to comply with the water quality goals and requirements of the State are followed by both regulatory-encouraged and regulatory-enforced efforts should water quality insufficiently improve as a result of voluntary efforts. The Action Plan intends to follow the framework of the *Non Point Source Management Plan* in the control of sedimentation in the Garcia River watershed.

C. PUBLIC PARTICIPATION

Garcia River Watershed Advisory Group

Public participation has been a large part of the development of this *Garcia River Watershed Water Quality Attainment Reference Document for Sediment* and the Action Plan. Regional Water Board staff obtained input regarding the Reference Document from the Garcia River Watershed Advisory Group (WAG) with the hope that landowners and other interested members of the public who had the specific knowledge of the conditions in the watershed and the practices which impact it would participate in creating a protective and practical Action Plan.

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. Few agricultural landowners joined the WAG initially, but later formed the Garcia River Watershed Agricultural Landowners Group, with the assistance of the California Farm Bureau. The chairperson of that group then joined the WAG to represent the agricultural group.

The WAG began meeting on a monthly basis starting in August 1996. The initial months were spent organizing the group, developing a direction and agenda, and deciding on the rules by which the group would operate. By January 1997, technical discussions were underway, including a myriad of presentations from landowners, agencies and conservation groups on subjects ranging from data collection and analysis, to off-road vehicle use.

Also in January 1997, three subcommittees formed to begin more specific discussion of technical issues of importance to the development of the Action Plan: numeric targets, implementation measures, and restoration. The subcommittees were intended to involve the technical experts from each of the represented groups in focused discussion of the identified topics. The Targets Subcommittee and Implementation Subcommittee developed narrative statements reflecting the course of their discussions. The WAG voted to adopt the recommendations of the Implementation Subcommittee, but found those of the Targets Subcommittee to be inadequately worded. At least one WAG member has since voiced concern about a subset of the recommendations made by the Implementation Subcommittee.

The WAG provided an excellent forum for collecting existing information and discussing its interpretation. The WAG, however, did not produce its own strategy. The Reference Document outlined here is the work of Regional Water Board staff. It includes, where appropriate, the suggestions raised at WAG meetings. And, its development follows consideration of the concerns regarding various subject raised by WAG members.

By October 1997, the last WAG meeting scheduled to discuss the Reference Document was held, (the WAG met a total of 14 times); the subcommittees met approximately 15 times; and the North Coast Regional Water Quality Control Board held 3 public meetings during which the status of the Reference Document and Action Plan was discussed. Since October 1997, several draft documents have been distributed for public review and comment.

Future Opportunities for Public Participation

Regional Water Board staff propose that there be continued public participation in the implementation of the Action Plan. For example, the public will continue to have opportunities associated with Timber Harvest Plan review and the review of other environmental permitting processes in which elements of the Action Plan are being implemented. In addition, Regional Water Board staff propose that the Regional Water Board receive tri-annual updates at its public board meetings on the progress in implementation of the Action Plan. Finally, Regional Water Board staff propose that the Garcia River Watershed WAG continue meeting, at least on a quarterly basis, so as to discuss, review, and consider the implementation of the Action Plan.

Recommendations of the Garcia River Watershed Advisory Group

1. The North Coast Regional Water Quality Control Board should consider making a request of the State Water Resources Control Board that it pursue a Memorandum of Understanding, or other similar agreement, with the Army Corps. of Engineers which identifies a means of streamlining the permitting process for the implementation of restoration projects which have been approved as part of a watershed restoration or enhancement plan.

2. The North Coast Regional Water Quality Control Board should consider making a request of the County of Mendocino that it develop and adopt a County Road and Grading Ordinance and a County Riparian Ordinance to address the issues of erosion, sediment delivery, and riparian health.

3. The North Coast Regional Water Quality Control Board should consider adopting Hagans and Weaver's *Handbook for Forest and Ranch Roads* (1994) as a guidebook for landowners and agencies in developing and implementing road construction, maintenance and obliteration priorities.

4. The North Coast Regional Water Quality Control Board should consider adopting the *Garcia River Watershed Enhancement Plan* (1992) as the guiding plan for restoration activities in the Garcia River basin. Funding for the development of an update to the enhancement plan should be given a high priority as should the funding of restoration projects which complement upslope sediment delivery control activities.

5. The North Coast Regional Water Quality Control Board should consider funding the development of educational outreach programs aimed at conveying to the public the sensitivity of the beneficial uses of the Garcia River basin, including the fishery and recreation, to activities which disturb the stream channel, stream bank, or riparian zone.

D. GENERAL DESCRIPTION OF THE WATERSHED

Introduction

The Garcia River is a watershed of approximately 73,223 acres in Mendocino County which discharges to the Pacific Ocean just north of the city of Point Arena, California. It is a forested watershed consisting of mixed conifer (primarily fir and redwood) and hardwood (primarily tan oak and madrone) forests. A defining feature of the basin is the San Andreas fault which is the principal factor controlling the drainage pattern of the Garcia River watershed, including the Garcia mainstem which follows the San Andreas fault itself for its last 15 miles or so.

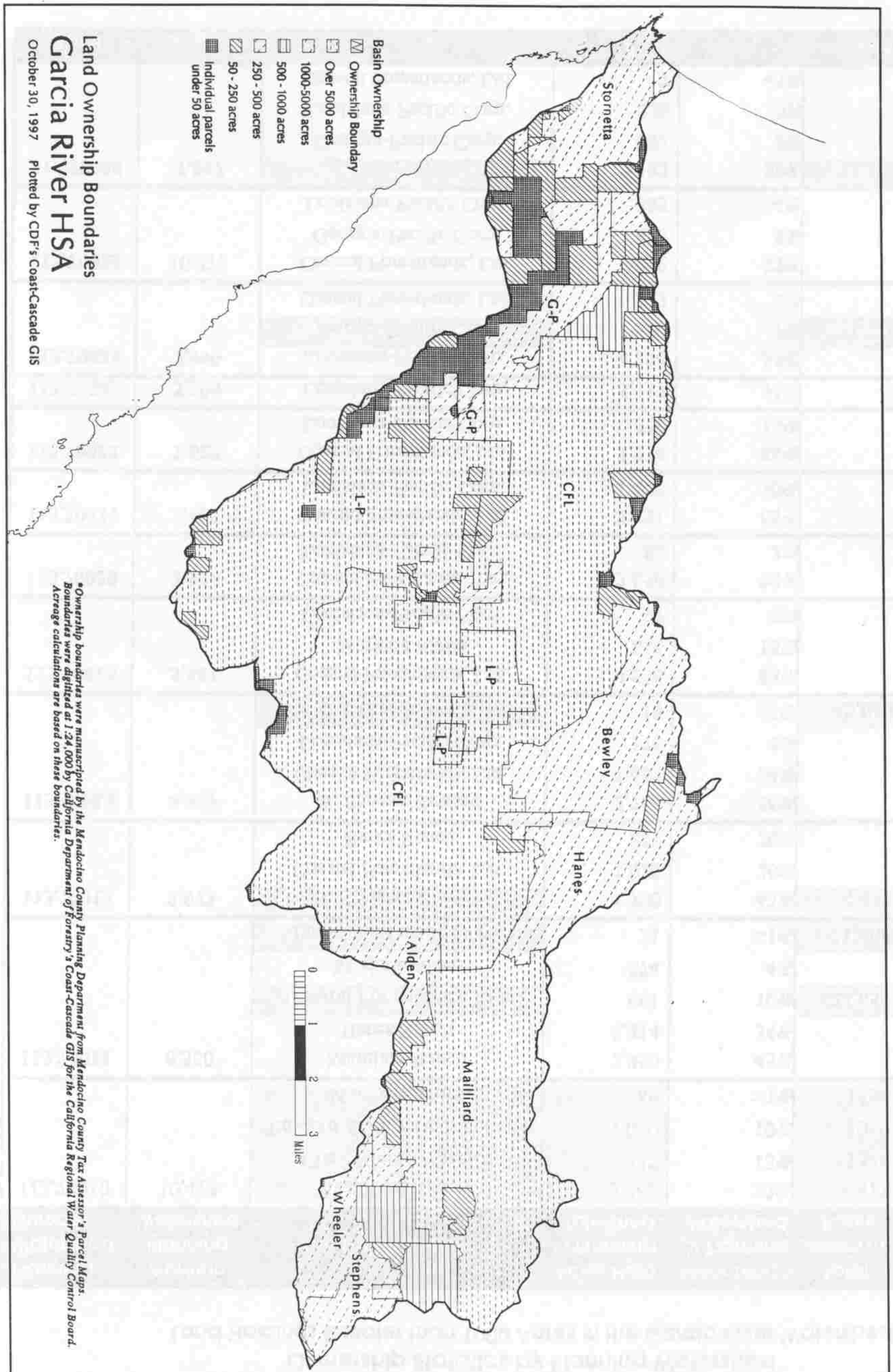
The California Department of Forestry and Fire Protection has divided the basin into 12 separate sub-basins or Cal Water Planning Watersheds (Planning Watersheds). Figure 4 depicts the Garcia River watershed and Planning Watershed boundaries. Figure 5 identifies each of these Planning Watersheds by number, the predominant streams within each Planning Watershed, the names of the predominant landowners in each Planning Watershed, and the number of acres in each Planning Watershed.

Land Use

According to the *Garcia River Watershed Enhancement Plan* (Mendocino County RCD 1992), the Garcia River watershed has undergone two waves of timber cutting and a long history of dairy farming and ranching. The first wave of timber cutting occurred during the late 1800s in which a number of mills and flumes were erected in the Garcia River basin providing building lumber, shingles, and railroad ties, among other commodities. This activity lasted until 1915 when the last of the timber harvesting activities ceased.

The second wave of timber cutting began in the 1950s in response to the post-World War II demand for new housing and as a result of the new logging machinery which allowed for cheaper cutting and transportation. The period of heaviest cutting in the Garcia River watershed was between 1954 and 1961 (Mendocino County RCD 1992), but industrial and non-industrial timber harvesting continues today. Statistics kept since 1987 indicate that 38,363 acres of the 73,223 acre watershed were harvested from 1987 to 1997 (52% of the basin). Forty-two percent of that harvesting occurred in 1988 and 1989. Most of the harvesting in this period occurred on property owned by Coastal Forestlands, Ltd. with additional harvesting on the Georgia-Pacific Corporation, Louisiana-Pacific Corporation, Bewley, Hanes, Alden and Mailliard properties, as well as that of smaller landowners (<1000 acres).

The predominant silvicultural practice utilized during the period from 1987 to 1997 was a shelterwood removal cut (62% of the harvesting). Section 913.1(d) of the 1997 California Forest Practice Rules define shelterwood removal. It states: “The shelterwood regeneration method reproduces a stand via a series of harvests (preparatory, seed and removal). The preparatory step


Land Ownership Boundaries
Garcia River HSA
October 30, 1997 Plotted by CDF's Coast-Cascade GIS
Basin Ownership
Ownership Boundary
Over 5000 acres
1000-5000 acres
500 - 1000 acres
250 - 500 acres
50 - 250 acres
Individual parcels under 50 acres
Stornetta
G-P
L-P
CFL
Bewley
Hanes
Alden
Mailliard
Wheeler
Stephens
0 1 2 3 Miles
*Ownership boundaries were manuscripted by the Mendocino County Planning Department from Mendocino County Tax Assessor's Parcel Maps. Boundaries were digitized at 1:24,000 by California Department of Forestry's Coast-Cascade GIS for the California Regional Water Quality Control Board. Acreage calculations are based on these boundaries.

Ownership Statistics by Planning Watershed
Land Holdings Greater than 1000 Acres in the Garcia River Watershed

Planning Watershed Number	Acres in Planning Watershed	Landowner	Acres Held in Planning Watershed	Percentage of Planning Watershed	Total Acres in Basin	Percentage Held in Basin
113.70010	10,473	Mailliard Ranch	5,462	52%	8,411	11.5%
		Clare Rolph Wheeler	1,345	13%	1345	2%
		Edward & Parletta Stephens	1,050	10%	1050	1%
		Marjorie Alden	89	>1%	1180	2%
113.70011	6,550	Mailliard Ranch	2,950	45%		
		Hanes Ranch	2,214	34%		
		Coastal Forestlands, Ltd.	661	10%	24,659	34%
		Marjorie Alden	274	4%		
		Louisiana-Pacific Corp.	31	>1%	11,668	16%
113.70012	3,972	R. Stewart Bewley	1,700	43%	4,467	6%
		Coastal Forestlands, Ltd.	1,025	26%		
		Hanes Ranch	811	20%		
113.70013	4,929	R. Stewart Bewley	2,768	56%		
		Coastal Forestlands, Ltd.	1,657	34%		
		Louisiana-Pacific Corp.	176	4%		
		Hanes Ranch	18	<1%	3,043	4%
113.70014	5,481	Coastal Forestlands, Ltd.	4,536	83%		
		Marjorie Alden	816	15%		
		Louisiana-Pacific Corp.	97	2%		
113.70020	3,954	Coastal Forestlands, Ltd.	3,859	98%		
		Louisiana-Pacific Corp.	85	2%		
113.70021	3,425	Coastal Forestlands, Ltd.	2,221	65%		
		Louisiana-Pacific Corp.	1,040	30%		
113.70022	2,625	Coastal Forestlands, Ltd.	2,214	84%		
		Louisiana-Pacific Corp.	378	14%		
113.70023	5,595	Louisiana-Pacific Corp.	5,117	91%		
113.70024	7,999	Louisiana-Pacific Corp.	4,374	55%		
		Georgia-Pacific Corp.	549	7%	1,779	2%
		Coastal Forestlands, Ltd.	527	7%		
113.70025	10,373	Coastal Forestlands, Ltd.	7,952	77%		
		Georgia-Pacific Corp.	838	8%		
		Louisiana-Pacific Corp.	385	4%		
113.70026	7,847	Stornetta	2,182	28%	2,182	3%
		Georgia-Pacific Corp.	392	5%		
		Louisiana-Pacific Corp.	236	3%		
		Coastal Forestlands, Ltd.	7	<1%		
Total	73,223				59,784	81.5%

is utilized to improve the crown development, seed production capacity, and wind firmness of designated seed trees. The seed step is utilized to promote natural reproduction from seed. The removal step is utilized when a fully stocked stand of reproduction has become established, and this step includes the removal of the protective overstory trees. The shelterwood regeneration method is normally utilized when some shade canopy is considered desirable for the establishment of regeneration." Eighty-four percent (84%) of the harvesting in this period was conducted using tractor-based yarding methods. Cable yarding was conducted on 15% of the harvested acres.

Before, during, and between the years of timber cutting, the area has supported a diversity of farming and ranching activities. In addition to the development of the estuary for farming, ranching, and dairy, several thousand acres of cut-over timberland was put into range land by 1912. Slashing camps were started, with axe-men cutting all young virgin and second growth trees. In 1915, the White Lumber Company sold all of its holdings, including much of the timbered land in the Point Arena area, and was sold as small ranches and farms (Mendocino County RCD 1992). A similar practice occurred in the 1960s when the County of Mendocino issued permits for land conversions from forest to grazing lands. A total of approximately 7,372 acres in the upper watershed (Planning Watersheds 113.70010 - 113.70013) were permitted for land conversion, 5,268 acres of it formerly timbered. The number of acres of permitted land which was eventually converted is currently unknown.

The Department of Fish and Game conducted a survey of tributaries in the Garcia River in the early 1960s identifying the degree to which individual sub-basins were damaged by land use activities. Their findings were published in 1966 as *Stream Damage Surveys - 1966.* The Department of Fish and Game concluded that out of 104 miles of stream surveyed in the Garcia River watershed, 37 miles were severely damaged (36%), 15 miles were moderately damaged (14%), 37 miles were lightly damaged (36%), and 15 miles were undamaged (14%).

Land ownership is predominated by industrial timber companies who own a total of 52% of the basin. Seven large family holdings account for another 29.5% of the basin in parcels ranging from 1-11.5% of the basin in size. The remaining 18.5% is shared by about 76 other private owners, two Rancherias, one Air Force Radar Station, and a State Forest Reserve. (See the Ownership Statistics by Planning Watershed, Land Holdings Greater than 1000 Acres in the Garcia River Watershed and the Land Ownership Boundaries map).

Geology

The geology of the basin is described by the California Department of Conservation, Division of Mines and Geology on three USGS quadrangles entitled "Geology and Geomorphic Features related to Landsliding." The maps were compiled primarily through aerial photo interpretation and cover the Point Arena, Eureka Hill, and Gualala USGS quads.

According to the Division of Mines and Geology maps, the San Andreas fault follows a path along the North Fork of the Gualala River over the ridge into the Garcia River basin, along the South Fork Garcia River, through the mainstem of the Garcia River, and over the ridge into the Brush Creek basin before going off shore just north of the Manchester Beach State Park.

The geologic material to the northeast of the San Andreas Fault primarily consists of Coastal Belt Franciscan with periodic outcrops of Franciscan Melange and potential Ohlson Ranch Formation. The Coastal Belt Franciscan is from the Tertiary-Cretaceous period and consists of well consolidated, hard sandstone interbedded with small amounts of siltstone, mudstone, and conglomerate. It is pervasively sheared, commonly highly weathered, and tends to easily disaggregate, resulting in numerous debris slides along creeks and roads within debris slide amphitheaters/slopes.

The Franciscan Melange is a pervasively sheared sandstone and mudstone with minor amounts of conglomerate resulting from regional tectonic movement. Failures occur on slopes more gentle than those in more competent units elsewhere, generally by shallow debris slides along roads and creeks, and by deeper-seated failures elsewhere. The Franciscan Melange includes exotic outcrops of limestone, chert, serpentine, and greenstone.

The Ohlson Ranch Formation is from the Pliocene and consists of semi-consolidated marine nearshore deposits of silt, sand and gravel lying unconformably over Franciscan rocks.

The geologic material to the southwest of the San Andreas Fault primarily consists of Marine Terrace Deposits with periodic outcrops of German Rancho Formation, Galloway-Schooner Gulch formation, and Monterey Group. The Marine Terrace Deposits are from the Quaternary period and consist of poorly to moderately consolidated deposits of marine silts, sands, and quartz-rich pea gravels forming extensive flat benches paralleling the coastline. These units are probably much more extensive than currently mapped in part because in many places they are overlain by unconsolidated alluvial fan/colluvial deposits.

The German Rancho Formation is from the Paleocene-Eocene period and consists of consolidated, moderately hard, coarse-grained sandstone interbedded with minor mudstone and less common conglomerate. It is overlain in many places by undifferentiated marine terrace sands and is highly sheared and colluvial in appearance near the San Andreas fault system.

The Galloway-Schooner Gulch formation is from the Miocene and consists of moderately consolidated sandstone. The Monterey Group is also from the Miocene and consists of well consolidated brown to white porcelaneous shale and siltstone overlain by consolidated sandstone, siltstone and sandy mudstone. It contains dolomitic concretions and asphaltic sands.

The geology of the upper and mid-upper watershed is not very well represented by the current data.

Soil/Vegetation Regions

The soils of the Garcia River watershed have been surveyed by the Natural Resource Conservation Service, formerly the Soil Conservation Service. Personnel at the Natural Resource Conservation Service have categorized the soil types found in the Garcia River watershed based on the vegetation that each soil supports. The vegetation types include: cropland, former redwood habitat converted to cropland or pasture, coastal prairie/scrub, mixed evergreen, redwood forest, northern seashore, coastal cypress/pine, chaparral, oak woodland/grassland, pits and dumps, riverwash, urban, and other land uses.

The upper watershed (Planning Watersheds 113.70010 - 113.700 13) is comprised of a mixture of oak woodland/grassland, chaparral, mixed evergreen, and redwood forest soils. The mid-upper watershed (Planning Watersheds 113.77014 - 113.70022) is predominated by redwood forest soils, but includes some oak woodland/grassland and chaparral soils, as well. The mid watershed (Planning Watershed 113.70023 - 113.70025) is similarly predominated by redwood forest soils, but includes converted redwood, coastal cypress/pine, riverwash, and other soils. The lower watershed (Planning Watershed 113.70026) is predominated by cropland soils, but includes coastal prairie/scrub, coastal cypress/pine, northern seashore, redwood, converted redwood, and riverwash soils.

The soil types represented in the watershed overall predominantly support redwood forest (> 50%), followed by mixed evergreen and oak woodland/grassland complexes.

Hydrology

Drainage Area

1. *Stream densities*

The California Department of Forestry and Fire Protection (CDF) has developed a Geographic Information System (GIS) for the Garcia River which primarily contains information culled from 10 years of Timber Harvest Plans (THPs). One of the data layers contained in the Garcia River GIS are stream densities per Planning Watershed divided into stream classes, as defined by the Forest Practice Rules. Figure 6 summarizes the stream density information.

Figure 6: Summary of the total miles of stream in each Planning Watershed from CDF's GIS for the Garcia River watershed based on ten years of THPs from 1987 to 1997 and USGS data. Shaded boxes represent > average values.

Planning Watershed	Predominant Stream	Square miles	Class I (mi/mi^2)	Class II (mi/mi^2)	Class III (mi/mi^2)	Unclassified Perennial (mi/mi^2)	Unclassified Intermittent (mi/mi^2)
113.70010	Pardaloe	16.36	0.47	0.33	2.29	0.19	1.83
113.70011	Larmour	10.23	0.50	0.80	1.71	0.48	0.99
113.70012	Stansbury	6.21	1.03	1.23	4.22	0.00	0.00
113.70013	Blue Waterhole	7.70	0.67	0.96	2.47	0.58	0.14
113.70014	Inman	8.56	0.88	1.86	6.56	0.00	0.00
113.70020	Signal	6.18	0.84	1.48	4.35	0.00	0.12
113.70021	Graphite	5.35	1.01	1.65	4.45	0.00	0.00
113.70022	Beebe	4.10	0.74	2.42	3.13	0.00	0.00
113.70023	South Fork	8.74	0.35	0.26	0.51	0.85	0.63
113.70024	Rolling Brook	12.50	0.53	0.71	1.23	0.32	0.33
113.70025	North Fork	16.21	0.76	1.82	3.94	0.03	0.00
113.70026	Hathaway	12.26	0.28	0.86	1.00	0.45	0.19
113.700	Garcia basin	114.40	0.67	1.20	2.99	0.24	0.35

Based on this data, the highest densities (> average) of Class I and Class II streams (providing aquatic habitat) and unclassified perennial streams are found in the following order of priority: Planning Watershed 113.70022 (Beebe Creek sub-basin), Planning Watershed 113.70014 (Inman Creek sub-basin), Planning Watershed 113.70021 (Graphite Creek sub-basin), Planning Watershed 113.70025 (North Fork sub-basin), Planning Watershed 113.70020 (Signal Creek sub-basin), Planning Watershed 113.70012 (Stansbury Creek sub-basin), and Planning Watershed 113.70013 (Blue Waterhole Creek sub-basin). These are the Planning Watersheds, according to the Registered Professional Foresters who submitted THPs, that have the greatest density of aquatic habitat suitable for fish.

2. *Flows*

Flows for the Garcia River watershed are reported by Philip Williams & Associates, Ltd. in the *Garcia River Gravel Management Plan* (1996). Flows for the basin were measured at the USGS gaging station 11467600 located at Connor Hole about 0.9 miles west of the North Fork Garcia River. Hydrologic data was collected from 1962 to 1983 (and with a crest gage from 1952 to 1956). The bankfull flow at this location was estimated at 14,000 cfs. A rough estimate of bankfull flows in each Planning Watershed is given based on the percent area above Connor Hole represented by the drainage area of each sub-basin. Figure 7 provides a summary of the estimated bankfull flows associated with each Planning Watershed and some individual tributary systems.

Figure 7: Summary of estimated bankfull flows associated with each Planning Watershed and some individual tributary systems from CDF's GIS for the Garcia River watershed and USGS data collected at Connor Hole

Planning Watershed	Drainage Area (acres)	Estimated Bankfull Discharge (cfs)
113.70010	10,473	2,335
Pardaloe Creek	5,634	1,256
Mill Creek (upper watershed)	4,839	1,079
113.70011	17,023	3,796
Larmour Creek	1,595	1,079
113.70012	20,995	4,682
Whitlow Creek	1,222	272
113.70013	25,924	5,781
Blue Waterhole Creek	4,750	1,059
113.70014-- Inman Creek	5,481	1,222
113.70020-- Signal Creek	3,954	882
113.70021	38,784	8,648
113.70022	41,409	9,233
113.70023	47,004	10,481
South Fork Garcia	2,791	622
113.70024	55,003	12,265
Rolling Brook	1,695	378
113.70025	65,376	Unknown
Above USGS Gaging Station @ Connor Hole	62,786	14,000
North Fork Garcia	6,548	1,460
113.70026	73,223	Unknown

The slower moving stream segments may be most suitable for salmonids, particularly coho salmon which prefer slower moving water. In addition, the bankfull flow estimates can be used to test whether or not the channel configuration of individual tributaries or Planning Watersheds is sufficient to carry the estimated bankfull flow. It is important to keep in mind, however, that the bankfull flow estimates have not been corrected for rainfall, elevation, or soil/vegetation differences among Planning Watersheds.

3. *Diversions*

Water diversions are recorded by Fugro West in the *Gualala Aggregates Sand and Gravel Project DEIR* (1994). In all, there are eleven owners permitted to divert water from the Garcia River watershed. A maximum of 6.33 cfs of diverted flow is permitted from surface water flow and a maximum of 0.22 cfs of diverted flow is permitted from underflow to the Garcia River. The City of Point Arena receives its drinking water from the 0.22 cfs of diverted underflow. None of the City's drinking water comes from surface flows from the Garcia River and thus the MUN beneficial use is listed as "potential." The estimate of underflow diversions does not include underflow which is diverted by the two Rancherias bordering the Garcia River. Five of the permittees primarily divert water from the river during the period of April 1st through October 31st. The other permittees are allowed to divert water on a year-round basis.

Precipitation

Average annual rainfall in the Garcia River watershed is reported by the Fire Resource Assessment Program of the California Department of Forestry and Fire Protection and is contained in a Geographic Information System maintained by CDF. This data source reports that the average annual rainfall for the watershed ranges from 45.0 inches near the coast to 75.0 inches farther inland. Figure 8 depicts the average annual rainfall across the Garcia River watershed.

The maximum precipitation for indicated durations is reported by the Department of Water Resources in *Rainfall Analysis for Drainage Design Volume II-- Long-Duration Precipitation Frequency Data*, Bulletin No. 195, October 1976. Predictions are given for Point Arena at the estuary and Yorkville near the headwaters. The annual rainfall expected with a 2-year recurrence interval is 39.10 inches in Point Arena and 48.84 inches in Yorkville. The annual rainfall expected with a 50-year recurrence interval is 63.94 inches in Point Arena and 79.87 inches in Yorkville. The annual rainfall expected with a 100-year recurrence interval is 67.71 inches in Point Arena and 84.59 inches in Yorkville.

Monthly precipitation data from the City of Point Arena (1939 -1988), from the Point Arena Lighthouse (1902 - 1941), and from Manchester H.M.S. (1965-1986) indicates that, on the average, rainfall peaks in the month of January with 7.86, 8.00 and 8.85 inches, respectively. Figure 9 summarizes the annual precipitation data from these locations.

The rainfall data generally indicates that rainfall is up to nearly 90% greater in the headwaters region than along the coast and that the year's rainfall generally falls between October and April with the highest rainfall occurring in January.

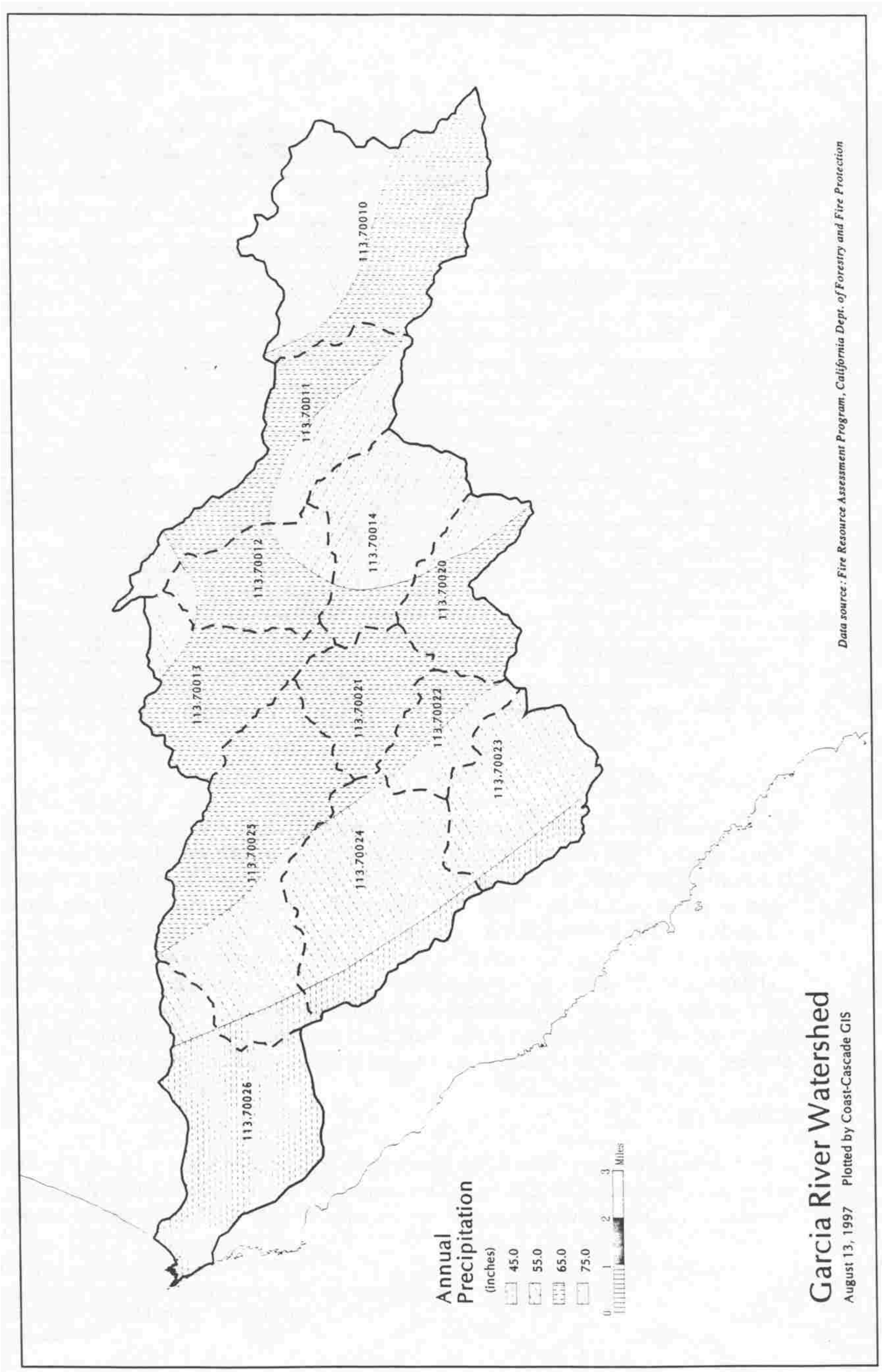
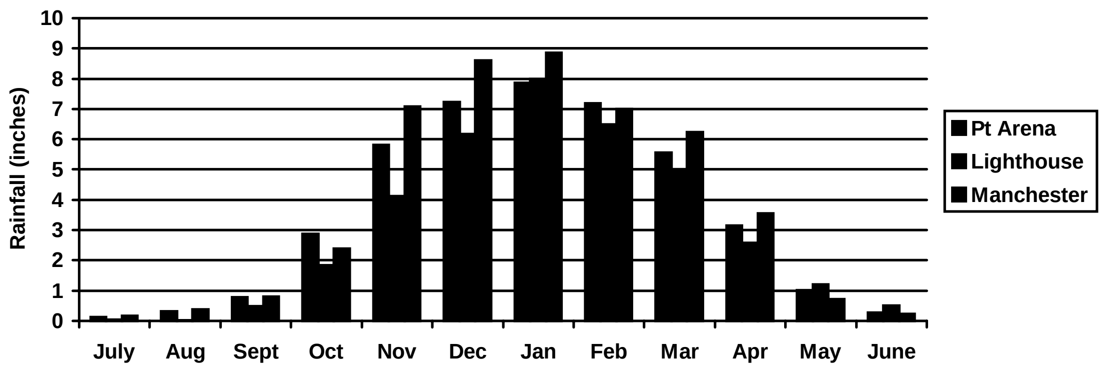

113.70010
113.70011
113.70012
113.70014
113.70020
113.70013
113.70021
113.70022
113.70023
113.70025
113.70024
113.70026
Annual Precipitation
(inches)
45.0
55.0
65.0
75.0
0 1 2 3 Miles
Garcia River Watershed
August 13, 1997 Plotted by Coast-Cascade GIS
Data source: Fire Resource Assessment Program, California Dept. of Forestry and Fire Protection

Figure 9: Average annual rainfall distribution (inches) in the vicinity of the Garcia River estuary.



<u>Flooding</u>

Peak flow data is reported by Philip Williams & Associates, Ltd. in the *Garcia River Gravel Management Plan* (1996). Data is compiled from the USGS gaging station at Connor Hole located about 0.9 miles west of the North Fork Garcia River. It was operated by USGS from 1952 to 1983. Friends of the Garcia has been operating it in recent years.

Graham Matthews and Associates in a letter to the Mendocino County Planning Commission dated January 31, 1991 correlated peak flows in the nearby Navarro River basin with those of the Garcia River basin to extend the flow record of the Garcia River. From the extended flow record, Philip Williams and Associates, Ltd. reported the following flood frequencies for the Garcia. Figure 10 summarizes the flood frequencies.

Figure 10: Flood frequencies at the USGS gaging station in the Garcia River at Connor Hole.

Recurrence Interval (years)	**Discharge (cfs)**
2	14,000
5	21,400
10	26,000
20	29,700
50	36,000
100	40,100

Figure 11 summarizes the peak flow discharges recorded at the USGS gaging station on the Garcia River at Connor Hole.

Figure 11: Summary of peak flow discharges in the Garcia River watershed at the USGS gaging station at Connor Hole.

Date	USGS Gaging Station 11467600-- Garcia River near Point Arena (cfs)	Estimated recurrence (years)
1952	19,400	2-5
1955	26,300	10-20
1963	23,900	5-10
1964	26,100	10-20
1966	28,700	10-20
1969	20,800	2-5
1970	26,600	10-20
1973	19,300	2-5
1974	30,300	20-50
1986	28,038	10-20
1993	20,350*	2-5
1995	37,000*	50-100

* Friends of the Garcia data

Notable from this data set is that the 1964 flood had a recurrence interval on the Garcia River of somewhere between 10 and 20 years whereas the 1995 flood had a recurrence interval of 50 to 100 years. A stream channel opening analysis summarized in the Problem Statement section identifies an increase in stream channel opening since 1952 but a significant recovery since 1966, indicating that though a much larger event, the 1995 storm had a less significant impact on stream channel widening than did the 1966 storm.

Summary

In summary, the Garcia River watershed is a 73,223 acre basin in Mendocino County which has had a long history of timber harvesting and agriculture. These activities continue today. The basin is composed primarily of Franciscan Complex geology and is controlled in large part by the San Andreas Fault Zone. The predominant soils in the basin support redwood forest, as well as mixed evergreen, oak woodland/grassland, chaparral, and other types of vegetation. Bankfull flows in the lower river are approximately 14,000 cfs while 50 year storm events exceed 36,000 cfs and 100 storm events exceed 40,000 cfs. Since 1952 there has been only one storm with a recurrence interval greater than 50 years, that being in 1995. Rainfall in the basin ranges from an average of 45 inches per year in the lower watershed to 75 inches per year in the upper watershed. Rainfall predominantly occurs between the months of October and April with the largest proportion of it falling in January.

I. PROBLEM STATEMENT

Introduction

The Problem Statement section summarizes the existing information relevant to a general understanding of the Garcia River watershed and the condition of its fishery. The existing information is relatively voluminous; but nonetheless does not specifically and comprehensively describe the conditions in individual tributaries. A general understanding of the condition of the watershed, however, can be ascertained by viewing in total the information which exists, and on a limited basis, comparing the existing information to the numeric targets described in the Numeric Targets section. Future evaluation of the condition the watershed will require more comprehensive instream data and many more years of record. The Problem Statement section concludes with a series of succinct problem statements which summarize the fishery-related problems which are associated with sediment and sedimentation.

Information describing the upland condition can be found in the Source Analysis section of the Reference Document. A synthesis of the instream and upland data can be found in the Load Capacity Calculation section.

Channel Morphology

Slope

Channel slopes were calculated by GIS by overlapping hypsography (topographic lines) with hydrography (streams). The entire mainstem from the headwaters to the estuary has a gradient ranging from 0-3%. Similarly, several larger tributaries also have relatively low gradients, including: Pardaloe Creek, Mill Creek (in the upper watershed), the lower end of Blue Waterhole Creek, the lower end of Whitlow Creek, much of Inman Creek, several stretches of Signal Creek, several stretches of the South Fork Garcia, several stretches of the North Fork Garcia and Hathaway Creek. These are the stream segments which have the greatest potential to provide salmonid habitat, particularly for coho which prefer slower moving stream segments. Many of the smaller tributaries are steeper in gradient ranging up to greater than 20%. There is suitable steelhead habitat in many of these moderate to steep regions.

Substrate Composition

The California Department of Fish and Game, as part of its fish population surveying, estimated the amount of material in each sediment size class across the substrate surface of each survey reach. The survey reaches are relatively short (approximately 100 meters) and do not comprehensively cover the whole watershed. However, the Fish and Game data provides a snap shot of conditions in various reaches. Figure 12 summarizes these estimates.

Figure 12: Estimates of substrate composition from Department of Fish and Game Stream Surveys

Planning Watershed	**Stream**	**Date**	**%Clay**	**%Silt**	**%Sand**	**%Grvl**	**%Rbbl**	**%Bldr**	**%Bdrk**
113.70010	Mill	06/24/94	0	2	5	90	1	1	1
	Pardaloe	06/24/94	0	1	10	30	45	15	0
113.70011	None								
113.70012	None								
113.70013	Blue Waterhole	08/20/87	0	1	2	37	10	50	0
113.70014	None								
113.70020	Signal	08/19/87	0	0	1	13	42	40	2
		11/06/95	0	5	3	25	55	10	2
113.70021	None								
113.70022	None								
113.70023	South Fork	08/17/87	0	0	1	74	25	0	0
		10/13/88	0	1	3	26	70	0	0
		10/19/89	10	0	5	50	30	65	0
		10/08/91	0	0	2	67	30	1	0
		10/06/92	0	0	2	30	68	0	0
	Fleming	08/17/87	0						0
		10/13/88	0	1	2	95	2	0	0
		10/19/89	0	0	10	50	40	0	0
		11/09/90	5	5	1	64	30	0	0
		10/08/91	0	0	2	92	5	1	0
113.70024	Rolling Brook	08/18/87	0	1	1	85	10	3	0
	Lee	10/19/89	0	0	2	18	60	10	0
113.70025	North Fork	10/27/83	0	20	5	45	30	0	0
113.70026	Hathaway	09/25/86	0	100	0	0	0	0	0
	Garcia	08/18/87	0	0	70	28	2	0	0
		08/20/87	0	1	25	54	5	10	0
		11/11/87	0	1	18	80	1	0	0

With the exceptions of Hathaway Creek and the North Fork Garcia which were found to have high levels of silt (>15%), the Garcia River mainstem which was found to have high levels of sand (>15%), and Signal Creek and an unnamed tributary which were found to have high levels of boulders (>40%), most of the stream reaches surveyed by the Department of Fish and Game had predominantly gravel and rubble substrates. The data also indicates that the particle size distribution has fluctuated, dramatically in some sub-basins, over time.

Instantaneous measurements of the composition of the channel substrate have been collected in various tributaries by the 3 industrial timber owners and 1 of the non-industrial timber owners. Several sampling locations have been monitored once per year for several years. Figure 13 summarizes the existing McNeil data.

Figure 13: 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.

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. In none of the stream surveyed were fines < 6.5 mm optimum for successful incubation.

Contractors to the Resource Conservation District through the *Garcia River Watershed Enhancement Plan* (1992) estimated dominant particle sizes and pool tail embeddedness at one point in time in several sub-basins. Their data indicates that the North Fork Garcia sub-basin, more than half of the surveyed area had potential spawning gravels which were more than 50% embedded. In the Pardaloe and Mill Creek sub-basins, 36% and 33% of the sub-basins respectively, had potential spawning gravels which were more than 50% embedded. The lower river simply lacked potential spawning gravels. Figure 14 summarizes the substrate data collected as part of the habitat typing conducted by the Mendocino County Resource Conservation District.

Figure 14: Summary of substrate data collected as part of the habitat typing conducted by the Mendocino County Resource Conservation District (1991)

	Estuary (113.70026)	**North Fork Garcia (113.70025)**	**Pardaloe Creek (113.70010)**	**Mill Creek (113.70010)**
Channel length (feet)	2,820	20,199	20,224	601
Dominant bank substrate	silt/clay/sand	boulder	bedrock	cobble/gravel
Embeddedness value 1 (%)	20	6	10	33
Embeddedness value 2 (%)	80	33	53	33
Embeddedness value 3 (%)	0	29	30	33
Embeddedness value 4 (%)	0	32	6	0

The Regional Water Board sponsored a study of North Coast streams from which to develop testing indices for cold water fish habitat. *The Testing Indices of Cold Water Fish Habitat* (Knopp, 1993) involved measuring a variety of parameters in disturbed and undisturbed basins. Blue Waterhole Creek in the Garcia River watershed was one of the basins included in this study. The d_{50} values measured in Blue Waterhole Creek were 55.3 mm and the V* values measured were 0.40.

Stream Channel Opening

Pacific Watershed Associates reviewed the 1952, 1966 and 1996 aerial photographs for the Garcia River watershed and conducted a modified RAPID analysis (Grant, 1988) to document channel conditions. The modified RAPID analysis involves measuring the linear distance of open stream channels on aerial photographs. In the work conducted by Pacific Watershed Associates, stream channel reaches which displayed enlarged channel widths and open stream channels were interpreted as "response reaches" of stream channels which were affected by influxes of sediment. Open stream channels are channels which are wide enough that riparian vegetation no longer covers them and they are therefore visible on aerial photographs.

The data indicates that with the exception of the Pardaloe Creek/Mill Creek and the Hathaway Creek Watershed, the length of open stream which existed in 1952 was substantially increased due to stream channel widening and/or stream bank instability by 1966. Since 1966, however, that trend has reversed and the extent of stream channel opening has begun to recover. In the Pardaloe Creek/Mill Creek Planning Watershed (113.70010), the extent of stream channel opening actually improved between the years of 1952 and 1966, unlike the rest of the basin. But, since 1966, stream channel opening has been increased beyond the 1952 levels. The Hathaway Creek Planning Watershed (133.70026) has shown 0% stream channel opening in all but the Garcia River mainstem since 1952.

The Planning Watersheds which have recovered or more than recovered their 1952 stream channel opening status include: Blue Waterhole Creek (113.70013) and Inman Creek (113.70014). Stansbury/Whitlow Creeks (113.70012) have nearly recovered (within 25%) of their 1952 stream channel opening status. Graphite Creek (113.20021), Beebe Creek (113.70022), South Fork Garcia (113.70023), and Rolling Brook (113.70024) Planning Watersheds are in the process of recovery (within 100% of their 1952 status). But, Larmour Creek (113.70011), Pardaloe Creek (113.70010), and the North Fork Garcia (113.70025) still have more than twice the amount of open stream channel than existed in those Planning Watersheds in 1952.

In assessing this data and the degree of recovery, it's important to note that while not yet extensive throughout the basin, there were timber harvesting and other land clearing operations underway prior to 1952. The 1952 aerial photographs indicate activity in the Pardaloe/Mill Creek (113.70010), Larmour Creek (113.70011), Stansbury/Whitlow Creeks (113.70012), Blue Waterhole Creek (113.70013), Inman Creek (113.70014), Signal Creek (113.70020), Rolling Brook (113.70024), and North Fork Garcia (113.70025) Planning Watersheds with the most extensive activity observed in Whitlow Creek and Blue Waterhole Creek. As above, both the Stansbury/Whitlow Creeks and Blue Waterhole Creek Planning Watersheds have shown substantial stream channel opening recovery as compared to measurements taken from 1952 aerial photographs. But the miles of open stream measured in each of these Planning Watersheds in 1952 is more than twice that which was measured in the Pardaloe Creek/Mill Creek and Larmour Creek Planning Watersheds, the other upper watershed sub-basins.

Aquatic Habitat

Habitat Types and Distribution

As part of the *Garcia River Watershed Enhancement Plan* (1992), habitat typing data was collected in the estuary, the lower 7 miles of the mainstem Garcia, the North Fork, Pardaloe Creek and Mill Creek. This data was collected using the Flosi and Reynold's protocol for habitat typing. Figure 15 summarizes the findings.

Of the stream segments surveyed, the data generally indicates that pool depth is adequate for salmonid rearing in the lower reaches of the watershed, but not in any of the other surveyed sub-basins. Similarly, the ratio of pools to riffles is optimum for salmonid rearing only in the lower watershed. The data also indicates that canopy density, particularly that which is attributable to coniferous tree species, is low in each of the surveyed sub-basins with the potential exception of the Mill Creek sub-basin. Canopy density is indirectly related to stream bank stability and large woody debris recruitment. And, in fact, the occurrence of large woody debris was rated quite low in each of the surveyed reaches, again with the possible exception of the Mill Creek sub-basin.

Figure 15: Summary of fish habitat data collected as part of the habitat typing conducted by the Mendocino County Resource Conservation District, 1991.

Parameters	Estuary (113.70026)	North Fork Garcia (113.70025)	Pardaloe Creek (113.70010)	Mill Creek (113.70010)
Channel type (Rosgen)	?	?	?	B3
Channel length (feet)	2,820	20,199	20,224	601
Riffle/flatwater mean width (feet)	49.0	17.1	10.0	17.8
Total pool mean depth (feet)	3.5	1.2	0.9	1.6
Base flow (cfs)	0.0	1.0	0.0	0.0
Water temperature (F)	65-65	57-60	00-72	56-56
Air temperature (F)	62-62	51-71	00-85	75-75
Dominant bank vegetation	deciduous trees	deciduous trees	deciduous trees	grass
Vegetative cover (%)	79	44	31	63
Dominant bank substrate	silt/clay/sand	boulder	Bedrock	cobble/gravel
Canopy density (%)	13	48	18	71
Coniferous component (%)	0	9	15	41
Deciduous component (%)	100	91	86	59
Pools by stream length (%)	56	29	32	24
Pool >=3’ deep (%)	100	29	18	67
Mean pool shelter rating	32	92	48	50
Dominant shelter	terrestrial vegetation	boulders	Boulders	boulders
Occurrence of LWD (%)	3	8	5	26
Dry channel (Feet)	0	0	110	0
Length of stream section not surveyed within survey reach (feet)	0	0	0	0
Embeddedness value 1 (%)	20	6	10	33
Embeddedness value 2 (%)	80	33	53	33
Embeddedness value 3 (%)	0	29	30	33
Embeddedness value 4 (%)	0	32	6	0

In addition to the Resource Conservation District data, the Department of Fish and Game, as part of its fish population surveying in the Garcia basin, also estimated the percent of the study area in pools, riffles and runs. Figure 16 summarizes the data collected by the Department. The data indicates that with the exception of Signal Creek, the ratio of pools to riffles is less than optimum for salmonid rearing.

Figure 16: 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				

Planning Watershed	Stream	Date	Pools (%)	Riffles (%)	Runs (%)
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

Instream Cover

As part of its fish population surveying in the Garcia basin, the California Department of Fish and Game rated the value of individual cover components within its study reaches. Rated cover components included: turbulence, instream objects, undercut banks, and overhanging vegetation. Figure 17 summarizes the Department's data.

Figure 17: Summary of instream cover ratings from the Department of Fish and Game Stream Surveys. NM=Not measured.

Planning Watershed	Stream	Date	Turbulence Rating	Instream Object Rating	Undercut Bank Rating	Overhang Vegetation Rating
113.70010	Mill	06/24/94	5	30	2	30
	Pardaloe	06/24/94	60	80	0	30
113.70011	None					
113.70012	None					
113.70013	Blue Waterhole	08/20/87	35	40	0	0
113.70014	None					
113.70020	Signal	08/19/87	70	90	2	5
		11/06/95	15	60	30	10
113.70021	None					
113.70022	None					
113.70023	South Fork	08/17/87	30	25	0	0
		10/13/88	15	80	0	0
		10/19/89	50	30	20	1
		10/08/91	5	50	1	1
		10/06/92	60	60	15	5
	Fleming	08/17/87	30	30	15	1
		10/13/88	15	25	10	2

Planning Watershed	Stream	Date	Turbulence Rating	Instream Object Rating	Undercut Bank Rating	Overhang Vegetation Rating
		10/19/89	50	35	5	15
		11/09/90	30	60	20	10
		10/08/91	40	60	20	5
113.70024	Rolling Brook	08/18/87	20	70	5	1
	Lee	10/19/89	40	50	5	1
113.70025	North Fork	10/27/83	NM	NM	NM	NM
113.70026	Hathaway	09/25/86	5	30	5	80
	Garcia	08/18/87	3	5	40	50
		08/20/87	5	10	0	0
		11/11/87	5	1	1	15

According to Flosi and Reynolds (1994), instream shelter within each habitat unit can be rated according to a standard system. This rating system is a field procedure for habitat inventories which utilizes objective field measurements. It is intended to rate, for each habitat unit, the complexity of shelter that serves as instream cover or that creates areas of diverse velocities which are focal points for salmonids. In this rating system, instream shelter is composed of those elements within a stream channel that provide protection from predation for salmonids, areas of reduced water velocities in which fish can rest and conserve energy, and separation between territorial units to reduce density related competition. Complexity is rated 0-3 based on the number of individual cover types and combinations of cover types. Percent cover is an estimate from an overhead view of the areas of the habitat unit, occupied by instream shelter.

With few exceptions, this data generally indicates that undercut banks and overhanging vegetation are poorly developed cover components in those stream reaches surveyed. This finding suggests that stream banks may not be optimally vegetated with tree and shrub species and, as a result, banks may not be adequately protected from stream bank erosion.

Barriers

Historic barriers to salmonid migration include a bedrock waterfall on the mainstem Garcia River in Planning Watershed 113.70014 which was blown up by the Department of Fish and Game in the 1960s. The waterfall formed an effective barrier to the anadromous fishery until that time. Instream roads, landings, skid trails, slash and other logging debris were also documented by the Department of Fish and Game as effective barriers to anadromous fish migration in the 1960s. Debris removal projects sponsored by the Department of Fish and Game since then have effectively removed those barriers, with few exceptions.

Current barriers to anadromous fish migration include sediment deltas at the mouths of several tributaries and aggraded reaches of stream which dewater during summer months. Sediment deltas were reported by members of the Garcia WAG in tributaries in Planning Watersheds 113.70022, 113.70023 and 113.70024. An aggraded reach of stream which dewaters during summer months was reported in the North Fork Garcia River. Flow conditions which are too low during summer months and which occasionally serve to trap juvenile salmonids were reported throughout the mainstem Garcia River.

Population Composition and Distribution

1. *Live Population Surveys*

Anecdotal evidence provided by members and participants in the Garcia River Watershed Advisory Group process indicates that coho salmon and steelhead were once regular and abundant visitors to the Garcia River watershed (*Monetary Estimates for Anadromous Fisheries Value of the Garcia River – Appeal No. 227-79*, California State Coastal Commission, 1979). The Department of Fish and Game estimated in 1960 that there were 2000 coho and 4000 steelhead spawning in the basin. By the 1970s, Fish and Game creel census data tallied the steelhead catch in the 100-200 fish per year range and the coho catch in the 0-20 fish per year range (op. cite). Zero to two King salmon per year were also reported in the 1970s creel census.

Beginning in 1983 through the present, the California Department of Fish and Game has collected fish population data in many streams throughout the basin by electrofishing (the taking of fish by a system based on their tendency to respond positively to a source of direct electric current) stream reaches of approximately 100 meters (*Biosample Database. Modified by North Central District Resource Assessment*, California Department of Fish and Game, 1996). Figure 18 summarizes the Department's data.

Figure 18: Summary of fish population data from the Department of Fish and Game Stream Surveys

Planning Watershed	**Stream**	**Date**	**Steelhead density (fish/m^2)**	**Steelhead biomass (kg/hectare)**	**Coho density (fish/m^2)**	**Coho biomass (kg/hectare)**
113.70010	Mill	06/24/94	1.31	22.33		
	Pardaloe	06/24/94	1.78	53.87		
113.70011	None					
113.70012	None					
113.70013	Blue Waterhole	08/20/87	0.84	50.05		
113.70014	None					
113.70020	Signal	08/19/87	1.3	109.09		
		11/06/95	1.73	69.44		
113.70021	None					
113.70022	None					
113.70023	South Fork	08/17/87	1.05	23.20	0.12	3.48
		10/13/88	0.51	16.37	0.52	19.88
		10/19/89	0.65	27.28		
		10/08/91	0.85	28.74		
		10/06/92	0.57	20.71		
	Fleming	08/17/87	1.54	37.11		
		10/13/88	0.22	10.35	0.50	19.65
		10/19/89	0.57	24.62		
		11/09/90	0.32	21.80		
		10/08/91	0.10	5.68		

Planning Watershed	Stream	Date	Steelhead density (fish/m^2)	Steelhead biomass (kg/hectare)	Coho density (fish/m^2)	Coho biomass (kg/hectare)
113.70024	Rolling Brook	08/18/87	3.47	76.94		
	Lee	10/19/89	0.31	20.39		
113.70025	North Fork	10/27/83	2.19	194.66		
113.70026	Hathaway	09/25/86				
	Garcia	08/18/87				
		08/20/87				
		11/11/87	0.52	48.72		

Source: *Biosample Database. Modified by North Central District Resource Assessment*, California Department of Fish and Game, 1996.

According to the data, the highest steelhead densities (> average) have been found in the North Fork Garcia, Signal Creek, Rolling Brook, Pardaloe, Blue Waterhole Creek, and the lower Garcia River. The highest coho densities have been found in the South Fork Garcia and Fleming Creek.

One should keep in mind when evaluating this data that the Department of Fish and Game planted coho salmon in the Garcia River and various tributaries during the late 1970s and early 1980s. Coho were planted in the Garcia River at the Highway 1 bridge or Eureka Hill bridge in 1978, 1981, 1982, 1983, and 1985. They were planted in Hutton Gulch at a rearing facility operated by Save Our Salmon in 1978, 1980, 1981, and 1982. They were planted in the South Fork Garcia River in 1988. One can assume that at least some portion of the coho collected in the South Fork Garcia and Fleming Creek in 1988, for example, were those planted by the Department.

As part of its annual spawning survey, the Salmon Trollers Association have noted the number of live adult fish it observes. Live coho were seen in Signal Creek and the South Fork Garcia in 1996-97. One to three coho were also seen in 1992 in a small tributary in the lower watershed after a spill of bentonite which occurred during the installation of fiber optic cable by contractors to AT&T. A consultant to Coastal Forestlands, Ltd. reported that Registered Professional Foresters have mentioned seeing coho in Hathaway Creek in recent years, as well.

2. *Redd Survey*

Beginning in 1989 through the present, the Salmon Trollers Association has surveyed various stream reaches in the Garcia River basin for the presence and number of redds. These spawning surveys have begun in or around November and have been performed regularly through the winter months until as late as April, on occasion. Figure 19 summarizes the Association's findings. According to the data, the highest redd densities (> average) were found in Pardaloe Creek (1995-96, 1996-97), Mill Creek (1995-96, 1996-97) and the South Fork Garcia (1998-90, 1996-97).

Figure 19: Summary of redd density data collected by the Salmon Trollers Association.

Planning Watershed	Stream	Date	Redds/mile
113.70010	Pardaloe	01/11/96-4/15/96	22.0
		01/11/97-4/15/97	10.0
	Mill	01/11/96-4/15/96	20.5
		12/20/96-02/13/97	10.0
113.70011	None surveyed		
113.70012	None surveyed		
113.70013	None surveyed		
113.70014	Inman	01/08/96-03/18/96	2.0
		12/17/96-02/08/97	2.5
113.70020	Signal	01/08/96-03/18/96	8.6
		12/17/96-02/08/97	3.4
113.70021	None surveyed		
113.70022	None surveyed		
113.70023	South Fork Garcia	11/30/89-02/22/90	9.8
		02/01/91-02/15/91 (low flows)	0.3
		12/21/97-02/23/97	9.5
	South Fork Garcia tributary	01/16/97-02/02/97	8.0
113.70024	None surveyed		
113.70025	None surveyed		
113.70026	None surveyed		

3. *Carcass Survey*

The Salmon Trollers Association counted and tagged the fish carcasses it observed during its spawning surveying. Steelhead carcasses were found in the South Fork Garcia in 1989-90 and in Mill and Pardaloe Creeks in 1995-96. One coho carcass was found in Inman Creek in 1996-97.

The fish population data generally indicates that coho populations have dramatically declined since 1960. The coho that are remaining in the basin appear to favor the small tributaries of the lower watershed, the South Fork Garcia, Signal Creek, and Inman Creek. Steelhead populations appear to have generally declined as well, but range more broadly through the basin now than do the coho.

Water Quality

Water quality data has been collected at three general locations in the Garcia River watershed. Turbidity, suspended solids, and settleable matter have been collected by Coastal Forestlands, Ltd. at several sites on the North Fork Garcia River. The data generally indicates that tributaries to the North Fork have contributed little turbidity, suspended solids, or settleable matter to the North Fork Garcia River mainstem above that which is carried in the North Fork during storm flow. There are no established background levels for the North Fork Garcia against which to compare the actual results.

Data has also been collected by the North Coast Regional Water Quality Control Board on the mainstem Garcia River from a location at Buckridge Road and another at Highway 1. The results of this sampling are summarized below. Of the parameters reported, only dissolved oxygen has a numeric standard adopted in the Basin Plan for the Garcia River. There are no excursions of the Basin Plan limits. The U.S. Environmental Protection Agency has developed a standard for total ammonia which is based on temperature and pH. Neither of the values reported exceed EPA's standards. Figure 20 summarizes the water quality data collected at Highway 1 and Buckridge Road.

Figure 20: Summary of water quality data collected at Buckridge Road and the Highway 1 bridge, Garcia River watershed.

Sampling Date	Sampling Location	pH	Temp (°C)	Dissolved Oxygen (mg/L)	Total Dissolved Solids (mg/L)	Total Ammonia (mg/L)
04/18/89	Buckridge Road	7.82	14.5	10.4	NM	NM
	Highway 1	7.65	16.7	10.3	NM	NM
05/02/90	Buckridge Road	8.0	17.0	11.5	120	0.10
	Highway 1	7.75	14.0	10.6	130	0.11

NM = Not measured

Finally, data has been collected by the U.S. Air Force at the Radar Station at the headwaters of Rolling Brook. This data has been collected in association with a hazardous waste cleanup at the facility. While trichloroethene (TCE) was found in concentrations up to 7.4 ppb in a spring immediately down gradient of a leaking landfill, none has been found further down stream at the surface water sampling station in Rolling Brook, itself. Staff at the Regional Water Quality Control Board conclude that TCE evaporates before reaching the surface waters of Rolling Brook and the greater Garcia River.

Physical Disturbance

During discussions of the Garcia River Watershed Advisory Group from August 1996 through October 1997 several members of the group voiced concern about the impacts of off-road vehicles on the micro and macro environment of the stream system. A popular entry point for off-road vehicles to the stream is reported to be at the Vorhees Grove which is accessed and surrounded by property owned by Louisiana-Pacific Corporation just west of the confluence of the South Fork Garcia with the mainstem. Complaints included direct disturbance to fish and redds, disturbance to the gravel substrate, and the formation of tracks across areas of low water flow which can serve to trap young of that year. Other comments included mention of the potential for physical disturbance to fish, redds and habitat by gravel mining activities.

Limiting Factors

A team of technical experts representing the U.S. Environmental Protection Agency, the Natural Resource Conservation Service, the Regional Water Quality Control Board, the California Department of Fish and Game, the California Department of Forestry and Fire Protection, the Division of Mines and Geology, the Mendocino County Resource Conservation District, and the Mendocino County Water Agency met to discuss the above data and draw conclusions regarding the factors limiting the success of salmonids in individual Planning

Figure 21: Comparison of existing instream data with instream numeric targets.

	Barriers?	Avg. embedded-ness >25%?	Fines (<0.85 mm) > 14%?	Fines (<6.5 mm) > 30%?	Avg. pool depth < 3 ft.?	Avg. pool frequency < 40%?	Avg. V* > 0.21?	Avg. d_{50} < 69mm?	Lack of LWD?	Excessive Stream channel opening?
113.70010										Yes
Mill	?	Yes	Yes	Yes	Yes	No	?	?	No	?
Pardaloe	?	Yes	No*	No*	Yes	Yes	?	?	Yes	?
113.70011										Yes
Tribs	?	?	?	?	?	?	?	?	?	?
Garcia	?	?	?	?	Yes*	?	?	?	?	Yes*
113.70012										Yes
Whitlow	?	?	?	?	Yes*	Yes*	?	?	?	Yes*
Other tribs	?	?	?	?	?	?	?	?	?	?
Garcia	?	?	?	?	?	?	?	?	?	?
113.70013										Yes
Blue Waterhole	?	?	No*	No*	Yes*	Yes	Yes	Yes	?	?
Garcia	?	?	Yes	Yes	?	?	?	?	?	?
113.70014										Yes
Inman	?	?	No	Yes	Yes*	Yes*	?	?	?	Yes
113.70020										Yes
Signal	?	?	No*	No*	Yes*	No	?	?	?	Yes
113.70021										Yes
Casper	Yes	?	?	?	?	?	?	?	?	?
Graphite	Yes	?	?	?	?	?	?	?	?	?
Garcia	?	?	?	?	?	?	?	?	?	?
113.70022										Yes
Beebe	Yes	?	?	?	Yes*	?	?	?	?	Yes*
Garcia	?	?	?	?	?	?	?	?	?	?
113.70023										Yes
South Fork	Yes	?	Yes*	Yes*	Yes*	Yes	?	?	?	Yes*
Fleming	Yes	?	Yes*	Yes*	Yes*	Yes	?	?	?	?
Garcia	?	?	?	?	Yes*	?	?	?	?	Yes

	Barriers?	Avg. embedded-ness >25%?	Fines (<0.85 mm) > 14%?	Fines (<6.5 mm) > 30%?	Avg. pool depth < 3 ft.?	Avg. pool frequency < 40%?	Avg. V* > 0.21?	Avg. d_{50} < 69mm?	Lack of LWD?	Excessive Stream channel opening?
113.70024										Yes
Mill	Yes	?	?	?	?	?	?	?	?	?
Rolling	?	?	Yes*	Yes*	Yes*	Yes	?	?	?	?
Lee	?	?	No*	No*	Yes*	Yes	?	?	?	Yes*
Hutton	Yes	?	?	?	Yes*	Yes*	?	?	?	Yes*
Garcia	?	?	?	?	?	?	?	?	?	?
113.70025										Yes
North Fork	Yes	Yes	Yes	Yes	Yes	Yes	?	?	Yes	Yes*
Alder	Yes	?	?	?	?	?	?	?	?	?
Garcia	?				?	?	?	?	?	?
113.70026										No
"Bentonite"	?	?	?	?	?	?	?	?	?	?
Hathaway	?	?	Yes*	Yes*	?	No	?	?	?	?
Garcia	?	?	Yes*	Yes*	?	Yes	?	?	?	?
Estuary	No	Yes	?	?	No	No	?	?	Yes	Yes*

Based on qualitative assessment conducted by the Inter-agency Limiting Factors Technical Team

Watersheds throughout the Garcia River basin. Figure 21 above summarizes the instream data and compares it to the numeric targets contained in the Numeric Targets section of the Action Plan. Where data did not exist, but members of the team had personal familiarity with the Planning Watershed in question, the conclusions were qualified. Figure 21 can be interpreted to conclude the following:

- Where there are sediment or low flow barriers, migration is limited
- Where embeddedness exceed 25%, spawning is limited
- Where fines (<0.85 mm) are greater than 14%, embryo development is limited
- Where fines (<6.5 mm) are greater than 30%, fry emergence is limited
- Where the average pool depth is less than 3 feet, rearing is limited
- Where the average pool frequency is less than 50%, rearing is limited
- Where the average V* is > 0.21, stream channel stability is limited
- Where the average d50 is less than 69 mm, stream channel stability is limited
- Where there is a lack of large woody debris, stream channel stability is limited
- Where there is excessive stream channel opening, stream channel stability is limited

Problem Statements

As reported by Brown et al. (1994), there are many factors influencing the decline of coho salmon in California, most notably: stream alterations brought about by poor land use practices and the effects of periodic floods and drought, the breakdown of genetic integrity of native stocks, introduced diseases, overharvest, and climatic change. The general issue of concern to the Action Plan, however, relates specifically to stream alterations associated with sediment delivery which have resulted from land management activities. Other stressors, such as elevated stream temperatures, have been identified in the Garcia River watershed but will be addressed in a separate document.

The goal of the Action Plan is to improve the condition of instream habitat for cold water fish by: 1) reducing the controllable sources of sediment, 2) improving the capacity of the riparian zone to filter mobile sediment and thereby reduce sediment delivery, and 3) increasing the potential for the recruitment of structural elements to the channel to improve the capacity of the instream system to efficiently transport delivered sediment and create usable habitat.

The problem statement, as required for a TMDL per section 13242 of the California Water Code, can be found in the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan).

Three factors are important in describing the issue of sedimentation: sediment production, sediment delivery, and sediment transport. Sediment is produced from the hillside from deep-seated landslides, shallow-seated landslides, gullies, rills, and surface erosion. Sediment is also produced by the slumping or sloughing of stream banks. The increase in sediment production by itself does not necessarily cause water quality impacts. It is only when sources of sediment are delivered to a watercourse-- or have a high likelihood of delivery-- that water quality concerns arise. Sediment is delivered either by direct transport to a watercourse or by the diversion of a watercourse through a sediment source.

Even sediment delivery by itself does not necessarily equate with water quality impacts. The Garcia River watershed is naturally a highly erodible watershed due to its unstable geology, including a Franciscan-dominated bedrock, and the effects of the San Andreas Fault system. As such, debris torrents and other mass wasting events regularly supply the stream system with sediment. It is this natural process of sediment delivery which characterizes the Garcia River as a gravel-bed stream.

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 appear 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). As such, 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.

Specific Problem Statement 1: The migration of anadromous fish in the Garcia River watershed from the ocean, within the basin, and back to the ocean is or is likely to be 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).

Specific Problem Statement 2: Spawning gravels of the Garcia River watershed are or are likely to be impacted 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, 4) and impairing the ability of fry 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.

Specific Problem Statement 3: Spawning gravels of the Garcia River watershed are or are likely to be 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.

Specific Problem Statement 4: Pools of the Garcia River watershed potentially suitable as rearing habitat are or are likely to be 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, and 3) reduces the availability of fish cover as a result of decreased depths and the burial of large woody debris and other structural elements. This statement relates to the SPAWN beneficial use and the potential for sediment and settleable material to impact rearing habitat.

Specific Problem Statement 5: Increased sediment delivery to the Garcia River watershed impacts, or is likely to impact stream channel stability by causing: 1) aggradation, stream channel widening, greater flood potential, and greater stream bank erosion, and 2) the burial of channel structural elements such as large woody debris with a reduction in sediment transport efficiency. This statement relates to the COLD beneficial use and the potential for sediment to impact stream channel stability and habitat niches.

II. NUMERIC TARGETS

Introduction

The Numeric Targets section of the *Reference Document for the Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Reference Document) supports the identification of the numeric targets listed in the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan). These numeric targets describe the future condition of the instream environment for optimal salmonid reproductive success. Establishing numeric targets allows landowners, land managers, and resource protection agencies to determine how far the Garcia River watershed is along the path to recovery for cold water fish. The Numeric Targets for the Garcia River watershed are found in the Action Plan.

It is important to keep in mind that the numeric targets for the Garcia River watershed are *targets*, not water quality objectives. They are meant to express the goals we hope through improved land management and restoration to eventually achieve. They are not, however, standards upon which regulatory action will be taken, and therefore are not themselves enforceable. Landowners, land managers and the public should view the numeric targets as guideposts which serve to assist groups in evaluating the success of their work.

Though not water quality objectives, the numeric targets are indeed intended to be consistent with the water quality objectives contained in the *Water Quality Control Plan for the North Coast Region* (the Basin Plan). The numeric targets are intended to protect the beneficial uses of concern (COLD, MIGR, SPAWN, and EST) and to attain the water quality objectives of concern (suspended material, settleable material, sediment, and turbidity). Scientific literature and the comments from the Garcia River Watershed Advisory Group and its subcommittees were considered in the development of numeric targets.

Overview of the Numeric Targets

The numeric targets are organized by salmonid life cycle (adult upstream migration, spawning, embryo development, fry emergence, rearing, and downstream migration of smolts) as described in the beneficial uses MIGR and SPAWN. Numeric targets are also proposed which relate to channel structure and stability, as described in the beneficial uses COLD and EST. Final targets as described in the Action Plan are identified for: migration barriers, embeddedness, percent fines < 0.85 mm, percent fines < 6.5 mm, pool frequency, V*, d_{50}, large woody debris, width-to-depth ratio, thalweg profile, and stream channel opening.

In any given watershed, a range of targets might accurately describe the conditions suitable for salmonids, based on both the natural variation in the population and habitat. In the Garcia River watershed, however, the range over which the population and habitat naturally vary is currently unknown. The existing information provided to Regional Water Board staff was insufficient to identify conditions in this kind of detail. Thus, though a range of targets is appropriate where the data supports it, at this point in time, Regional Water Board staff have identified numeric targets which reflect the optimum conditions required by salmonids as demonstrated in laboratory experiments and field experiments in other watersheds. These numeric targets can be modified as site-specific data better illuminates the range of natural variability in populations and habitat quality and quantity in the Garcia River watershed, itself.

What follows is a discussion of the identified numeric targets organized by salmonid life stage and channel structure/stability requirements. Each section includes a brief description of the life stage or channel stability issue in question and a summary of the scientific literature reviewed, as appropriate.

Migration-related Targets

Anadromous fish enter their natal streams after some time in the ocean-- generally two years for coho salmon and one to three years for steelhead trout. The migration of adult salmon upstream requires that there be no impassable barriers to their passage from the ocean to their spawning streams. Similarly, once the fry emerge from the gravel, there must be no barrier to the passage of these small fish from the spawning reaches to and among rearing habitats, particularly during the summer when flows may be low and temperatures warm. And finally, once the juveniles are ready to return to the ocean, there must be no barrier to their passage from their rearing reaches to the estuary and out to the ocean.

The migration-related numeric target is described in the Action Plan. This target does not apply to natural barriers, such as bedrock waterfalls, which are not associated with land management activities and thus are not controllable. Human-caused migration barriers include aggraded stream reaches which become too shallow (less than 0.18 meters in depth) or are dewatered (flow subsurface) during the summer months; plugged or hanging culverts or poorly constructed stream crossings which prevent the migration of anadromous fish past sections of road fill to upstream habitat; or any similar feature.

Spawning-related Targets

1. Median particle-size diameter (d_{50})

The redds of spawning anadromous fish are composed of specifically-sized gravel particles. According to Reiser and Bjornn (1979), gravel suitable for coho redds ranges from 1.3 to 10.2 cm in diameter. Steelhead use somewhat smaller sized particles for redd-building.

During the process of building a redd, the female salmonid uses her body and tail to dig a pit in the gravel, thus winnowing out fine particles and leaving behind particles too big for her to move. The result, according to Lisle and Lewis (1992) is that "almost regardless of the original condition of gravel, the spawning female can alter the grain size and porosity of gravel to ensure that the ova begin with an adequate flow of oxygenated water." Other researchers suggest that salmonids reduce the percentage of fines <0.85 mm up to 20% through the redd-building process.

Based on this line of reasoning, there is no target proposed for spawning-size gravel at this time. It is assumed that sites where the volume of fines is so large as to bury spawning-sized particles will be identified through the bulk core sampling and the application of a percent fines target, as described under Embryo Development-related Targets below and in the Action Plan. Site-specific data indicating that the lack of spawning-sized gravels is in fact prohibiting the development of redds can be used to develop a target in the future.

2. Embeddedness

One factor not easily measured through a bulk core sample is the degree to which the larger fraction of surface particles in the substrate are embedded (or cemented) which corresponds to the relative ease with which spawning fish can move the substrate. The phenomenon described by Lisle and Lewis (1992) in which the spawning female can alter the grain size and porosity of the gravel by simply building the redd does not occur in areas where the substrate is held so firmly in place by a hardened fine particle matrix that the gravels are virtually cemented together.

An embeddedness measurement is used by the California Department of Fish and Game as described by Flosi and Reynolds (1994) in its *California Salmonid Stream Habitat Restoration Manual*. In this protocol, cobble particles are randomly selected from pool tails and examined to determine the percent to which they are surrounded or covered by fines. Individual particles are picked up and the line indicating the depth to which they were buried is estimated and scored as 0-25% embedded (score=1), 26-50% embedded (score=2), 51-75% embedded (score=3), or 76-100% embedded (score=4).

Since embeddedness is a somewhat qualitative parameter, its reproducibility is not entirely certain. As such, there is no final target, or desired future condition, proposed for embeddedness at this time. However, a trend towards improved levels of embeddedness is proposed as an interim target. The improving trend would be represented by a decrease in embeddedness as measured over a rolling 10 year period. If site-specific data and monitoring experience indicates that embeddedness data can be collected in a reproducible manner, a desired future condition will then be established. The embeddedness numeric target is described in the Action Plan. This target is intended to be consistent with the settleable matter and sediment water quality objective and protect the spawning life stage of cold water fish and their associated habitat as described in the SPAWN and COLD beneficial uses.

Embryo Development-related Targets

1. Percent fines <0.85 mm

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 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 an arbitrarily established value based on the available sieve sizes at the time of the initial studies in this area.

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

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

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

Louisiana-Pacific Corporation, Georgia-Pacific Corporation, and Coastal Forestlands, Ltd. propose for the Garcia River watershed as appropriate 20-30% fines (undefined particle size) in *potential* redd sites and 16-20% fines (undefined particle size) in *actual* redd sites. (The distinction made between potential and actual redd sites is based on the fact that salmonids significantly clean the gravels during the process of redd-building. (See conclusions of Lisle and Lewis (1992)). The companies' estimate that 20% fines in potential redd sites will provide for a 55% embryo survival based on a figure in Waters (1995) which is derived from Hall and Lantz (1969). Waters (1995) concludes that 20% fines less than 0.8 mm has become well established as the criterion above which significant mortality of embryos can be expected. This is compared to three years of data from 1989 to 1991 in the North Fork Garcia River, a managed stream in the

Garcia River watershed, which show fines <1.0 mm ranging in potential redd sites from approximately 15 to 35%.

The lack of uniformity among the data, the differences between streams in Northern California and the rest of the Pacific Northwest, the uncertainties of the Burns data relative to storm impacts, the fines levels seen in managed streams in the Garcia River basin, and the Watershed Advisory Group Targets Subcommittee's recommendation to protect for at least 70% embryo survival, a numeric target for percent fines <0.85 mm was developed. This numeric target is described in the Action Plan.

The percent fines numeric target found in the Action Plan is a best professional judgment which takes into account that the 11% fines <0.85 mm which was observed seen in unmanaged streams in the Pacific Northwest 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 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.

The percent fines numeric target described in the Action Plan can be modified as site-specific data are developed which indicates that significant embryo survival in the Garcia River requires less fines or can withstand more fines than is indicated here. Data developed on nearby reference streams, for example, can be used to modify this target, as appropriate.

2. Geometric Mean Particle Size Diameter (d_g)

The geometric mean particle size diameter has been proposed by some researchers as a statistic by which to describe the substrate composition (Platts et al. 1979, Shirazi et al. 1981). Emergence was plotted against the geometric mean [$d_g=(d_{16}d_{84})^{½}$] and found to be related. Others have argued that the geometric mean can be similar for very different gravel mixtures because, for example, a large d_{84} can offset a small d_{16} (Tappel et al. 1983; Kondolf, unpublished).

Due to this disagreement, there is no d_g target proposed at this time. However, the d_g can be calculated as part of the particle size distribution data collected to measure percent fines. If site-specific data indicate that d_g provides a good measure of substrate quality in the Garcia River basin, a target can be considered in the future, either in place of or in addition to the proposed percent fines target.

3. Fredle Index (f_i)

The fredle index, developed by Lotspeich and Everest (1981) incorporates elements that integrate gravel permeability and pore size. It is calculated as $f_i=d_g/S_o$ where $S_o=(d_{75}/d_{25})^{½}$. Lotspeich and Everest (1981) related the fredle index to survival to emergence of coho salmon and steelhead placed into laboratory mixes of gravels. Chapman (1988) used Tappel and Bjornn's (1983) data and also found a highly significant regression of survival on f_i between

f_i=1.0 and f_i=4.0. Kondolf (unpublished), on the other hand, reasons that the measure of dispersion is calculated from d_{75} and d_{25} and thus reflects the spread of only the middle 50% of the distribution. It is thus insensitive to ecologically significant differences in fine sediment contents less than 25%.

As with d_g, there is no proposed target for f_i at this time. However, the f_i can be calculated as part of the particle size distribution data collected to measure percent fines. If site-specific data indicate that f_i provides a good measure of substrate quality in the Garcia River basin, a target can be considered in the future, either in place of or in addition to the proposed percent fines target.

4. Location of Targets Application

Lisle and Lewis (1992) conclude that the initial particle-size distribution of the substrate prior to redd-building has less of an influence on the ultimate level of fines and embryo survival than does the intrusion of fines and/or scouring and filling of redds after the redds have been built. As such, the percent fines targets as described in the Action Plan should apply to neither potential nor actual redd sites (sites sampled prior to or immediately after redd-building). They should instead apply to the gravel area which makes up the pool tail (the most common spawning location) with samples collected soon after the cessation of winter and spring storms. The results will provide a prediction of whether a particular gravel bed could have supported a healthy population of emergent fry, had adult fish spawned there. Further, the percent fines targets as described in the Action Plan will apply only to fishing-bearing and historically fish-bearing streams. (To ensure protection of alevins, sampling should be postponed until all redds have been evacuated.)

Fry Emergence-related Targets

1. Percent fines <6.5 mm

After 4 to 6 weeks, the embryos are ready to emerge from the gravel as fry-- or free-swimming fish. Fry emergence can be prevented by the presence of fine sediment in the gravel interstices. 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. 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.

Tappel and Bjornn (1983) predicted that 14% fines <0.85 mm when in combination with 30% fines <9.50 would provide an average of 50% survival to emergence for steelhead. No distribution of particles sizes which includes 14% fines was predicted to result in 70% survival or greater. For chinook salmon, they predicted that 14% fines <0.85 mm when in combination with 32% fines <9.50 mm would provide an average of 70% survival to emergence. Both steelhead and chinook are expected to have greater emergence success than coho salmon when redds are sedimented.

Phillips et al. (1975) conducted a laboratory experiment constructing troughs with different sand/gravel mixtures. Coho and steelhead fry were introduced into the intergravel environment several days prior to absorption of the yolk sac. Fry were buried and their emergence rates later measured. Phillips et al. (1975) reported that the mean survival for coho ranged from 96% in the control groups with no fine sand to 8% in cells containing 70% sand. The steelhead experiment showed similar results, with survival ranging from 99% to 18%, respectively. Variation was greatest in the 30% sand range (1-3 mm).

McCuddin (1977) conducted a laboratory experiment similar to Phillips et al. (1975) and reported that the ability of chinook salmon and steelhead trout embryos to survive and emerge from the substrate decreased sharply when sediment less than 6.4 mm in diameter comprised more than 20-25% of the substrate. He recommended that sedimentation of gravel streambeds of the Idaho Batholith be limited to a maximum of 25% by volume of sediment less than 6.4 mm in diameter.

Chapman (1988) evaluated data from a number of other studies. He reported that the amount of fines <3.3 mm in spawning gravels used by coho salmon in 15 unlogged Oregon watersheds varied from 27 to 55% (Koski 1966, Moring and Lantz 1974). Kondolf (unpublished) evaluated the data from a number of other studies, too. He concluded that if one arbitrarily chooses a 50% survival to emergence rate, the data indicate that fines, as defined either as <3.35 mm or <6.35 mm, should not comprise more than 30% of the overall particle size distribution.

Based on these findings and observations, the proposed numeric target for fines <6.5 mm was developed. The numeric target for fines <6.5 mm is described in the Action Plan. 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 (Koski 1966) identified no sites with less than 27% fines <6.4 mm.Variation in the results due to droughts and floods are expected. As such, a smooth, annually-regular trend towards the desired condition is not predicted. 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 SPAWN and COLD beneficial uses.

The target can be modified as site-specific data are developed which indicate that significant embryo survival in the Garcia River requires less fines or can withstand more fines than is indicated here. Data developed on nearby reference streams, for example, can be used to modify this target, as appropriate.

2. Location of Targets Application

See Embryo Development-related Targets, Location of Targets Application, above.

Rearing-related Targets

According to Reiser and Bjornn (1979), the rearing period extends from fry emergence to seaward migration and can range from one year for coho salmon to three or four years for steelhead trout. Important habitat components for juvenile salmon and trout are: 1) fish food production areas, 2) water quality and quantity, 3) cover, and 4) habitat space (Reiser and Bjornn 1979). As such, a discussion of rearing is divided into these categories below. Rearing-related targets are described based on both their relationships to sediment and large woody debris.

1. Fish Food Production Areas

Macroinvertebrates comprise the bulk of juvenile salmon food supply. Macroinvertebrate production relies, in part, on a gravel substrate that is relatively free from fine sediment. Though macroinvertebrate data in the Garcia River watershed is scant, the current indication is that the food supply is not limiting the production of salmonids in the basin. As such, there is no proposed target at this time. Should site-specific data indicate that food supply is a limiting factor, a target can be considered in the future.

2. Water Quality

a. *Water Temperature*

Fry begin their lives as free-swimming fish in the late spring or early summer. As such, they are immediately confronted with low summer flows and the summer water temperatures. Reiser and Bjornn (1979) concluded that water temperature influences the growth rate of juvenile salmonids, their swimming ability, the availability of dissolved oxygen, the ability of juvenile salmonids to capture and use food, and their ability to withstand disease outbreaks.

Summer water temperatures are potentially influenced by a number of factors, including: orientation of the stream channel to the sun, density of riparian shade canopy, the extent of groundwater influences, depth of the surface water column, and width of the stream channel. The Garcia River watershed has not at this date been listed on the 303(d) list for impairments due to elevated temperatures. However, the *Assessment of Aquatic Conditions in the Garcia River Watershed* (1997) concludes that summer water temperatures are a factor potentially limiting salmonid productivity. While there are sediment-related factors which influence water temperature which could be addressed here, Regional Water Board staff propose to address water temperature in a separate document.

b. *Dissolved Oxygen*

According to Reiser and Bjornn (1979), the concentration of dissolved oxygen in streams is important to salmonids during rearing. Growth rate, food consumption rate, and the efficiency of food utilization of juvenile coho salmon all declined when oxygen was 4 or 5 mg/l (Herrmann et al. 1962). Dissolved oxygen concentrations are normally near saturation, except in small streams with large amounts of debris from logging or other sources (Hall and Lantz 1969) or larger, slow-moving streams receiving large amounts of municipal or industrial waste.

While there is scant dissolved oxygen data for the Garcia River basin, the *Assessment of Aquatic Conditions in the Garcia River Watershed* (1997) did not identify dissolved oxygen (DO) as a potential limiting factor. There is currently in place a Basin Plan prohibition which regulates the discharge of slash and debris into streams or watercourses. And, with the exception of the dairy and farming activities at the mouth of the river, there are no large municipal or industrial waste discharges to the mainstem Garcia. Further, there is a Basin Plan numeric water quality standard requiring the instream dissolved oxygen to be 7.0 mg/L as a minimum.

For these reasons, there is no additional dissolved oxygen target proposed at this time. The spawning-related, incubation-related, and rearing-related targets are presumed to be sufficient, as is the existing water quality objective for dissolved oxygen. Should data indicate that dissolved oxygen levels may in fact be limiting salmonid production, the Regional Water Board will consider listing the water for DO on the 303(d) list and/or developing a separate control strategy.

c. *Suspended Sediment*

Reiser and Bjornn (1979) reported that suspended fine sediment can adversely affect salmonid rearing habitat if present in excessive amounts. High levels of suspended solids may abrade and clog fish gills, reduce feeding, and cause fish to avoid some areas. (Troutman 1933, Pautzke 1938, Smith 1939, Kemp 1949, Wallen 1951, Cooper 1956, Bachman 1958, Cordone and Kelley 1961). Cordone and Kelley (1961), however, suggest that indirect rather than direct effects of too much fine sediment damage fish populations. Indirect damage to the fish population by destruction of the food supply, lowered egg or alevin survival, or changes in rearing habitat probably occurs long before the adult fish would be directly harmed (Ellis 1936, Tebo 1955, 1957, 1974, Tarzwell 1957, Ziebell 1957, Bartsch 1960, Chapman 1962, Bjornn et al. 1977).

Following this line of reasoning, there is no additional suspended or deposited sediment target set at this time. The proposals for spawning-related, incubation-related, and rearing-related targets are presumed to be sufficient. If site-specific data indicate that suspended sediment is a factor potentially limiting the production of salmonids in the Garcia River basin, then additional targets can be considered at that time.

d. *Habitat Space*

i. General discussion

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 washed down river and out to sea. Steelhead prefer riffles for rearing during their first summer, but make more regular summer use of pool habitat as they grow in size. The *Garcia River Watershed Assessment* (1997 draft) 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.

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.

The water quality objectives adopted for the North Coast Region generally apply to the discharge of waste to waters of the State. The water quality standards, however, also describe the instream conditions which are sufficient to support beneficial uses. In the case of sediment control in the Garcia River basin, these objectives are primarily articulated in terms of the ability of any substance to cause "nuisance or adversely affect beneficial uses." For example, the objective for settleable material says that "water shall not contain substances that result in deposition of material that causes nuisance or adversely affects beneficial uses." It is the large woody debris, boulders and other pool-forming channel structures which help to ensure that sediment discharged to a stream is not deposited in such a way as to cause nuisance or adversely affect beneficial uses.

Similarly, the beneficial use for the cold water fishery (COLD) is described as follows: "uses of water that support cold-water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats." Pools, large woody debris and other habitat components are included in the beneficial use requirement.

In addition, the beneficial use for spawning, reproduction and early development (SPAWN) is described as follows: "uses of water that support high quality aquatic habitats suitable for reproduction and early development fish." "High quality" habitat for coho rearing necessarily includes deep, dark pools, with plenty of cover, such as from large woody debris (McMahon 1983). The formation of aquatic habitats, including pools, requires large woody debris, boulders, or other pool-forming channel structure, as described above.

Klamt (1976) and Bjornn et al. (1977) observed that as sediment was added to pools in artificial and natural streams, the instream habitat was buried and the pool capacity for rearing salmonids decreased. Other researchers conclude that North Coast streams include pool habitat primarily due to the presence of large woody debris (Keller et al 1995). As such, large woody debris is particularly critical to the formation of pool habitat, as well as channel stability.

ii. Pool Dimension

As reported by Reiser and Bjornn (1979), Thompson (1972) determined that the preferred pool depth for coho salmon is 0.30-1.22 meters. Nickelson and Reisenbichler (1977) determined that the preferred pool depth is >0.30 meters. Everest and Chapman (1972) determined that the preferred pool depth for one year old steelhead is 0.60-0.75 meters. Hanson (1977) determined that the preferred pool depth for one year old steelhead is 0.51 meters as a mean, for two year old steelhead is 0.58 meters as a mean, and for a three year old steelhead is 0.60 meters as a mean. Klamt (1976) and Bjornn et al. (1977) found that addition of sediment to a pool in central Idaho reduced abundance of salmonids in the pool in direct proportion to the loss of pool volume greater than 0.15 m deep.

Flosi and Reynolds (1994) concluded from the Department of Fish and Game's habitat typing data that better California coastal coho streams have as much as 50% of their total habitat length in primary pools. 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.

The Flosi and Reynolds (1994) findings are in general agreement with that of other researchers and represent California streams. The numeric target for pool dimension is described in the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan). This target is intended to be consistent with the water quality objectives for sediment and settleable matter and protect the rearing life stage of cold water fish and their associated habitat as described in the SPAWN and COLD beneficial use.

iii. Pool Frequency

Flosi and Reynolds (1994) concluded from the Department of Fish and Game's habitat typing data that better California coastal coho streams have as much as 50% of their total habitat length in primary pools. Upon review of additional data, however, Flosi has revised this figure to 40% (personal communication). 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.

The numeric target for pool frequency is described in the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan). As site-specific data is collected, this target can be revised, as necessary. 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.

Channel Structure/Stability-Related Targets

In 1993, the North Coast Regional Water Quality Control Board in cooperation with the California Department of Forestry published the work of Chris Knopp entitled *Testing Indices for Cold Water Fish Habitat*. In his study Knopp measured a range of habitat variables in 60 streams within the North Coast Planning Basin of California. Sampling was limited to the Franciscan geologic formation. The sampled channels all exhibited small cobble substrate, slopes between 1-4 percent, and were Rosgen B-3 and C-3 channel types. The study included stream reaches in index watersheds, moderately disturbed watersheds, and highly disturbed watersheds.

Index watersheds 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. Moderately disturbed watersheds were defined as drainages with recent management but with good protection of stream courses. And, highly disturbed watersheds were defined as drainages exhibiting large areas of disturbed soil, unpaved, low slope roads, inconsistent or poor stream course protection, and inconsistent avoidance of unstable terrain.

The habitat variables collected included: V*, habitat typing, channel stability ratings, stream width/depth ratios, temperature, intragravel dissolved oxygen, macroinvertebrates, fish populations, riparian canopy age class distribution and recruitment volumes, woody debris, woody debris complexity, suspended sediment, bedload, stream discharge, various pool parameters, RASI, D50, embeddedness, McNeil core samples, and numerous others.

Knopp stratified the data based of disturbance history and found a significant correlation between disturbance history and three of the variables: V*, D50, and RASI. The following is the background, reference information of numeric targets which represent the average range associated with both undisturbed basins and basins with little activity in 40 years. The numeric targets themselves are found in the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan).

1. <u>V*</u>

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. 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).

The V* values identified by Knopp (1993) 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. Knopp (1993) found that in the index reaches, the V* mean measured 0.21 or less and the maximum measured 0.45 or less.

The V* numeric targets are described in the Action Plan. 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.

2. <u>Median Particle Size Diameter (d_{50})</u>

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. Knopp (1993) found that in the index streams, the mean d_{50} measured 69 mm or greater while the minimum d_{50} measured 37 mm or greater.

The numeric targets for the median particle size diameter (d_{50}) are described in the Action Plan. 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.

3. Riffle Armor Stability Index

The Riffle Armor Stability Index (RASI) values identified by Knopp (1993) represent the cumulative percent of the riffle substrates that are smaller or equal in size to the largest mobile particle on the riffle surface as determined by three 200-count pebble counts at each station. RASI values show a clear trend with increasing upslope disturbance. The combined index reaches were significantly different from both the moderately and highly disturbed reaches. But, the moderately disturbed reaches were not statistically different from the highly disturbed reaches. Nor were the index reaches representing hillslope disturbance older than 40 years statistically different from moderately and highly disturbed reaches. Based on this last observation, there is no proposed target for RASI at this time.

4. Large Woody Debris (Pool-forming Elements)

Keller et al. (1995) studied the effects of large organic debris on channel morphology and sediment storage in selected tributaries of Redwood Creek in Humboldt County, CA. They concluded that large woody debris (stems greater than 30 cm in diameter) exerts a major control on channel form and process, and thus on anadromous fish habitat.

Effects of large woody debris on channel morphology and sediment storage tend to be complex for several reasons. First, large woody debris may reside in the stream channel for centuries and is a permanent part of the fluvial system. Second, large woody debris exert considerable control over channel morphology, particularly in the development of pools. Third, large woody debris produces numerous sediment storage sites, supporting a sediment buffer system that modulates the routing of sediment through the fluvial system. Finally, large woody debris in steep streams significantly concentrates potential energy expenditure over short reaches where accumulations of debris exist (Keller et al. 1995).

According to Keller et al. (1995), the percentage of pools in undisturbed tributaries influenced by large woody debris during low flow conditions ranges from 50-100%, depending on the slope of the stream reach. The percentage of pools influenced by large woody debris in reaches with slopes <1% equaled 50%. The percentage of pools influenced by large woody debris in reaches with slopes between 1-3% equaled 78% on average. The percentage of pools influenced by large woody debris in reaches with slopes greater than 3% equaled 91% on average. These figures might provide reasonable reference targets for large woody debris in a stream system still containing old growth redwood. However, the Garcia River contains little such habitat.

The numeric target for large woody debris (pool-forming elements) is described in the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan). The numeric target is intended to be consistent with the water quality objectives for settleable material and sediment to protect the habitat of cold water fish as described in the COLD beneficial use.

5. Width-to-depth ratio

Rosgen (1996) has developed a stream classification system which is based on the pattern, profile, and dimension of the stream channel. The pattern of a stream channel is described by its sinuosity. The profile of a stream channel is described by its degree of entrenchment as compared to the available flood plain. The dimension of a stream channel is described by its bankfull width-to-depth ratio. The width-to-depth ratio is based on field collected data using a cross-section and verified with flow frequency data. The other parameters can be measured from aerial photographs.

Rosgen (1996) concludes that a channel is stable when it has developed a stable dimension, pattern, and profile such that over time channel features are maintained and the stream system neither aggrades nor incises. For a stream to be stable it must be able to consistently transport its sediment load, both in size and type, associated with local deposition and scour. When the stream laterally migrates, but maintains its bankfull width and width/depth ratio, stability is achieved even though the river is considered to be an “active” and “dynamic” system.

The bankfull channel is defined by the channel-forming flow which is typically associated with a storm with a 1.5-2.0 recurrence interval. When measuring the bankfull width-to-depth ratio, technicians should check the flow records to ensure that the ratio as measured in the field in fact represents the bankfull channel. Channels which flood as a result of storms with a 1.5-2.0 recurrence interval may be aggraded whereas those which do not fill during such a storm may be incised.

The proposal is to develop a hypothesis at every monitoring site regarding the stream channel type which would best describe a stable condition as described above. The width-to-depth ratio identified in Rosgen's classification system will then be applied as the target ratio for that site, as measured by a bankfull channel cross-section. The numeric target for width-to-depth ratio is described in the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan). The numeric target is consistent with the water quality objectives for settleable material and sediment in order to protect the habitat of cold water fish as described in the COLD beneficial use.

6. Thalweg profile

The thalweg of a stream channel is described by the lowest point of the stream channel. A longitudinal profile of the stream thalweg describes the change in elevation of the thalweg through its course. A thalweg profile which is relatively flat, for example, has an elevation change which only represents the overall stream gradient and is necessarily limited in the amount of aquatic habitat niches it provides. A flat thalweg profile is an indication of sedimentation. Similarly, a stream channel which has abundant structural elements, such as large woody debris, has a great deal of elevation change and provides multiple aquatic habitat niches.

As the complexity of instream channel structure increases, the complexity of the thalweg profile also increases. As such, Regional Water Board staff propose that the thalweg profile be used as a metric to measure trends in channel complexity, including habitat availability and channel stability. A positive trend in the thalweg profile occurs as the deviation from the mean thalweg elevation adjusted for overall stream gradient increases. The specific numeric target for the Thalweg profile is described in the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan). The numeric target is 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.

7. Stream Channel Openings

Pacific Watershed Associates reviewed the 1952, 1966 and 1996 aerial photographs for the Garcia River watershed and conducted a modified RAPID analysis (Grant, 1988) to document channel conditions. The modified RAPID analysis involves measuring the linear distance of open stream channels on aerial photographs. In the work conducted by Pacific Watershed Associates (PWA), stream channel reaches which displayed enlarged channel widths and open stream channels were interpreted as "response reaches" of stream channels which were affected by influxes of sediment. Open stream channels are channels which are wide enough that riparian vegetation no longer covers them and they are therefore visible on aerial photographs.

The data indicates that with the exception of the Pardaloe Creek/Mill Creek and the Hathaway Creek Planning Watershed, the length of open stream which existed in 1952 was substantially increased due to stream channel widening and/or stream bank instability by 1966. Since 1966, however, that trend has reversed and the extent of stream channel opening has begun to recover. In the Pardaloe Creek/Mill Creek Planning Watershed (113.70010), the extent of stream channel opening actually improved between the years of 1952 and 1966, unlike the rest of the basin. But, since 1966, stream channel opening has been increased beyond the 1952 levels. The Hathaway Creek Planning Watershed (133.70026) has shown 0% stream channel opening in all but the Garcia River mainstem since 1952.

The Planning Watersheds which have recovered or more than recovered their 1952 stream channel opening status include: Blue Waterhole Creek (113.70013) and Inman Creek (113.70014). Stansbury/Whitlow Creeks (113.70012) have nearly recovered (within 25%) their 1952 stream channel opening status. Graphite Creek (113.20021), Beebe Creek (113.70022), South Fork Garcia (113.70023), and Rolling Brook (113.70024) Planning Watersheds are in the process of recovery (within 100% of their 1952 status). But, Larmour Creek (113.70011), Pardaloe Creek (113.70010), and the North Fork Garcia (113.70025) still have more than twice the amount of open stream channel than existed in those Planning Watersheds in 1952.

In assessing this data and the degree of recovery, it is important to note that while not yet extensive throughout the basin, there were timber harvesting and other land clearing operations underway prior to 1952. The 1952 aerial photographs indicate activity in the Pardaloe/Mill Creeks (113.70010), Larmour Creek (113.70011), Stansbury/Whitlow Creeks (113.70012), Blue Waterhole Creek (113.70013), Inman Creek (113.70014), Signal Creek (113.70020), Rolling Brook (113.70024), and North Fork Garcia (113.70025) Planning Watersheds with the most extensive activity observed in Whitlow Creek and Blue Waterhole Creek. As above, both the Stansbury/Whitlow Creek and Blue Waterhole Creek Planning Watersheds have shown substantial stream channel opening recovery as compared to measurements taken from 1952 aerial photographs. But the miles of open stream measured in each of these Planning Watersheds in 1952 is more than twice that which was measured in the Pardaloe Creek/Mill Creek and Larmour Creek Planning Watersheds, the other upper watershed sub-basins. Figure 22 provides a summary of the modified RAPID analysis results.

Figure 22: Summary of stream channel openings measured from 1952 through 1996, adapted from PWA (1997).

Planning Watershed	**Class 1, 2 and 3 Stream Miles**	**Miles of Open Stream**			**Percent of Open Stream**		
		1952	1966	1996	1952	1966	1996
113.70010 Pardaloe	83.6	1.8	0.5	3.9	2%	1%	5%
113.70011 Larmour	45.7	2.0	9.4	8.6	4%	21%	19%
113.70012 Stansbury	40.2	3.5	5.1	4.3	9%	13%	11%
113.70013 Blue Waterhole	37.1	5.4	9.4	4.2	15%	25%	11%
113.70014 Inman	79.6	1.7	4.1	1.5	2%	5%	2%
113.70020 Signal	41.9	0.0	4.6	1.2	0%	11%	3%
113.70021 Graphite	36.8	2.1	5.3	3.7	6%	14%	10%
113.70022 Beebe	25.8	1.7	5.7	3.1	7%	22%	12%
113.70023 South Fork	22.7	4.4	9.2	5.6	20%	41%	25%
113.70024 Rolling Brook	39.0	1.1	5.0	1.5	3%	13%	4%
113.70025 North Fork	106.0	0.7	5.5	2.8	1%	5%	3%
113.70026 Hathaway	34.0	0.0	0.0	0.0	0%	0%	0%

[1] The miles of open stream reported for Planning Units 113.70025 and 113.70026 do not include open stream segments along the Garcia River mainstem. The researcher judged that this stretch of the mainstem represented alluvial deposits and therefore would more naturally have open canopy segments.

Based on the data reflecting the extent of stream channel opening, the numeric targets for stream channel openings were developed. These numeric targets are described in the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan). 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.

a. *Upper watershed streams*

The upper watershed includes: Pardaloe Creek/Mill Creek (113.70010), Larmour Creek (113.70011), Stansbury Creek/Whitlow Creek (113.70012), and Blue Waterhole Creek (113.70013) Planning Watersheds. Pardaloe Creek/Mill Creek (113.70010), in 1966, had no more than 1% open stream by length.

b. *Mid-upper watershed streams*

The mid-upper watershed includes: Inman Creek (113.70014), Signal Creek (113.70020), Graphite Creek (113.70021), and Beebe Creek (113.70022) Planning Watersheds. In 1952, the Signal Creek Planning Watershed (113.70020) had 0% open stream while the Graphite Creek Planning Watershed (113.70021) had 6% of open stream.

c. *Mid watershed streams*

The mid watershed includes: South Fork Garcia (113.70023), Rolling Brook (113.70024), and the North Fork Garcia (113.70025). While the Rolling Brook and North Fork Planning Watersheds are similar in terms of the terrain, orientation, etc., the measurements for the North Fork Garcia Planning Watershed do not include open stream miles along the mainstem whereas the measurements for the Rolling Brook Planning Watershed do. Thus, a direct comparison is not possible. Similarly, the South Fork Garcia Planning Watershed had 20% open stream miles by length in 1952 whereas the Rolling Brook and North Fork Planning Watersheds had 3% and 1%, respectively. Thus, a direct comparison here is not possible, either.

d. *Lower watershed streams*

The lower watershed includes the Hathaway Creek Planning Watershed (113.70026), excluding the mainstem of the Garcia River. In all years, the Hathaway Creek Planning Watershed (113.70026), excluding the mainstem Garcia, had 0% open stream channel by length.

Summary

In summary, Numeric Targets are proposed which are consistent with the water quality standards contained in the *Water Quality Control Plan for the North Coast Region* and are designed to describe the desired future conditions which will support the following beneficial uses: COLD, MIGR, SPAWN, and EST. The numeric targets are described in the *Garcia River*

Watershed Water Quality Attainment Action Plan for Sediment (Action Plan). The numeric targets are goals, only, and are not directly enforceable.

Attainment Schedule

The extended time period for attainment of numeric targets contained in the Action Plan will allow for hillslope implementation measures to be completed and the natural system to assimilate the modified sediment delivery rates and instream structure that results.

Annual and Seasonal Variation

Several factors influence the dynamics of a stream system, including seasonal variation and the variation in storm events from year to year. As such, one can expect the results of various stream metrics to reflect these variations. For that reason, there is an understanding that several years of data will be required to show a trend and that trends will be influenced by unusual storm conditions. Interpreting the annual data will require consideration of rainfall and flow when evaluating the trends. The final numeric targets, where they have been set, generally represent summer flow conditions and demonstrate the degree to which the stream system has achieved a stable condition.

III. SOURCE ANALYSIS

Introduction

The Source Analysis section of the Reference Document summarizes the existing information relevant to a general understanding of the Garcia River watershed and the occurrence of mass wasting (e.g., landsliding), fluvial erosion (e.g., gullying), and surface erosion (e.g., sheetwash) in the basin. The Source Analysis is located in the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan).

This Source Analysis section of the Reference Document begins with a review of the general information regarding the geomorphology and riparian functioning of the basin. The Source Analysis section of the Reference Document, however, relies primarily on the work of Pacific Watershed Associates (PWA), *Sediment Production and Delivery in the Garcia River Watershed, Mendocino County, California: An Analysis of Existing Published and Unpublished Data* (1997) developed under contract to Tetra Tech, Inc. and the U.S. Environmental Protection Agency. 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 (CDF) through the Mendocino County Resource Conservation District; 2) Louisiana-Pacific Corporation; 3) Coastal Forestlands, Ltd.; and 4) Philip Williams and Associates conducted under contract to the Mendocino County Water Agency.

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. OCEI's assessment is the only assessment to date that evaluates upland conditions throughout the Garcia River watershed. 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.

Louisiana-Pacific Corporation (LP) 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."

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 LP'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.

The existing information is relatively voluminous; but, it nonetheless 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 watershed, 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.

The Source Analysis section of the Reference Document concludes with a series of succinct problem statements which summarize the upland-related problems which are associated with sedimentation of the instream environment. Information describing the instream condition can be found in the Problem Statement section of the Reference Document. A synthesis of these two sections is provided in the Synthesis section of the Reference Document.

Geomorphology

1. <u>Division of Mines and Geology</u>

The geomorphology of the basin is described by the California Department of Conservation, Division of Mines and Geology on three USGS quadrangles entitled "Geology and Geomorphic Features related to Landsliding." The maps were compiled primarily through aerial photo interpretation and cover the Point Arena, Eureka Hill, and Gualala USGS quads. The General Description of the Watershed section of the Reference Document summarizes the information pertaining to the basin's geology.

The Division of Mines and Geology maps indicate a series of parallel faults along the San Andreas fault zone, encompassing the mid portion of the Garcia River mainstem (113.70023-113.70025). Along this reach of the mainstem the landscape is predominated by large translational/rotational slides, including a large earthflow in a tributary basin on the north side of the river immediately downstream of the confluence with the South Fork Garcia. The maps also indicate widespread debris side slopes with numerous debris slides, debris flows/torrent track, active slides and disrupted ground throughout the mapped region.

A translational/rotational slide is defined as a relatively cohesive slide mass with a failure phase that is deep-seated in comparison to that of a debris slide of similar areal extent. The sense of motion along the slide plane is linear in a translational slide and arcuate or "rotational" in a rotational slide. Complex versions with a rotational hard and translational movement or earthflows downslope are common. Translational movement along a planar joint or bedding discontinuity may be referred to as a block glide.

An earthflow is defined as a mass movement resulting from slow to rapid flowage of saturated soil and debris in a semiviscous, highly plastic state. After the initial failure, the flow may move, or creep, seasonally in response to destabilizing forces.

A debris side slope is defined as a geomorphic feature characterized by steep (generally greater than 65 percent), usually well vegetated slops that have been sculpted by numerous debris slide events. Vegetated soils and colluvium above shallow soil/bedrock interface may be disrupted by active debris slides or bedrock exposed by former debris sliding. Slopes near their angle of repose may be relatively stable except where there are weak bedding planes and extensive bedrock joints and fractures parallel to the slope.

A debris slide is defined as unconsolidated rock, colluvium, and soil that has moved slowly to rapidly downslope along a relatively steep (generally greater than 65 percent), shallow translational failure plane. It forms steep, unvegetated scars in the head region and irregular hummocky deposits (when present) in the toe region. Scars are likely to ravel and remain unvegetated for many years. Revegetated scars are recognized from aerial photographs by steep, even-faceted slopes and a light-bulb shape.

A debris flow/torrent track is defined as a long stretch of bare, generally unstable, stream channel banks scoured and eroded by the extremely rapid movement of water-laden debris. It is commonly triggered by debris sliding in the upper part of the drainage during high intensity storms. Scoured debris may be deposited downslope as a tangled mass of organic material in a matrix of rock and soil. Debris may be reactivated or washed away during subsequent events.

Disrupted ground is defined as an irregular ground surface caused by complex landsliding processes resulting in features that are indistinguishable or too small to delineate individually at the scale of mapping undertaken in this work. It may also include areas affected by downslope creep, expansive soils, and/or gully erosion. The boundaries are usually indistinct. Active slides, too, are too small to delineate at the scale undertaken in this work.

2. Erosion Hazard Ratings

Erosion hazard ratings (EHR) are recorded for the basin as compiled by CDF in a 10-year history of timber harvesting from 1987 through 1997. The recorded EHRs are self-reported (*Erosion Hazard Ratings (EHR) System for Sheet and Rill Erosion*, California Soil Survey Committee, 1989) and indicate that the basin is predominantly rated by landowners who have harvested timber in the last 10 years as medium in erosion hazard. High EHRs are recorded along several of the major tributaries of the Garcia River basin with extreme EHRs recorded in the upper reaches of the North Fork Garcia, the lower end of Hutton Gulch, along unnamed tributaries in Planning Watersheds 113.70021 and 113.70022, on the north side of Signal Creek, in the upper reaches of Inman Creek, and in the upper reaches of Whitlow Creek.

Louisiana-Pacific Corporation, which has not submitted many Timber Harvest Plans in the Garcia since 1987, reports in its draft *Sustained Yield Plan for Coastal Mendocino County* (1997) that Planning Watersheds 113.70020 through 113.70025 are predominated by high EHRs. Extreme EHRs are recorded in Ohlson Gulch, Alder Creek, some of the upper reaches of the

North Fork, the headwaters of Rolling Brook, several of the unnamed tributaries of Planning Watershed 113.70021 and 113.70022, and the upper reaches of Signal Creek. The marked difference in EHRs reported in Timber Harvest Plans versus that which is reported in LP's draft SYP indicates a degree of inconsistency in application of the EHR system amongst its users.

3. Summary of Geomorphology

Given the predominant geology (as described in the General Description of the Watershed section), geomorphic features, and erosion hazard rating, the Garcia River watershed can generally be described as unstable and highly erodible.

Riparian Functioning

1. Stream Channel Opening

The stream channel opening analysis conducted by Pacific Watershed Associates is described in the Problem Assessment section of the Reference Document and provides a general understanding of the changes in stream channel width throughout the basin over time. The width of the stream channel is a function of a number of different factors, including stream bank stability. Stream bank stability, in turn, is a function of a number of factors, including the density and maturity of the riparian zone. While the stream channel opening analysis does not directly measure the health of the riparian zone over time, it gives an indication of where in the stream system, the riparian zone has been more vulnerable to changes in the instream conditions.

The data indicates that dramatic changes in stream channel width have occurred since 1952 in the Larmour Planning Watershed (113.70011) with above average changes in Planning Watershed 113.70010 (Pardaloe), 113.70020 (Signal), 113.70021 (Graphite), 113.70022 (Beebe), and 113.70023 (South Fork). There has been no change in stream channel width in Planning Watershed 113.70014 (Inman) and 113.7026 (Hathaway). Despite greater stream channel opening now as compared to that which was exhibited in 1952, however, the data indicates that dramatic recovery has occurred since 1966.

2. Soil/Vegetative Regions

It is important to keep in mind that the soils of the Garcia River watershed support a variety of vegetative regions, not all of them including conifer tree species. In particular, the following tributary streams are bordered by soils supporting oak woodland/grassland and/or chaparral:

- Mid and upper Pardaloe Creek
- Small tributaries to Mill Creek (113.70010)
- Small tributaries to the Garcia River (113.70011)
- Small tributaries to Larmour Creek
- Small tributaries to Whitlow Creek
- Eastern bank of Blue Waterhole Creek

- Western bank of Garcia River (113.70021)

In addition, the following sections of the Garcia River mainstem are bordered by soils which have been converted from redwood type soils to cropland or pasture:

- 113.70023 below the confluence with the South Fork Garcia to Mill Creek
- 113.70024 below the confluence with Rolling Brook to the western Planning Watershed boundary
- 113.70025
- 113.70026 past the Manchester Rancheria

The lower portion of Planning Watershed 11.370026, including the estuary, is primarily cropland and contains few if any conifers in the riparian zone.

3. Lower Garcia River

Circuit Rider Productions, Inc. mapped the riparian vegetation of the lower 13 miles of the Garcia River using aerial photographs. Their work is described in the *Garcia River Gravel Management Plan* (1996) produced by Philip Williams & Associates for the Mendocino County Water Agency. In summary, Circuit Rider Productions, Inc. says of the historic conditions in the riparian zone that the Garcia once supported large stands of old growth Coast Redwood (Sequoia sempervirens)-- a species which occupied both the upland and riparian zones within the watershed. The main stem was extensively logged between approximately 1870 and 1910 and the tributaries were logged in the 1950s and 1960s.

Circuit Rider Productions, Inc. reports that the removal of large redwood trees which existed within the riparian zone would be expected to result in significant changes in vegetation and in-stream dynamics. As large, evergreen overstory trees, the redwoods would have shaded understory vegetation and the stream, resulting in a different understory assemblage than what exists in the present deciduous dominated riparian forest, as well as providing for a different assemblage of avifauna and wildlife.

Circuit Rider Productions, Inc. states that redwoods would have contributed much larger woody debris than is provided by species such as alder, walnut or mature willows, and the redwood logs would be expected to persist in the stream much longer than most riparian species, which are subject to rapid decay. Unlike many other riparian species, which are relatively short lived, the coast redwood lives for hundreds, or even thousands of years. Redwoods, like members of the willow family, develop adventitious roots along their trunks in response to siltation, and are well adapted to inundation.

Circuit Rider Productions, Inc. reports that without a detailed assessment of flood elevations and soils, it is not possible to determine the historic extent of riparian vegetation. Much of the floodplain had been cleared of vegetation by as early as 1850. Aerial photo coverages extend back to 1942, and land uses on the floodplain do not appear to have changed significantly within this fifty year period. An examination of remnant stands of large riparian trees on the floodplain terrace indicates that the areas presently in agricultural production may have historically supported mid-aged to late successional riparian habitat.

From its analysis of aerial photographs, Circuit Rider Productions, Inc. concludes that the majority of the existing 496 acre riparian zone along the lower 13 miles of the Garcia River is well vegetated and exhibits canopy closure as well as a diversity of land forms. A relatively greater percentage of the riparian habitat is in an early to mid-successional state, with no areas characterized by late successional vegetation of significant size. It remains to be seen, given the reclamation of much of the historic floodplain, whether the riparian zone within the study area will develop greater proportions of late successional or mature habitat over time. The natural trend towards development of late successional habitat may be constrained by adjacent land uses to such a degree that the system will continue to favor early successional habitat unless those constraints are removed.

4. Habitat Typing Data

Habitat typing data collected by contractors to the Mendocino County Resource Conservation District in 1991, identified in survey reaches in Mill Creek and Pardaloe Creek in the headwaters, the North Fork Garcia, and the Estuary, the composition and density of riparian vegetation and occurrence of large woody debris. Figure 23 summarizes the canopy-related data collected as part of the habitat typing conducted by the Mendocino County Resource Conservation District in 1991.

The data indicates that in those reaches surveyed, the canopy density (with the possible exception of Mill Creek) is generally poor. Further, the component of canopy attributable to coniferous tree species is generally low. This finding correlates with the additional finding that the occurrence of large woody debris (LWD) in these same survey reaches was also generally low.

Figure 23: Summary of canopy-related data collected as part of the habitat typing conducted by the Mendocino County Resource Conservation District, 1991.

Parameter	**Estuary (113.70026)**	**North Fork Garcia (113.70025)**	**Pardaloe Creek (113.70010)**	**Mill Creek (113.70010)**
Channel length surveyed (feet)	2,820	20,199	20,224	601
Canopy density (%)	13	48	18	71
Coniferous component (%)	0	9	15	41
Deciduous component (%)	100	91	86	59
Occurrence of LWD (%)	3	8	5	26

5. Instream Cover Data

The California Department of Fish and Game (DFG) has conducted stream surveys in various tributary basins throughout the Garcia River watershed since the mid-1980s. One parameter measured during these stream surveys is instream cover. The instream cover data collected by DFG is summarized in the Problem Statement section of the Reference Document. In general, the data indicates that undercut banks and overhanging vegetation are poorly developed cover components in the stream reaches surveyed. This finding suggests that stream banks may not be optimally vegetated with tree and shrub species and, as a result, banks may not be adequately protected from stream bank erosion.

6. Summary of Riparian Functioning

Stream channel widening since 1952 indicates that the riparian zone has not fully recovered since the large-scale timber harvesting operations of the 1950s and 1960s. Nonetheless, there has been significant recovery since 1966. The existing riparian zone-related data indicates that as a general matter, the riparian zone associated with many stream reaches in the Garcia River watershed are populated by deciduous trees and shrubs but have a dearth of coniferous tree species. Further, though not the case in the lower river or Mill Creek in the headwaters, many of the reaches of the basin have poor canopy closure, including poorly developed overhanging vegetation and undercut banks for instream cover. These findings indicate that stream banks continue to be excessively vulnerable to instream conditions, likely exacerbated by limited riparian vegetation in many places and limited large woody debris and large woody debris recruitment throughout much of the basin.

Erosional Processes Active in the Basin

1. Overview

Pacific Watershed Associates (1997) states that quantifying sediment sources involves determining the volume of sediment delivered to stream channels by the variety of erosional processes operating within the watershed. Their work is contained in Appendix C. For the Garcia River watershed, these can be divided into four primary processes or sediment delivery mechanisms: 1) mass movements (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 first three processes can deliver sediment to stream channels both naturally and as a result of land use activities. Sediment production by mass movement processes occurs commonly during large, infrequent storm events (episodic erosion), whereas fluvial and surface erosional processes can occur in any water year (chronic erosion) or as a result of large storms (episodic erosion). (PWA, 1997)

The fourth sediment delivery mechanism, the direct sedimentation to stream channels by heavy equipment, is a land use practice that was widespread in the Garcia River watershed prior to 1975. Since the implementation of the Z'berg-Nejedly Forest Practice Act in 1973, the practice of road building and yarding logs down stream channels which resulted in direct sedimentation into stream channels has been prohibited. Over the last three to four decades, the primary location where this mechanism of sediment delivery still occurs, to some extent, is where heavy equipment sidecast spoils along roads and skid trails. (PWA, 1997)

Because the existing data for the Garcia River watershed does not include a quantification of sediment delivery for each of the potential delivery sources in the basin, PWA compared the Garcia River watershed data to sediment budgets developed in other similar watersheds. In particular, the sediment budget for Redwood Creek in Humboldt County, comprehensively evaluates the proportion of sediment delivered from a variety of sources.

2. Mass Wasting Analysis

O'Connor Environmental, Inc. (OCEI) (1997) estimated annual and total sediment delivery to stream channels within the Garcia River basin from an analysis of aerial photographs covering the time period from 1957 to 1996-- a 40 year period. OCEI then modified the photo-based estimates to include the field data collected by Louisiana-Pacific Corporation in its assessment of mass wasting in the South Fork Garcia River and Rolling Brook. The modifications included an increase in sediment production from shallow rapid landsliding and inclusion of stream bank failure as a sediment delivery mechanism.

Pacific Watershed Associates (1997) further modified the estimates produced by OCEI based on its comparison of OCEI's estimates with those produced by Coastal Forestland, Ltd. (CFL). CFL also conducted an aerial photograph analysis but arrived at somewhat different results than did OCEI. CFL's assessment included analysis of only one set of aerial photographs. Thus, older landslides now obscured by tree cover were likely missed. However, the aerial photographs used by CFL were at a better scale for identifying smaller landslide features. As a result, CFL identified a larger overall number of mass wasting features than did OCEI. Pacific Watershed Associates (1997) estimates that the greater number of mass wasting features identified by CFL produced approximately 20% more sediment than was estimated by OCEI. A 20% modification is thus applied to OCEI's original sediment delivery estimates.

The average, modified, annual sediment delivery rate for the Garcia River watershed, including consideration of stream bank failures, then, is estimated at 405 tons/mi^2/year. The total annual sediment delivery is estimated at 1,852,660 tons. Figure 24 provides a summary of the mass wasting analysis results, including the modified estimates.

a. *Sediment Production in Individual Planning Watersheds*

As outlined in Figure 24, the basins producing sediment at rates higher than the basin-wide average include:

- Planning Watershed 113.70024 (Beebe Creek) 736 tons/mi^2/yr
- Planning Watershed 113.70012 (Stansbury/Whitlow Creeks) 588 tons/mi^2/yr
- Planning Watershed 113.70021 (Graphite Creek) 543 tons/mi^2/yr

Figure 24: Estimated total sediment delivery and average sediment delivery rates from mass wasting over the period of record (approximately 1957 to 1996) for individual Cal Water Planning Units in the Garcia River watershed. Adapted from O'Connor Environmental, Inc. (1997) and Pacific Watershed Associates (1997).

Planning Watershed	Predominant Sub-basins	Area (mi^2)	Original Sediment Delivery Rate ($t/mi^2/yr$)	Original Sediment Delivery estimate (tons)	Shallow rapid landslide component (tons)	Shallow rapid landslide component adjusted based on L-P data (tons)	Other landslide component adjusted based on CFL data (tons)	Estimated Inner gorge component (tons)	Total modified Sediment Delivery estimate (tons)	Modified Annual Sediment Delivery rate ($tons/mi^2/yr$)
113.70010	Pardaloe & Mill Creeks	16.4	8	5,500	5,500	8,250	0	137,800	146,050	223
113.70011	Larmour Creek & Garcia	10.2	211	86,000	34,800	52,200	61,440	85,700	199,340	489
113.70012	Stansbury Creek, Whitlow Creek & Garcia	6.2	298	74,000	16,400	24,600	69,120	52,100	145,820	588
113.70013	Blue Waterhole Creek	7.7	263	81,000	29,400	44,100	61,920	64,700	170,720	554
113.70014	Inman Creek	8.6	79	27,000	13,600	20,400	10,680	72,200	103,280	300
113.70020	Signal Creek	6.2	77	19,000	8,100	12,150	13,080	52,100	77,330	312
113.70021	Graphite Creek & Garcia	5.4	238	51,000	35,900	53,850	18,120	45,400	117,370	543
113.70022	Beebe Creek & Garcia	4.1	396	65,000	27,500	41,250	45,000	34,400	120,650	736
113.70023	South Fork & Garcia	8.7	218	76,000	21,600	32,400	65,280	73,100	170,780	491
113.70024	Rolling Brook, Lee Creek, Hutton Gulch & Garcia	12.5	156	78,000	40,400	60,600	45,120	105,000	210,720	421

Planning Watershed	Predominant Sub-basins	Area (mi^2)	Original Sediment Delivery Rate ($t/mi^2/yr$)	Original Sediment Delivery estimate (tons)	Shallow rapid landslide component (tons)	Shallow rapid landslide component adjusted based on L-P data (tons)	Other landslide component adjusted based on CFL data (tons)	Estimated Inner gorge component (tons)	Total modified Sediment Delivery estimate (tons)	Modified Annual Sediment Delivery rate ($tons/mi^2/yr$)
113.70025	North Fork & Garcia	16.2	157	102,000	78,000	117,000	28,800	136,100	281,900	435
113.70026	Hathaway Creek, Garcia & estuary	12.3	0	0	0	0	0	103,300	103,300	210
113.700	TOTAL	114.5	145 (avg)	664,500	311,200	466,800	423,960	961,900	1,852,660	405

- Planning Watershed 113 70013 (Blue Waterhole Creek) 554 tons/mi^2/yr
- Planning Watershed 113.70011 (Larmour Creek) 489 tons/mi^2/yr
- Planning Watershed 113.70023 (South Fork Garcia) 491 tons/mi^2/yr
- Planning Watershed 113.70025 (North Fork Garcia) 435 tons/mi^2/yr
- Planning Watershed 113.70024 (Rolling Brook) 421 tons/mi^2/yr

These basins produce over 75% of the mass wasting-related sediment in the basin, an estimated total of 1,417,300 tons/year. Pacific Watershed Associates (1997 draft) concludes that either these basins are: 1) more sensitive to disturbance than perceived by land managers, and/or 2) the current Forest Practice Rules are not adequately protecting water quality resources, and/or 3) land use activities have not been implemented in the field as proposed or recommended by the Forest Practice Rules.

The basins producing sediment at rates lower than the basin-wide average include:

- Planning Watershed 113.70026 (Hathaway Creek) 210 tons/mi^2/yr
- Planning Watershed 113.70010 (Pardaloe Creek) 223 tons/mi^2/yr
- Planning Watershed 113.70020 (Signal Creek) 312 tons/mi^2/yr
- Planning Watershed 113.70014 (Inman Creek) 300 tons/mi^2/yr

These Planning Watersheds produce less than 25% of the basin's mass wasting-related sediment, an estimated total of 429,960 tons/year. Pacific Watershed Associates (1997) concludes that these four Planning Watersheds may be inherently more stable and less prone to either natural or management induced mass wasting than the other Planning Watersheds in the watershed.

In six out of the twelve Planning Watersheds in the Garcia River watershed, the rate of sediment delivery associated with mass wasting was at its highest in 1965 and has steadily declined since that time. These Planning Watersheds include: 113.70011 (Larmour Creek), 11.370013 (Blue Waterhole Creek), 113.70020 (Signal Creek), 113.70021 (Graphite Creek), 113.70022 (Beebe Creek), and 113.70023 (South Fork Garcia). In four out of the twelve Planning Watersheds, the rate was at its highest in 1978 and has declined since that time. These Planning Watersheds include: 113.70010 (Pardaloe Creek), 113.70012 (Stansbury Creek), 113.70023 (Rolling Brook), and 113.70025 (North Fork Garcia). In only one Planning Watershed did the rate of sediment delivery associated with mass wasting reach its highest measured point in the period from 1978 to 1996. That Planning Watershed is 113.70014 (Inman Creek) where the rate of sediment delivery due to mass wasting has more than doubled since 1965 and more than tripled since 1978. Planning Watershed 113.70026 (Hathaway Creek) has had no significant measurable mass wasting in any of the periods investigated.

b. *Sediment Production Associated with Land use Activities*

In the 40 year period of study, O'Connor Environmental estimated that about 82% of the mass movement features were associated with either timber harvest units or roads, landings and skid trails. The remaining 18% was inferred to be of natural origin. About 22% of the shallow rapid landslides were associated with timber harvest units while 60% of them were associated with roads and skid trails. About 16% of the debris torrents were associated with timber harvest units while 63% were associated with roads and skid trails. About 75% of the persistent deep-seated landslides were associated with land use activity, but the breakdown between timber harvest units and roads and skid trails was not estimated.

In general, O'Connor Environmental, Inc. (1997) estimated that greater than 60% of the total number of mass movement features were associated with roads and skid trails while about 20% of them were associated with harvest units. The remaining 20% of the estimated sediment yield should be viewed as a minimum estimate of the natural, background sediment production from mass movement processes for each Planning Watershed for the 40 year time period studied. Roads and skid trails were judged to be associated with the largest proportion of the sediment delivery attributable to mass wasting.

3. Fluvial Erosion

According to Weaver and Hagans (1996), fluvial erosion includes gullies, road and skid trail crossing failures, and stream bank erosion caused by stream flow 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. Pacific Watershed Associates (PWA) compared the available sediment delivery data for the Garcia River watershed to sediment budgets developed for other similar watersheds and concluded that anywhere from 40-60% of the total sediment budget was attributable to fluvial and surface erosion processes. PWA (1997) estimates that of this non-landslide component of the sediment budget, 65-75% of it is attributable to fluvial erosion alone, including haul road, ranch road, and skid trail crossings; gullies along roads, skid trails and on adjacent hillslopes caused by stream diversion and concentrated runoff.

a. *Sediment Production associated to Roads, Landings and Skid Trails*

Studies conducted in the coastal and Cascade mountains of Northern California, Oregon and Washington have found roads to be a primary land use-related contributor to on-site erosion and downstream sediment yield that impact fish bearing streams (Swanson and Dyrness 1975, Swanston and Swanson 1976, Dyrness 1967, Reid 1981, Weaver et al. 1981a, Frissell and Liss 1986, Fiksdal 1974, Farrington and Savina 1977, LaHusen 1984, Hagans et al. 1986, Weaver et al. 1987b, and Pacific Watershed Associates 1994a and b).

One of the most damaging sources of fluvial erosion is from streams which are diverted out of their natural channels and flow down bare hillslopes when stream crossing culverts become plugged (Weaver and Hagans 1996). Not only will a diversion gully continue to deliver sediment to its down gradient stream course until it is repaired, but stream crossings inadequately designed to carry storm flows act as “loaded guns” ready to produce new gully diversions as soon as the crossings fail. Similarly, the ditch along the inside of a road (inside ditch) may overflow and cut across the fill surface if adequate relief (e.g., water bars or rolling dips) is not provided at critical intervals.

By comparison with sediment budgets developed in other similar watersheds (Casper Creek, Mendocino County; Navarro River, Mendocino County; Redwood Creek, Humboldt County) PWA has estimated that 26-45% of the overall sediment budget is attributable to fluvial erosion from roads and skid trails. See the Action Plan for an overall estimate of sediment delivery due to fluvial erosion.

b. *Sediment Production associated with Stream Bank Failure*

Though stream banks fail for a variety of reasons, all stream bank erosion results in sediment delivery to the stream. The concept of "dynamic equilibrium" assumes that low order, low gradient stream channel meander over time. Therefore, stream channel meandering necessarily results in the periodic erosion of stream banks. Stream banks also erode, however, when they are destabilized by the removal of vegetation or other armoring elements along the banks. Land use activity such as timber harvesting, grazing, or other similar human activity near the stream bank often times serve to destabilize the banks in the manner described above.

Louisiana-Pacific Corporation estimated the rate of inner gorge slope failure in its field work in the South Fork Garcia River and Rolling Brook. OCEI has referred to this as streamside landslides and reports L-P's estimate for sediment delivery as averaging 210 tons/mi^2/year. This figure is included in the mass wasting erosion component.

The stream channel opening analysis conducted by Pacific Watershed Associates (1997) provides an indirect indication of the amount of stream bank erosion which has occurred since 1952. Figure 25 estimates the miles of stream which have experienced stream bank erosion based on the stream channel opening data.

Figure 25: Estimate of the miles of stream affected by stream channel opening, adapted from PWA (1997).

Planning Watersheds	Miles of Class I stream	Percent stream channel open in the 1996 photos	Estimated miles of stream bank eroded by of 1996	Percent stream channel open in the 1952 photos	Estimated miles of stream bank eroded by of 1952	Estimated miles of stream bank eroded since 1952
113.70010	7.7	0.05	0.4	0.02	0.2	0.2
113.70011	5.1	0.19	1.0	0.04	0.2	0.8
113.70012	6.4	0.11	0.7	0.09	0.6	0.1
113.70013	5.2	0.11	0.6	0.15	0.8	-0.2
113.70014	7.5	0.02	0.2	0.02	0.2	0
113.70020	5.2	0.03	0.2	0.00	0	0.2
113.70021	5.4	0.10	0.5	0.06	0.3	0.2
113.70022	3.0	0.12	0.4	0.07	0.2	0.2
113.70023	3.1	0.25	0.8	0.20	0.6	0.2
113.70024	6.6	0.04	0.3	0.03	0.2	0.1
113.70025*	12.3	0.03	0.4	0.01	0.1	0.3
113.70026*	3.4	0.00	0	0.00	0	0

*The analysis conducted in Planning Watersheds 113.70025 and 113.70026 exclude assessment of the mainstem Garcia River based on the fact that these reaches were continuously open from 1952 to 1996.

Finally, several specific observations of stream bank erosion have been made in the lower river which appear to be associated with local land use changes (removal of riparian vegetation and channel encroachment) and obstacles such as fallen trees (Moffatt and Nichol 1995). These have drawn the attention of the Mendocino County Resource Conservation District and others since the landowners have sought assistance in repairing the bank failures occurring on their properties.

See the Action Plan for an overall estimate of sediment delivery due to fluvial erosion.

c. *Sediment Production associated with Agricultural Activities*

Fluvial erosion can occur when agricultural activities such as grazing, feed lots, row crops or other agricultural activities serve to concentrate runoff or stormwater flow. As with the other causes of fluvial erosion, sediment production associated with agricultural activities was not quantified as part of the Mass Wasting and Surface Erosion analyses conducted by O'Connor Environmental, Inc. Thus, there is no specific estimate of the amount of sediment production in the Garcia River watershed which is attributable to fluvial erosion associated with agricultural activities.

Fluvial erosion on agricultural lands associated with roads is included in the road-related component of the sediment budget. While other agricultural activities certainly contribute to the overall fluvial erosion-related sediment delivery rate for the Garcia River watershed, the contributions are assumed to be small relative to the other sources and are not included in the preliminary sediment budget. As site-specific data is collected, the preliminary sediment budget should be updated to include this component, as appropriate.

4. <u>Surface Erosion</u>

According to PWA (1997), surface erosion is 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. Surface erosion rates are increased when the soil surface is disturbed such as occurs during road or skid trail building and use, grazing, plowing, etc. Further, the likelihood of sediment delivery from surface erosion is increased when the riparian zone is disturbed. Loss of duff, grasses, shrubs, or trees along the stream corridor reduces the filtering capability of the riparian zone which otherwise serves to control the delivery of surface eroded sediment to the stream.

a. *Sediment Production associated with Roads and Skid Trails*

According to PWA(1997), current estimates of road and skid trail sediment production areas and volumes within the Garcia River watershed are limited to three sources: 1) the O'Connor Environmental, Inc. Surface Erosion Assessment (1997, draft), 2) the Coastal Forestlands, Ltd. (CFL) Watershed and Aquatic Wildlife Assessment, and 3) the Louisiana-Pacific Corporation Sustained Yield Plan (1997). All of the estimates include surface erosion from bare soil areas.

PWA (1997) reports that Coastal Forestlands, Ltd. and O'Connor Environmental, Inc. utilized similar methods in computing surface erosion from roads and skid trails. Each used the Washington State Watershed Analysis method which computes total tons of sediment delivered or tons/acre. CFL, however, did not report the results of its computations. Louisiana-Pacific Corporation used a modification of the Critical Sites Erosion Study method used by Lewis and Rice (1990). This method computes values as $yards^3$/acre/entry. Each entity used somewhat different assumptions and scenarios making comparison of the results difficult, though it appears that O'Connor Environmental, Inc. calculated erosion factors which are nearly an order of magnitude greater than those calculated by the companies.

O'Connor Environmental, Inc. assumed that annual rainfall in the basin overall is approximately 100 inches. It was assumed that the soils of the region are predominantly of the Hugh-Josephine complex which on steeper slopes (>30%) are generally described as having high to very high erosion hazard. It was assumed that erosion rates were higher for the first two years after road or skid trail construction, but declined following the first two years. For skid trails, it was assumed that skid trails were "refreshed" on each of three presumed harvesting cycles within the 40 year study period. Roads were assumed to be universally insloped with an inboard drainage ditch; to have a native surface road tread; to support general duty traffic; to have a cutslope gradient of 1:1 and fillslope gradient of 1.5:1; to have an initial ground cover density of zero on cut and fill slopes; and to have a gradient of 5-6%. Roads within 200 feet of a stream were assumed to deliver about 10% of the eroded soil. No sediment was assumed to be delivered from roads greater than 200 feet from a stream. Figure 26 summarizes OCEI's surface erosion estimates.

Though the estimates of surface erosion vary widely between O'Connor Environmental, Inc. and the other localized estimates, the basin-wide estimates at least allow for a comparison among Planning Watersheds. As outlined in Figure 26, the basins producing sediment at rates higher than the basin-wide average include:

- 113.70020 (Signal) 59 tons/mi^2/year
- 113.70021 (Graphite) 59 tons/mi^2/year
- 113.70014 (Inman) 58 tons/mi^2/year
- 113.70025 (North Fork) 58 tons/mi^2/year
- 113.70022 (Beebe) 56 tons/mi^2/year
- 113.70012 (Stansbury) 54 tons/mi^2/year
- 113.70013 (Blue Waterhole) 50 tons/mi^2/year
- 113.70024 (Rolling) 49 tons/mi^2/year
- 113.70011 (Larmour) 48 tons/mi^2/year
- 113.70023 (South Fork) 47 tons/mi^2/year

Figure 26: Summary of sediment delivery associated with surface erosion, adapted from OCEI (1997).

Planning Watershed	**Predominate Stream**	**Area (mi^2)**	**Estimated surface erosion from roads (tons)**	**Estimated surface erosion from roads ($t/mi^2/yr$)**	**Estimated surface erosion from skid trails (tons)**	**Estimated surface erosion from skid trails ($t/mi^2/yr$)**	**Estimated surface erosion from background creep (tons)**	**Estimated surface erosion from background creep ($t/mi^2/yr$)**	**Total estimated surface erosion ($t/mi^2/yr$)**
113.70010	Pardaloe	16.36	1,961	3	4,279	7	1,043	2	12
113.70011	Larmour	10.23	913	2	17,840	44	652	2	48
113.70012	Stansbury	6.21	2,165	9	10,820	44	396	2	54
113.70013	Blue Waterhole	7.70	1,287	4	13,426	44	491	2	50
113.70014	Inman	8.56	3,970	12	14,930	44	546	2	58
113.70020	Signal	6.18	3,178	13	10,770	44	394	2	59
113.70021	Graphite	5.35	2,740	13	9,328	44	341	2	59
113.70022	Beebe	4.10	1,676	10	7,151	44	261	2	56
113.70023	South Fork	8.74	393	1	15,239	44	557	2	47
113.70024	Rolling	12.50	1,428	3	21,790	44	797	2	49
113.70025	North Fork	16.21	7,653	12	28,256	44	1,033	2	58
113.70026	Hathaway	12.26	1,888	4	3,206	7	782	2	13
113.700	Garcia River Watershed	114.40	29,252	6 (average)	157,034	34 (average)	7,293	2 (average)	42 (average)

These Planning Watersheds produce approximately 94% of the surface erosion estimated in the Garcia River watershed.

Planning Watersheds 113.70010 (Pardaloe) and 113.70026 (Hathaway) are estimated to produce 12 and 13 tons/mi^2/yr of sediment, respectively. The contributions from these Planning Watersheds account for the remaining 6% of the surface erosion-related sediment yield estimated for the basin.

One of the variables included in the surface erosion assessment is road density. Road density statistics are given by CDF through is GIS which summarizes the data submitted in ten years of Timber Harvest Plans from 1987 to 1997. Native surface roads (dirt surface) present a greater risk of sediment delivery than do paved or rocked roads. Road densities, per Planning Watershed, range from 3.9 mi/mi^2 to 6.6 mi/mi^2 with an average of 5 mi/mi^2 in the basin overall. Native surface, seasonal roads, and temporary roads make up 78% of the total road density in the basin, an average of 4.1 mi/mi^2. Planning Watersheds 113.70014 (Larmour) and 113.70026 (Hathaway) have the lowest densities associated with native surface, seasonal roads, and temporary roads with less than 3.0 mi/mi^2. Planning Watershed 113.70020 (Signal) has the highest road density. Figure 27 summarizes the road density statistics. Another of the variables included in the surface erosion assessment is skid trail density. CDF does not have any specific statistics on the density of skid trails in each Planning Watershed. As such, OCEI made broad assumptions regarding the construction, use and density of skid trails throughout the basin. OCEI estimated the skid trail density at 27 mi/mi^2. This figure was used solely to predict basin-wide volumes of surface erosion. It does not, however, reflect known real conditions throughout the basin.

Figure 27: Summary of Road density statistics for the Garcia River Watershed compiled by CDF from a 10-year history of Timber Harvest Plans from 1987-1997.

Planning Watershed	**Predominant Stream**	**Permanent improved roads--rocked (mi/mi^2)**	**Unimproved seasonal and temporary roads--unsurfaced (mi/mi^2)**	**Total unpaved roads (mi/mi^2)**
113.70010	Pardaloe Creek	0.54	3.70	4.24
113.70011	Larmour Creek	1.33	2.61	3.94
113.70012	Stansbury Creek	1.20	4.54	5.74
113.70013	Blue Waterhole Creek	0.56	4.43	4.99
113.70014	Inman Creek	1.05	5.17	6.22
113.70020	Signal Creek	1.13	5.43	6.56
113.70021	Graphite Creek	1.93	4.10	6.03
113.70022	Beebe Creek	1.30	5.23	6.53
113.70023	South Fork Garcia	0.95	3.58	4.53
113.70024	Rolling Brook	0.93	4.76	5.69
113.70025	North Fork Garcia	1.56	4.83	6.39
113.70026	Hathaway Creek	1.76	3.06	4.82
113.700	GARCIA RIVER WATERSHED	1.19	4.29	5.48

b. *Sediment Production associated with Agricultural Activities*

Surface erosion can occur due to agricultural activities which disturb the soil surface, such as grazing, feed lots, plowing, etc. The Mass Wasting and Surface Erosion Module developed by O'Connor Environmental, Inc., however, did not consider surface erosion caused by such agricultural practices. As such, sediment production from surface erosion due to this land use has not been quantified. However, experience indicates that facilities such as feedlots, unguttered barns, over-grazed pastures, etc. often contribute surface eroded sediment to streams. Nonetheless, the volume and rates of surface erosion attributable to agricultural activities (other than roads) are assumed to small when compared to other sources and are not included in the Preliminary Sediment Budget described below. As site-specific data is developed, the sediment budget should be updated, including potential revisions to the overall Action Plan.

5. <u>Summary</u>

Sediment is delivered in the Garcia River watershed from a variety of sources, including mass wasting, fluvial erosion and surface erosion. Estimates of sediment delivery from mass wasting is derived from a 40 year history of aerial photographs and is adjusted based on field data. Seventy-five percent of the sediment delivered by this mechanism is delivered from 8 of the 12 Planning Watersheds in the basin. Sixty percent of the sediment delivered via mass wasting is estimated to be associated with roads while 20% is estimated to be associated with timber harvest units. The remaining is estimated to be associated with natural causes. Estimates of sediment delivery from surface erosion is derived from an assessment of road density statistics developed by CDF from 10 years of Timber Harvest Plans from 1987 to 1997 and measurements of skid trail densities in sample areas of the basin. Ninety-four percent of the sediment delivered by this mechanism is delivered from 10 of the 12 Planning Watersheds in the basin. No specific estimates of sediment delivery from fluvial erosion are developed. However, comparisons of the data in the Garcia River watershed to sediment budgets developed in other similar watersheds indicate that 40-60% of the overall sediment budget is attributable to fluvial and surface erosion. PWA (1997) concludes that of this non-landslide component of the sediment budget, 25-35% is attributable to surface erosion occurring on roads, cutbanks, ditches, skid trails and other bare soil areas. The final description of the average annual sediment load is located in the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan).

Preliminary Sediment Budget

1. <u>Sediment Inputs</u>

Pacific Watershed Associates (1997) reports that much of their initial attempt to determine the dominant processes and source areas of sediment production throughout the Garcia River watershed was based on the Level I watershed analysis conducted by OCEI (1997), and aided by Sustained Yield Plans prepared by CFL and LP, two of the larger landowners in the watershed. The receipt of LP Level II watershed analysis preliminary findings, based on field studies conducted during the summer of 1997 greatly improved their ability to assess the relative magnitude and distribution of sediment sources in the Garcia basin.

PWA (1997) further reports that over a 45 year period (1952-1997), the best available data for a portion of the lower Garcia River watershed indicates the long term sediment production rate averages, at a minimum, to be 1,380 tons/mi^2/year. The minimum rate of long term sediment production of the Garcia compares reasonably well with estimates of long term sediment production in two other North Coast watersheds, the Navarro River basin and Caspar Creek watershed.

PWA (1997) concludes that the estimated sediment production rate for the period of record should be considered a minimum value because several categories of sediment production have not been quantified by the existing studies. These include surface erosion on skid trails, sediment yield from road cutbanks and ditches, stream bank erosion caused by fluvial processes, and the movement of instream stored sediment. In addition, a Level II watershed analysis is needed throughout the more inland portions of the Garcia basin to determine if this long term rate is applicable to the entire watershed.

PWA (1997) estimates that based on the currently available data, the combined mass movement and stream bank erosional processes have accounted for between 40 and 60% of the average annual sediment production in the Garcia River watershed over the 45 year period from 1952 to 1997. Consequently, a comparable 40 to 60% of the long term average annual sediment production is associated with fluvial and surface erosional processes largely occurring along roads, skid trails and other bare soil areas.

PWA (1997) further estimates that of this latter non-landslide component, 65 to 75% of the sediment yield is associated with fluvial erosion at haul road, ranch road and skid trail stream crossings; and at gullies along roads, skid trails, and on adjacent hillslopes caused by stream diversions and concentrated runoff. The remaining 25 to 35% is judged to be derived from surface erosion processes (sheet wash and rill erosion) occurring on roads, cutbanks, ditches, skid trails and other bare soil areas. PWA (1997) suggest that their estimate of sediment production attributed to each erosion process is generally supported by the results of the LP Level II analysis completed in the summer of 1997.

2. <u>Instream Stored Sediment</u>

PWA (1997) evaluated data collected by LP 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. PWA (1997) reports that according to the LP data, 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. The steeper, lower order channels either did not store large volumes of sediment, or they have flushed much of their stored sediment to downstream areas. Figure 28 summarizes the data collected by LP.

Figure 28: Summary of instream stored sediment data collected by LP as presented by PWA (1997).

Inferred Stream Order	Length of inventoried stream (mi)	Sediment stored in terraces and floodplains (yd^3/mi)	Sediment stored in terraces and floodplains (%)	Sediment stored in the active channel (yd^3/mi)	Sediment stored in the active channel (%)
1 and 2+	5.8	3,650	19%	1,150	16%
3 and 4	6.9	12,900	81%	5,000	84%
Total	12.7	---	100%	---	10%

PWA (1997) concludes that a small percent 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. Much of it is now in longer term storage and may take up to a century or longer to release. However, stored sediment in the active channel compartment generally have much shorter residence times and can be expected to move more quickly (Madej and Ozaki, 1996). Remobilization of active channel-stored sediment could serve as a measurable contributor to sediment yield which can continue to delay full aquatic habitat recovery. PWA (1997) further concludes that the stored sediment within steeper gradient, lower order tributary channels will not be a sizable source of future sediment yield to fish bearing streams when compared to other potential hillslope sediment sources.

3. <u>Sediment Output</u>

The USGS conducted a bedload and suspended sediment load analysis from the Eureka Hill Bridge in water year 1992-1993. Philip Williams and Associates (1996) summarized the results of this data on a bedload rating curve and suspended sediment rating curve. Bedload transport is described by $Q_s = (0.0000004) \times Q^{2.6}$ where Q_s is bedload in tons per day and Q is discharge in cfs. Suspended sediment load transport is described by $Q_s = (0.000004) \times Q^{2.65}$ where Q_s is suspended load in tons per day and Q is discharge in cfs.

Philip Williams & Associates (1996) estimated the average annual bedload sediment transport rate to be about 160 tons/mi^2/year, equivalent to 13,420 tons/year and 9,940 yd^3/year. This compares to other estimates derived in Environmental Impact Reports for gravel mining of 27,000 tons/year (Fugro West, Inc., 1994) and 22,600 to 54,400 tons/year (Rau, Haydon, Bordessa, Franz, and Associates, 1990). Philip Williams & Associates (1996) estimated that bed material load was about 8 percent of the suspended load. Thus the average annual sediment output is estimated to be 2,160 tons/mi^2/year.

4. <u>Overall Sediment Budget</u>

The average annual sediment load is described in the Source Analysis section of the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan). The Reference Document found that the assessments conducted by PWA (1997) and Philip Williams & Associates (1996) indicate that at a minimum 1,380 tons/mi^2/year of sediment are entering the Garcia River watershed while 2,160 tons/mi^2/year are existing it. According to Philip Williams & Associates (1996) historic gravel mining extraction rates for the Garcia River 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 tons/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 result of the big storms over these years and/or that sediment production through the watershed from upstream hillslope areas was not severe.

Summary of Upland Data

Figure 29 summarizes the upland data present in the Garcia River Watershed. For general assessment purposes, the Planning Watersheds in which parameters were higher-- or lower than the basin wide average, depending on the parameter, were highlighted. Riparian zone canopy was assessed in terms of its relationship with the requirements in the Forest Practice Rules for canopy retention. The coniferous component was judged to be low if it was less than 50% of the canopy covering the riparian zone. The occurrence of large woody debris was judged to be low if less than 25% of the stream reaches surveyed contained large woody debris. And, instream cover associated with undercut banks and overhanging vegetation was judged to be low if the rating was less than 30.

Problem Statements

Specific Problem Statement 1: Increased sediment delivery to the Garcia River watershed impacts or is likely to impact stream channel stability by causing: 1) aggradation, stream channel widening, greater flood potential, and greater stream bank erosion and 2) the burial of channel structural elements such as large woody debris with a reduction in 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.

Specific Problem Statement 2: The removal of vegetation (particularly large conifers) from the riparian zone of the Garcia River watershed causes or is likely to cause: 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.

Specific Problem Statement 3: The density and use of roads, landings, skid trails, and agricultural facilities in the Garcia River watershed causes or is likely to cause: 1) increased surface erosion

Figure 29: Summary of all relevant upland data.

PARAMETERS	113. 70010	113. 70011	113. 70012	113. 70013	113. 70014	113. 70020	113. 70021	113. 70022	113. 70023	113. 70024	113. 70025	113. 70026
Geology												
Annual mass wasting sediment delivery rate (tons/mi²/yr)	223	489	588	554	300	312	543	736	491	421	435	210
Annual sediment delivery rate due to surface erosion (tons/yr)	12	48	54	50	58	59	59	56	47	49	58	13
Predominant EHR	?	?	M	M	M	H	M	M	?	?	M	?
Total road density (mi/mi²)	4.24	3.93	5.73	4.99	6.22	6.56	6.03	6.53	4.52	5.68	6.39	4.83
Total native surface road density (mi/mi²)	3.63	2.60	4.54	4.43	5.16	5.42	4.01	5.18	3.58	4.66	4.96	3.01
Riparian Functioning												
% of stream corridor with soils which support conifer	>75 M >50 P	>75	>75	>75	>75	100	>75	100	>75	>75	>75	<25
Riparian zone canopy density	71 M 18 P	?	?	?	?	?	?	?	?	?	48	13
Coniferous component of riparian zone (%)	41 M 15 P	?	?	?	?	?	?	?	?	?	9	0
Occurrence of large woody debris (%)	26 M 5 P	?	?	?	?	?	?	?	?	?	8	3
Instream cover rating for undercut banks	2 M 0 P	?	?	?	?	?	?	?	?	?	?	5 H 14 G
Instream cover rating for overhanging vegetation	30 M 30 P	?	?	?	?	?	?	?	?	?	?	80 H 13 G

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.

Specific Problem Statement 4: Operations on unstable slopes (e.g., inner gorges, headwall swales, active or potentially active landslides, or steep slopes) in the Garcia River watershed cause or are likely to 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.

IV. LOADING CAPACITY CALCULATION

Introduction

The Loading Capacity Calculation is contained in the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan). The Loading Capacity Calculation section of the *Reference Document for the Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Reference Document) combines the existing information associated with instream and upland conditions in an attempt to develop associations between the two sets of information. The existing information is relatively voluminous; but it nonetheless does not specifically and comprehensively describe the relationship between the upland and instream environments. A general understanding of the relationship, however, can be ascertained by developing hypotheses regarding the impacts one might expect in the instream environment as a result of upland conditions and determining if the instream data supports the hypotheses.

Summary of the Existing Data

Figure 30 at the end of this section includes all of the relevant instream and upland data existing for the watershed. The figure identifies general characteristics of the individual Planning Watersheds (and tributaries, where appropriate), and highlights those Planning Watersheds in which specific parameters are above or below the basin wide average, depending on the parameter. It also highlights those Planning Watersheds in which specific parameters do not meet associated thresholds. Thresholds are discussed in the Numeric Targets and Source Analysis sections of the Reference Document, depending on the parameter.

Synthesis

A series of hypotheses are made regarding the likely relationships between upslope and instream conditions. A general assumption is made that mass wasting predominantly delivers coarse sediment to the stream while surface erosion predominantly delivers fine sediment. Road density (miles of road per square mile) is used as a surrogate for the potential for any erosion from road systems.

Hypotheses

1. In Planning Watersheds where there are high rates of sediment delivery from mass wasting or fluvial erosion or the density of roads is high, pool habitat is likely to be limited.
2. In Planning Watersheds where there are high rates of sediment delivery from surface erosion or the density of unsurfaced roads is high, spawning habitat is likely to be limited.
3. In Planning Watersheds where canopy cover and the component associated with conifers is low, the occurrence of large woody debris is likely to be low.
4. In Planning Watersheds where the occurrence of large woody debris is low, the development of diverse habitat niches, including pools and sorted gravels is likely to be limited.
5. In Planning Watersheds where sediment delivery from mass wasting and road density is low and the occurrence of large woody debris is high, pool habitat is not likely to be limited.

6. In Planning Watersheds where sediment delivery from surface erosion is low, the density of unsurfaced roads is low, and the occurrence of large woody debris is high, spawning habitat is not likely to be limited.

<u>Observations</u>

These hypotheses are tested by comparing the relevant instream and upland data to see if the predicted correlations exist in any of the Planning Watersheds. The following general observations can be made:

Planning Watershed 113.70010

The elevated fines in Mill Creek are neither explained by the road density, surface erosion, or occurrence of large woody debris. Either the sampling locations are ones which demonstrate naturally high levels of fines or another land use besides roads is contributing fine sediment to the stream system. Coho have not been noted in the Mill Creek and steelhead densities are below the basin wide average. But redd densities are among the highest in the watershed suggesting that while spawning is occurring, embryo development and/or emergence may not be optimal.

The poor pool development in Pardaloe Creek while not explained by road density or mass wasting, is accompanied by a low occurrence of large woody debris, low conifer development in the riparian zone, and low under cut bank development (suggesting limited stream bank strength due to tree root development). Further, the soils along the stream corridors of the Pardaloe Creek sub-basin, particularly in the mid and upper reaches of the drainage, do not support coniferous tree species, but oak woodland/grasslands and chaparral, instead. As such, the development of large woody debris may be naturally lower than in other sub-basins in the watershed. As with Mill Creek, coho have not been noted in the Pardaloe Creek sub-basin and steelhead densities are below the basin wide average. But, redd densities are among the highest in the watershed suggesting that while spawning is occurring, rearing habitat may not be optimal.

Planning Watershed 113.70011

Not enough information regarding the instream conditions exists from which to preliminarily determine the potential links between upland and instream conditions. Mass wasting is higher than the basin wide average as is the surface erosion, though road densities are below the basin wide average. Stream channel opening recovery in this Planning Watershed is slower than elsewhere in the basin.

Planning Watershed 113.70012

Not enough information regarding the instream conditions exists from which to preliminarily determine the potential links between upland and instream conditions. Mass wasting is higher than the basin wide average as is surface erosion and road density. Stream channel opening recovery in this Planning Watershed is faster than the basin wide average.

Planning Watershed 113.70013

The elevated fines in Blue Waterhole Creek can be explained by higher than average surface erosion and unsurfaced road density. The occurrence of large woody debris-- or the potential for recruitment-- has not been measured in this Planning Watershed. The poor pool development in Blue Waterhole Creek can be explained by higher than average mass wasting, though the total road density is lower in Planning Watershed 113.70013 than the basin wide average. Coho have not been measured in this Planning Watershed and steelhead biomass is lower than the basin wide average. There is no redd density data.

Planning Watershed 113.70014

The elevated fines (<6.5 mm) can be explained by higher than average surface erosion and unsurfaced road density. The occurrence of large woody debris-- or the potential for recruitment-- has not been measured in this Planning Watershed. There is no data regarding the condition of pools in Inman Creek, though the mass wasting is lower than the basin wide average. Coho have been noted in this Planning Watershed though no fish population surveys have been conducted there. Redd densities are lower than the basin wide average suggesting that spawning conditions are not optimal.

Planning Watershed 113.70020

There is no data regarding the condition of spawning gravels in Signal Creek, though the predominant substrate is reported to be of rubble size. The excellent pool development can be explained by the lower than average mass wasting. However, the road density in this Planning Watershed is the highest in the basin suggesting the potential for road related erosion. The soils in this sub-basin are entirely capable of supporting coniferous tree species, but no data regarding large woody debris-- or the potential for recruitment-- has been collected. Coho have been noted in this Planning Watershed and steelhead densities are greater than the basin wide average. Redd densities, however, are lower than the basin wide average suggesting that spawning habitat may not be optimum but rearing habitat is well developed.

Planning Watershed 113.70021

Not enough data regarding the instream conditions exists from which to preliminarily determine the potential links between upland and instream conditions. Mass wasting is higher than the basin wide average as is surface erosion and total road density. Stream channel opening recovery in this Planning Watershed is slower than the basin wide average. While the density of fish-bearing and potentially fish bearing streams is reported to be higher than the basin wide average, the gradient of tributary streams is relatively high.

Planning Watershed 113.70022

Not enough data regarding the instream conditions exists from which to preliminarily determine the potential links between upland and instream conditions. Mass wasting is higher in this Planning Watershed than elsewhere in the basin. In addition, surface erosion, total road density and unsurfaced road density is higher than the basin wide average. Stream channel opening recovery in this Planning Watershed is slower than the basin wide average. While the density of fish-bearing and potentially fish bearing streams is reported to be higher than the basin wide average, the gradient of tributary streams is relatively high.

Planning Watershed 113.70023

There is no data regarding the condition of spawning habitat, though the predominant substrate is reported to be of rubble size in the South Fork Garcia and gravel size in Fleming Creek. The sub-optimal pool development can be explained by higher than average mass wasting. The assumed reduced risk of erosion due to a lower than average road density, however, is a confounding factor. There is no data on the occurrence of large woody debris or its potential recruitment from the riparian zone. The soils within the Planning Watershed, however, are capable of supporting coniferous tree species. The stream channel opening recovery in this Planning Watershed is slower than the basin wide average. Coho have been collected as have steelhead, though the steelhead biomass is lower than the basin wide average. Redd density, too, is lower than the basin wide average suggesting that neither spawning nor rearing conditions are optimal.

Planning Watershed 113.70024

There is no information regarding the condition of spawning habitat, though the predominant substrate size is reported to be of gravel size in Rolling Brook and rubble size in Lee Creek. The sub-optimal pool development can be explained by higher than average mass wasting and road density. There is no data on the occurrence of large woody debris or its potential recruitment from the riparian zone. The soils within the Planning Watershed, however, are capable of supporting coniferous tree species. The stream channel opening recovery in this Planning Watershed is faster than the basin wide average. Coho have not been measured in this Planning Watershed, but steelhead biomass is lower than the basin wide average. There is no data on redd density.

Planning Watershed 113.70025

Elevated fines can be explained by higher than average surface erosion and unsurfaced road density. Pool density was measured in an individual sampling location as optimal; but, in the habitat typing conducted throughout the stream channel it was measured as sub-optimal (see Problem Statement section). The sub-optimal pool development can be explained by higher than average mass wasting and road density, as well as a low occurrence of large woody debris and the potential for future recruitment. The soils within the Planning Watershed are capable of supporting coniferous tree species. Coho have not been measured in this Planning Watershed, but steelhead biomass is higher than the basin wide average. There is no redd density data.

Planning Watershed 113.70026

There is no data regarding the condition of spawning gravels in Hathaway Creek, though the predominant substrate is reported to be of silt size. Neither surface erosion or unsurfaced road density can explain the silt of which Hathaway Creek is composed. The substrate particle size is most likely a function of the proximity to the estuary and the upland soils associated with much of this Planning Watershed. The optimal pool development in Hathaway Creek can be explained by the lower than average mass wasting and road density. There is no data regarding the occurrence of large woody debris in Hathaway Creek-- or the potential for recruitment. And, though there is substantial overhanging vegetation, the soils in Hathaway Creek do not generally support the development of coniferous tree species. Coho have been noted in Hathaway Creek but no fish population surveying has been completed. There is also no data regarding redd density which is presumed to be low due to the substrate.

There is no data regarding the condition of spawning gravels in the Garcia River mainstem, though the predominant substrate is reported to be of gravel size. The sub-optimal pool development in the Garcia River mainstem is neither explained by mass wasting or road density, though the occurrence of large woody debris is low as is the potential for recruitment. Further, stream banks do not appear to be well vegetated and supported by substantial tree root systems. The soils of this Planning Watershed do not generally support the development of coniferous tree species. Coho have been noted in the lower mainstem Garcia River and steelhead biomass is reported to be lower than the basin wide average. There is no redd density data.

Summary

While the relationship between instream and upland conditions is not perfectly explained by the existing data, a general picture of the impacts and likely causes does emerge. Sediment delivery from human caused mass wasting, fluvial erosion and surface erosion has an impact on instream conditions, including pool and spawning gravel characteristics. Further, the condition of the riparian zone also has an impact on instream conditions, including pool and spawning gravel characteristics, availability of large woody debris and habitat niches. The hypotheses identified above require further testing through the development and assessment of additional data. As site-specific data is collected, the assessment should be updated, including potential revisions to the Reference Document.

Figure 30: Summary of all the relevant instream and upland data and information

PARAMETERS	113. 70010	113. 70011	113. 70012	113. 70013	113. 70014	113. 70020	113. 70021	113. 70022	113. 70023	113. 70024	113. 70025	113. 70026
General												
Total Acres	10,473	6,550	3,972	4,929	5,481	3,954	3,425	2,625	5,595	7,999	10,373	7,847
Total square miles	16.4	10.2	6.2	7.7	8.6	6.2	5.4	4.1	8.7	12.5	16.2	12.3
% of total watershed	14	9	5	7	8	5	5	4	8	11	14	11
Total stream density (mi/mi^2)	5.10	4.46	6.48	4.82	9.31	6.78	7.11	6.30	2.60	3.12	6.54	2.78
Total density of Class I, II and unclassified perennial streams (mi/mi^2)	0.99	1.78	2.26	2.21	2.74	2.32	2.66	3.16	1.46	1.56	2.61	1.59
Predominant landowner	M	M	B	B	CFL	CFL	CFL	CFL	LP	LP	CFL	S
Relative relief per acre	0.17	0.32	0.58	0.43	0.36	0.50	0.60	0.83	0.37	0.28	0.22	0.22
Land use												
Predominant vegetation type (based on soils)	ME/ OW	ME	ME/ RF	RF	RF	RF	RF	RF	RF	RF	RF	C
% permitted for land conversion in 1960s	17	27	17	64	0	0	0	0	0	0	0	0
Hydrology												
Drainage area (acres)	10,473	17,023	20,995	25,924	5,481	3,954	38,784	41,409	47,004	55,003	65,376	73,223
Estimated bankfull flow (cfs)	2,335	3,796	4,682	5,781	1,222	882	8,648	9,233	10,481	12,265	?	?
Average annual rainfall (inches)	60	70	65	65	75	65	65	60	55	55	60	45
Geology												
Annual mass wasting sediment delivery rate ($tons/mi^2/yr$)	223	489	588	554	300	312	543	736	491	421	435	210
Annual sediment delivery rate due to surface erosion (tons/yr)	12	48	54	50	58	59	59	56	47	49	58	13
Predominant EHR	?	?	M	M	M	H	M	M	?	?	M	?
Total road density (mi/mi^2)	4.24	3.93	5.73	4.99	6.22	6.56	6.03	6.53	4.52	5.68	6.39	4.83
Total native surface road	3.63	2.60	4.54	4.43	5.16	5.42	4.01	5.18	3.58	4.66	4.96	3.01

PARAMETERS	**113. 70010**	**113. 70011**	**113. 70012**	**113. 70013**	**113. 70014**	**113. 70020**	**113. 70021**	**113. 70022**	**113. 70023**	**113. 70024**	**113. 70025**	**113. 70026**
density (mi/mi^2)												
Riparian Functioning												
% of stream corridor with soils which support conifer	>75 M >50 P	>75	>75	>75	>75	100	>75	100	>75	>75	>75	<25
Riparian zone canopy density	71 M 18 P	?	?	?	?	?	?	?	?	?	48	13
Coniferous component of riparian zone (%)	41 M 15 P	?	?	?	?	?	?	?	?	?	9	0
Occurrence of large woody debris (%)	26 M 5 P	?	?	?	?	?	?	?	?	?	8	3
Instream cover rating for undercut banks	2 M 0 P	?	?	?	?	?	?	?	?	?	?	5 H 14 G
Instream cover rating for overhanging vegetation	30 M 30 P	?	?	?	?	?	?	?	?	?	?	80 H 13 G
Channel morphology												
Channel slope @ mouth of major tributaries (%)	1-3	3-5	1-3	3-5	1-3	1-3	10-15	10-15	3-5	3-5 RB 1-3 HG	3-5	<1
Predominant channel slope (%)	<3	<1	<3	<5	<3	<7	<7	<7	<5	<3	<3	<3
Predominant particle size identified by DFG	grvl P rbbl M	?	?	bldr	?	rbbl	?	?	rbbl SF grvl F	grvl RB rbbl L	grvl	silt H grvl G
Average percent fines <0.85 mm	25.80	?	?	18.2	12.8 I 15.8 G	?	?	?	?	?	24.53	?
Range of percent fines <0.85 mm	19-32	?	?	18.2	12.8 I 15.8 G	?	?	?	?	?	13-31	?
Average percent fines <6.5 mm	55.70	?	?	46.7	36.7 I 51.8 G	?	?	?	?	?	44.03	?
Range of percent fines <6.5 mm	54-58	?	?	46.7	36.7 I 51.8 G	?	?	?	?	?	27-52	?
Predominant confinement in the Garcia River	NA	C	MC/C	C	NA	NA	C	MC/C	MC	MC/C	U	U/MC
% 1996 channel is open	5	19	11	11	2	3	10	12	25	4	3*	0*

PARAMETERS	**113. 70010**	**113. 70011**	**113. 70012**	**113. 70013**	**113. 70014**	**113. 70020**	**113. 70021**	**113. 70022**	**113. 70023**	**113. 70024**	**113. 70025**	**113. 70026**
% change from 1952 channel	+3	+15	+2	-4	0	+3	+4	+4	+5	+1	+2	0
Aquatic Habitat												
Average percent pools	24 M 32 P	?	?	30	?	50	?	?	30 SF 33 F	15 RB 15 L	29	75 H 22 G 56 E
Largest cover component and average rating	O/V-30 M O-80 P	?	?	O-40	?	O-60	?	?	O-49 SF O-42 F	O-70 R B O-50 L	?	V-50 H V-22 G
Are there any natural barriers to migration?	Yes	Yes	No	Yes	No	No	No	No	No	No	Yes	No
Highest steelhead biomass (kg/hectare) and year	53.87 (1994)	?	?	50.05 (1987)	?	109.09 (1995)	?	?	37.11 (1987)	76.94 (1987)	194.66 (1983)	48.72 (1987)
Highest coho biomass (kg/hectare) and year	NA	?	?	NA	?	NA	?	?	19.88 (1988)	NA	NA	NA
Have coho been noted?	No	?	?	?	Yes	Yes	?	?	Yes	?	?	Yes
Highest redd density (redd/mile) and year	22.0 1995-6	?	?	?	2.5 1996-7	8.6 1995-6	?	?	9.8 1989-0	?	?	?

Shaded boxes are those Planning Watersheds in which the parameter in question is greater or lesser than average, depending on the parameter, or exceeds a threshhold limit.

* The channel opening analysis in Planning Watershed 113.70025 and 113.70026 did not include assessment of the Garcia River mainstem since it was predominantly open in the 1952 photographs.

Symbols

Predominant Landowner
- M=Mailliard
- B=Bewley
- CFL=Coastal Forestlands, Ltd.
- LP=Louisiana-Pacific Corporation
- S=Stornetta

Predominant vegetation type
- ME=Mixed evergreen
- OW=Oak woodland
- RF=Redwood forest
- C=Cropland

Predominant EHR (Erosion Hazard Rating)
- M=Medium
- H=High

Channel morphology and Aquatic habitat
- RB=Rolling Brook
- HG=Hutton Gulch
- P=Pardaloe Creek
- M=Mill Creek (113.70010)
- SF=South Fork Garcia
- F=Fleming Creek
- L=Lee Creek
- H=Hathaway Creek
- G=Garcia River
- I=Inman Creek
- E=Estuary

Predominant particle size
- grvl=gravel
- rbbl=rubble
- bldr=boulder

Predominant confinement
- C=confined
- MC=moderately confined
- U=unconfined

Largest cover component
- O=instream object
- V=overhanging vegetation

V. LOAD ALLOCATIONS

Introduction

The Load Allocations are described in the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan). The Load Allocations section of the Reference Document is directly tied to a body of known conservation measures or Best Management Practices (BMPs). The Load Allocations provide a quantitative assessment of 1) the protection of beneficial uses, and 2) the implementation and success of mitigation, altered land management, and restoration.

General Discussion

A Total Maximum Daily Load (TMDL) is the calculation of the maximum amount of a pollutant that can be discharged to a waterbody while still supporting beneficial uses. In the case of the Garcia River watershed, the pollutant of concern is sediment and the beneficial uses of concern relate to the cold water fishery, particularly the coho salmon fishery. The TMDL is expressed as the sum of the waste load allocations for point sources, the load allocations for nonpoint sources, natural background, and a margin of safety. The waste load allocations are the maximum amount of discharge allowed of individual point source dischargers. The load allocations are the maximum amount of discharge allowed of individual non-point source dischargers. In the case of the Garcia River watershed, there are no point source dischargers discharging sediment. The predominant non-point source dischargers of concern include timber harvesting operations and agricultural operations. The *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan) serves as a phased TMDL, implementation plan, and monitoring plan for the Garcia River watershed.

Three main issues were considered when developing the load allocation for sediment in the Garcia River watershed.

1. Sediment discharge does not occur uniformly across the landscape. Factors such as geology, soil type, vegetation, topography, hydrology, and others influence the rate of erosion and sediment discharge from any given point. The Garcia River watershed ranges from 2,470 feet at the headwaters to sea-level at the mouth. It includes oak woodland/grasslands, chaparral, coastal cypress/pine forest, redwood forest, mixed evergreen forest, coastal prairie/scrub and northern seashore plant communities. The basin geography is defined by various geologic faults, including the San Andreas Fault. Because of these factors, and others, erosion and sediment delivery is extremely variable within the basin. With the existing data limitations, a load allocation, such as expressed in a TMDL equation, can only be applied on average across the landscape. It can not be practically applied to any specific location or activity within the basin.
2. Sediment discharge occurs seasonally, primarily in response to storm events. In addition, the intensity of storm events is variable from year to year and decade to decade. As such, the TMDL for the Garcia River watershed is expressed as a long term annual average sediment loading 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 load, but expressing the TMDL as an annual average yield better reflects the dynamic nature of sediment movement throughout a watershed over time. The annual loading rate for this TMDL will be averaged over 40 years. The longer term annual average timestep is an appropriate approach to account for the large interannual variability in sediment loading, the period of record from which the sediment budget was derived and the long term timeframe in which beneficial use impacts occur and change.

3. Sediment *discharge* is only one component of the sedimentation problem in the Garcia River watershed. Remobilization of sediment stored in the watercourse channel and floodplain is another component not fully addressed by the TMDL calculation. The TMDL for the Garcia River watershed attempts to account for this issue and other limitations of the TMDL by incorporating conservative assumptions, in addition to the quantitative margin of safety used to calculate the TMDL.

It is based on these issues that the Action Plan includes a load allocation that is indirectly derived from the TMDL calculation. The load allocation as expressed in the Action Plan directs landowners "to identify and control all existing and future controllable discharges of sediment." In other words, the load allocation is zero controllable discharges for all landowners. (It is understood that mitigation measures to control sediment discharges are not 100% effective.) What follows is a discussion of the relationship between this innovative load allocation found in the Action Plan which is derived from the standard TMDL equation. To be clear, while a numeric load allocation can be derived from the standard TMDL equation, its practical utility is limited because of the issues described above. The load allocation has been redefined in the proposed Action Plan so as to provide a more useful and immediately implementable tool for the control of sediment discharges.

The zero controllable discharge allocation approach taken in the Action Plan provides an implementation tool that is much more readily applied in considering the need for sediment controls. Federal regulations provide for the adoption of load allocations expressed as "gross allotments." 40 CFR 130.2 The discharge allocation found in the Action Plan is consistent with the regulatory definition of load allocation.

Technical Rationale for the Load Allocation

The Code of Federal Regulations, Parts 130.2 and 130.7 describe a TMDL as including the following elements: a wasteload allocation, load allocation, estimate of natural background, and a margin of safety. For the purposes of sediment control in the Garcia River watershed, the TMDL has been calculated as a total maximum annual load averaged over a 40-year time period, as discussed above. The TMDL for the Garcia River watershed and the margin of safety is described in the Loading Capacity Calculation section of the Action Plan.

The Load Allocation figure described in the Action Plan estimates that which can be discharged from roads and timber harvest operations, including landings, skid trails, and timber harvest units. The sediment budget contained in the Action Plan does not include estimates of non-road related agricultural contributions of sediment. Were an average allowable discharge to be applied as a load allocation, however, it would be applied to all land uses across the watershed. This would be a conservative approach befitting the first phase of a TMDL for which the data were limited.

Analysis of the Load Allocation contained in the Action Plan

The load allocation contained in the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan) directs landowners "to control all existing and future controllable discharges of sediment." Controllable discharges are defined as discharges which result from human activities that can influence the quality of waters of the State and that can be reasonably controlled by prevention or mitigation. A numeric representation of this concept can be derived using the data contained in Table 2 of the Action Plan.

⇒ Sediment delivery associated with roads is estimated at 1,056 tons/mi^2/yr.
⇒ Sediment delivery associated with timber harvest units is estimated at 162 tons/mi^2/yr.
⇒ Sediment delivery associated with agricultural operations is not estimated because the data are insufficient.
⇒ Mitigation and preventative measures to control sediment delivery from roads are estimated to be 90% effective.
⇒ Mitigation and preventative measures to control sediment delivery from timber harvest units are estimated to be 50% effective.

Mitigation and preventative measures to control sediment delivery from agricultural operations in the riparian zone and on the hillslope are estimated to be 90% and 50% effective, respectively.

The existing sediment budget , though limited, provides an estimate of the rate of sediment delivery to waters of the State from human activities. We do not yet know, however, how much of the estimated sediment delivery "can be reasonably controlled." If one assumes that nearly all (90-100%) of the sediment delivery estimated as associated with landuse activities can affect waters of the State and be reasonably controlled, then the following equations are true where A is the human-caused discharge remaining when 100% of the sediment delivery sites are defined as controllable and B is the human-caused discharge remaining when 90% of the sediment delivery sites are defined as controllable. For the purposes of an estimate, this is a reasonable assumption based on conversations with erosion control experts who conclude that mitigation measures exist to control virtually all human related sediment delivery sites, particularly those associated with roads, skid trails and landings. Similarly, use of avoidance as a management practice can control human-related sediment delivery from unstable areas. Human-caused sediment delivery sites might only be defined as uncontrollable because of the cost of mitigation due to a site's size, location or complexity.

$$\begin{aligned} A &= [1,056 - (1,056)(0.90)] + [162 - (162)(0.50)] \\ &= 106 + 81 \\ &= 187 \text{ tons/mi}^2\text{/yr} \end{aligned}$$

$$B = [1,056 - (1,056)(0.90)(0.90)] + [162 - (162)(0.90)(0.5)]$$

= 201 + 89
= 290 ton/mi^2/yr

This analysis demonstrates that based on the existing data, a load allocation that directs landowners "to control all existing and future controllable discharges of sediment" (i.e., zero controllable discharges) would meet an approximate total numeric average allowable discharge of 280 tons/mi^2/yr for nonpoint sources. An average allowable discharge for nonpoint sources of 280 tons/mi^2/yr, were it implementable, would achieve a TMDL of 552 tons/mi^2/yr. Consequently, the load allocation contained in the proposed Basin Plan amendment is expected to achieve a TMDL of 552 tons/mi^2/yr.

Sediment Delivery Reductions and Land Management Measures

The Sediment Delivery Reductions and Land Management Measures components of the Action Plan's Load Allocations and Implementation Plan reflect a professional judgment of how successful the various BMPs generally are in controlling "controllable" 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.

Sediment Delivery Reductions and Land Management Measures contained in the Load Allocations and Implementation sections of the Action Plan are divided into the following primary categories:

- **Road-related erosion.** This category includes ranch, timber, and county roads, for example. It also includes road erosion related to mass wasting, fluvial erosion and surface erosion.
- **Timber-related erosion**. This category primarily includes mass wasting associated with timber harvest units; fluvial erosion associated with skid trails and landings; and surface erosion associated with skid trails and landings.
- **Agriculture-related erosion.** This category includes fluvial erosion associated with grazing, hillside vineyards, and other similar agricultural activities as well as surface erosion associated with tilling, grazing, concentrated feed lots, and other similar agricultural activities.
- **Gravel mining-related erosion.** This category primarily includes fluvial erosion associated with instream gravel mining activities.

In addition to sedimentation, the parameter of concern for which the Garcia River watershed is listed on the 303(d) list, elevated temperatures and the absence of large woody debris have also been identified as limiting factors of concern. Instream temperatures, though tied to the issue of sedimentation, will be addressed through a future approach. Large woody debris, however, as argued in the Numeric Targets section, is so intrinsically linked to the issue of sedimentation that it is addressed here in this Action Plan. That is, large woody debris provides structure to North Coast stream channels which allows for the scouring of pools and the sorting of sediment to form potential spawning gravels. The reduction of sediment delivery to the streams, alone, is unlikely to result in the necessary reduction in stream channel sedimentation as is required to support the beneficial uses and meet the water quality objectives.

Specific numeric *requirements*, however, have not been developed for large woody debris. Rather, the Land Management Measures section of the Action Plan's Implementation Plan strictly relies on the implementation of BMPs as the means of improving the recruitment of large woody debris to the stream channel. The Implementation Plan is described in the Action Plan.

Sediment Reduction Requirements and Schedule

In the Source Analysis section of the Reference Document and Action Plan, individual sources of sediment delivery were identified and, to the degree possible, quantified. A preliminary sediment budget was developed from the information. A minimum average annual sediment delivery rate of 1,380 tons/mi^2/year was estimated for the basin (PWA 1997). Of the sources of sediment delivery identified via aerial photograph review, associations between land use practices and sources was attempted, though a specific cause and effect relationship was not confirmed. For the purposes of the first phase of this Action Plan, a conservative approach is taken by assuming that land uses, which were identified as "associated" with sediment delivery sources, are in fact caused by those land uses. As site-specific data is developed and confirmed in the field, the preliminary sediment budget should be updated to reflect a more accurate understanding of the conditions in the basin. As a result, the Sediment Delivery Reductions should also be revised. Until that time, the Load Allocation that is described in the Action Plan will apply.

As stated above, the Load Allocation and Table 3 of the Action Plan were developed based on an estimate of how successful the known body of mitigation, altered land management, and restoration practices are likely to be. Based on their experience in controlling erosion and sediment yield from managed landscapes in the Pacific Northwest, and especially on the North Coast of California, Pacific Watershed Associates (PWA) (1997) believes the majority of management-related, accelerated sediment production and yield associated with fluvial, surface erosion, and road-related mass movement erosional processes can be prevented in the future. This is interpreted to mean that 90% of the sources associated with these settings can be controlled. The 90% figure is a conservative estimate which can be modified as site-specific data is developed which helps to more accurately describe the condition of individual tributaries and the success of diligently applied conservation measures.

Roads

Roads are identified in the Source Analysis section of the Reference Document as the largest human-caused source of sediment delivery to the watershed. Further, they are a source of existing and potential sediment delivery which cuts across all land uses, including: timber harvesting, agriculture, housing development, county roads, etc. Sixty percent of the mass wasting component of the overall sediment budget is estimated to be associated with roads. The fluvial erosion component of the sediment budget accounts for both road and skid trail-related erosion. PWA (1997) did not estimate the proportion of fluvial erosion associated with roads versus skid trails. Thus, for the purposes of this assessment, it is assumed that 50% of the fluvial erosion is attributable to each source. Similarly, the surface erosion component of the sediment budget accounts for both road and skid trail related erosion. PWA (1997) also did not estimate the proportion of surface erosion associated with roads versus skid trails. Again, for the purposes of this assessment, it is assumed that 50% of the surface erosion is attributable to each source.

Source Control

The *Handbook for Forest and Ranch Roads* (Weaver and Hagans 1994) (Handbook) provides an extensive review of the mitigation measures and altered road building, maintenance and decommissioning practices with which the existing and potential sources of sediment delivery from road systems can be successfully and significantly reduced. Road mitigation measures from the Handbook are detailed in the Implementation Plan Section of the Action Plan. If management practices such as are described in the Handbook are diligently applied, it is predicted that 90% of the sediment currently being delivered from road systems in the Garcia River watershed will be controlled.

It is important to emphasize that the sites of interest to this Action Plan are only those which are delivering or have the potential to deliver sediment to a water of the State. Sites which will deliver their soil to flat areas on the landscape without ever reaching a stream are not of concern in this Action Plan. It is also important to note that sites for which there are no known mitigation or control measures are not considered “controllable” and therefore not subject to the requirements of this Action Plan.

The road inventory can be conducted by landowners, consultants, or with the assistance of public agencies or citizen groups. Training was offered in 1998 through the U.C. Cooperative Extension for landowners to conduct the road inventories themselves. Future training may be available through the U.C. Cooperative Extension. (See the Education and Assistance section of the Reference Document). Informal assistance can also be provided through staff at the Regional Water Quality Control Board. Should additional formal opportunities for inventory training become necessary, the Regional Water Board will consider other options. Groups of landowners and other interested parties are encouraged to form their own road inventory crew which can be trained to conduct road inventories on multiple properties.

Timber-related Activities

Timber activities are identified in the Source Analysis section of the Reference Document as the second largest component of human-caused sediment delivery in the watershed. Twenty percent of the mass wasting component of the overall sediment budget is estimated to be associated with timber harvest units. As above, the fluvial and surface erosion components of the overall sediment budget are associated with both roads and skid trails, but no estimate of the proportion attributable to each is given by PWA (1997). Thus, for the purpose of this assessment, 50% of the fluvial and surface erosion estimates is assumed to be attributable to skid trails.

PWA (1997) believes that attaining reductions in the magnitude and frequency of mass movement processes occurring on hillslopes not associated with roads and skid trails are more problematic than the others described above. PWA (1997) suggests that the increased use of geologic analysis in developing timber harvest plans and improvements being made in modeling watershed processes can lead to a significant reduction in mass wasting processes occurring within management landscapes. This is attainable through the avoidance of highly unstable stream-side areas and the use of modified management methods in sensitive geomorphic locations including unstable stream-side geology, steep inner gorge slopes, and steep swales. This is interpreted to mean that 50% of the mass wasting sources not associated with roads or skid trails can be controlled. The 50% figure is a conservative estimate which can be modified as site-specific data is developed which helps to more accurately describe the condition of individual tributaries and the success of altered land management practices in preventing human-caused mass movement in the future.

1. *Mass Wasting*

a. Source Control

PWA (1997) reports that the increased use of geologic analysis in developing timber harvest plans and improvements being made in modeling watershed processes can lead to a significant reduction in mass wasting processes occurring within management landscapes. As summarized above, if appropriate geologic analysis and watershed modeling is conducted and timber harvest plans are designed to reflect the findings of such analyses, it is predicted that 50% of the sediment currently being delivered from timber harvest units via mass wasting in the Garcia River watershed will be prevented in the future.

The primary goal associated with the reduction requirement for mass wasting associated with timber harvest units is to avoid the human-caused generation of additional mass movement beyond that which currently exists on the landscape. As stated by PWA (1997), this is attainable through the avoidance of highly unstable stream-side areas and the use of modified harvest methods in sensitive geomorphic locations including unstable stream-side geology, steep inner gorge slopes and steep swales.

2. *Other Sites*

a. Source Control

The *Handbook for Forest and Ranch Roads* (Weaver and Hagans 1994) (Handbook) provides an extensive review of the mitigation measures and altered road building, maintenance and decommissioning practices with which the existing and potential sources of sediment delivery from road systems can be successfully and significantly reduced. Many of the same mitigation measures identified for road systems are applicable to skid trails and landings. As summarized above, if conservation measures such as are described in the Handbook are diligently applied, it is predicted that 90% of the sediment currently being delivered from skid trails and landings in the Garcia River watershed will be controlled. Collecting a baseline inventory of the existing and potential sediment delivery sites associated with skid trails and landings, however, is somewhat more difficult than the process associated with inventorying roads, due to the tremendous density of skid trails throughout the watershed. The areas of most concern for the Action Plan are those areas with the greatest potential to deliver sediment to a water of the State.

The skid trail and landing inventory can be conducted by landowners, consultants, or with the assistance of public agencies or citizen groups. Training was offered in 1998 through U.C. Cooperative Extension for landowners to conduct the inventories themselves. (See the Education and Assistance section of the Reference Document). Informal assistance can also be provided through staff at the Regional Water Quality Control Board. Should additional formal opportunities for inventory training become necessary, the Regional Water Board will consider other options. Groups of landowners and other interested parties are encouraged to form their own inventory crew which can be trained to conduct inventories on multiple properties.

Agriculture-related Activities

Agriculture-related activities are identified in the Source Analysis section of the Reference Document as the smallest human-caused source of sediment delivery in the watershed. This conclusion is skewed, to some degree, by the fact that the inputs to the sediment budget rely exclusively on aerial photograph interpretation, analysis of statistics kept by the Department of Forestry and Fire Protection, and field data supplied by the industrial timber companies. The aerial photograph analysis did not allow for the identification of sites or sources associated with small scale operations. Nor did the statistical analysis or field data reflect conditions related to agricultural activity. Based on the ownership and land use pattern in the Garcia River watershed, however, it is generally a safe assumption that the contributions associated with agricultural activity are small in comparison to roads and timber-related activities.

Nonetheless, the contributions of agricultural activities in individual tributaries where ranching or other agricultural activities are predominant can not be dismissed. In addition, the disproportionate concentration of agricultural activities in the floodplain terraces associated with river valleys also can not be dismissed, particularly because the full functioning of riparian zones is critical to ensuring stream bank protection and the filtering of the annual mobile surface eroded sediment which runs off from hillslopes both from natural and human-caused sources. An estimate of the impact these reductions will have on the reduction of the overall sediment budget, however, can not be given at this time. As site-specific data is developed, the overall sediment budget should be revised.

The Sediment Reduction Requirements are based on an initial assessment of the condition of the property, including riparian zone activities (e.g., grazing, row crops, etc.) and hillslope activities (e.g., grazing, hillside vineyards, barns, holding yards, etc.). The initial assessment will provide an understanding of the baseline condition in addition to an estimate of the rate of sediment delivery associated with activities in the riparian zone and on the hillslope. It is predicted that altered land management activities will be primarily responsible for achieving the Load Allocations, though direct mitigation or restoration may be necessary in some instances.

1. *Riparian Zone Management*

The riparian zone is defined as that zone of property within 100 feet of a Class I or II stream (as defined by the Forest Practice Rules) as measured from the active or bankfull channel. For Class III streams (as defined by the Forest Practice Rules), the riparian zone is defined as that zone of property within 50 feet of the stream as measured from the active or bankfull channel. Current activities in the riparian zone may include grazing, row crops, orchards, structures such as barns or holding yards, etc.

a. Source Control

The Natural Resource Conservation Service (NRCS) has developed a series of Best Management Practices (BMPs) applicable to sediment control on agricultural lands. Communications with personnel at the NRCS indicate that the BMPs developed by the NRCS for agricultural activities provide an extensive list of mitigation and land management practices with which the existing and potential sources of sediment delivery within riparian zones can be successfully and significantly reduced. If conservation measures such as described by NRCS are diligently applied, it is predicted that 90% of the sediment currently being delivered from the riparian zone due to agricultural activities will be controlled.

The assessment of riparian zone conditions including the identification of individual erosion sites is described in the Action Plan. Training was offered in 1998 through the U.C. Cooperative Extension for landowners to conduct the assessments themselves. (See the Education and Assistance section of the Reference Document). Informal assistance can also be provided through staff at the Regional Water Quality Control Board, Natural Resource Conservation Service, Mendocino County Resource Conservation District, or the U.C. Cooperative Extension. Should additional formal opportunities for assessment training become necessary, the Regional Water Board will consider other options. Groups of landowners and other interested parties might consider organizing themselves into their own assessment crew, obtaining the necessary training, and providing assessment services to multiple properties.

2. *Hillslope Sites*

The hillslope is defined as all property outside of the riparian zone as described above. Current activities on the hillslope may include: grazing, row crops, orchards, structures such as barns or holding yards, etc.

a. Source Control

Further communication with NRCS indicates that the Best Management Practices developed by the NRCS for agricultural activities provide an extensive list of the mitigation and land management practices with which the existing and potential sources of sediment delivery from hillslopes can be reduced with at least moderate success. If conservation measures such as described by NRCS are diligently applied, it is predicted that 50% of the sediment currently being delivered from the hillslope due to agricultural activities will be controlled.

The assessment of hillslope conditions including the identification of individual erosion sites as described in the Action Plan. Training was offered in 1998 through the U.C. Cooperative

Extension for landowners to conduct the assessments themselves. (See the Education and Assistance section). Informal assistance can also be provided through staff at the Regional Water Quality Control Board, Natural Resource Conservation Service, Mendocino County Resource Conservation District, or the U.C. Cooperative Extension. Should additional formal opportunities for assessment training become necessary, the Regional Water Board will consider other options. Groups of landowners and other interested parties might consider organizing themselves into their own assessment crew, obtaining the necessary training, and providing assessment services on multiple properties.

Gravel Mining

The Mendocino County Planning Department has developed and the Board of Supervisors approved the *Garcia River Gravel Management Plan* (1996). This plan evaluates the historic trends and current conditions in fluvial geomorphology, the coho and steelhead fishery, and the riparian zone. It examines the impacts of instream gravel mining on the Garcia River watershed and alternatives to river channel and floodplain extraction. The management plan associated with the *Garcia River Gravel Management Plan* (1996) provides several recommendations for both instream and floodplain gravel mining. The recommendations for instream gravel mining include:

- Permit mining volume based on measured annual replenishment. This is estimated at 6,700 tons/year (4,970 yd^3/year)
- Establish an absolute elevation below which no extraction may occur
- Limit in-channel extraction methods to "bar skimming" or an alternative method recommended by the Data Evaluation Team
- Grade the slope of excavated bars to prevent fish entrapment
- Extract gravel from the downstream portion of the bar
- Concentrate activities to minimize disturbance
- Review the cumulative effects of gravel extraction
- Maintain the flood capacity of the river channel
- Establish a long-term monitoring program, including: cross-sections, longitudinal profile, geomorphic maps, photo-documentation, hydrology and sediment transport studies, groundwater monitoring, habitat typing, aerial photography, substrate surveys, temperature monitoring, population surveys, and riparian vegetation surveys and mapping
- Evaluate the need that the in-channel reclamation be evaluated on an annual basis
- Minimize activities that release fine sediment to the river
- Retain a vegetation buffer at the edge of the water and against the bank
- Avoid dry road crossings
- Limit in-channel operations to the period between June 15 and October 15
- Avoid expansion of instream mining activities upstream of River Mile 3.7
- Produce an annual status and trends report to be submitted to the County, the Data Evaluation Team or the Agent of the County

The recommendations for floodplain gravel extraction include:

- Floodplain gravel extraction should be set back from the main channel
- The maximum depth of floodplain gravel extraction should remain above the channel thalweg
- The side slopes of floodplain excavation should range from 3:1 to 10:1
- Place stockpiled topsoil above the 25-year floodplain
- Floodplain skimming should be considered if future channel incision deepens the low flow channel
- Floodplain pits should be restored to wetland habitat or reclaimed for agriculture
- A plain must be submitted which account for long-term liability
- Establish a long-term monitoring program (as described above)
- Produce an annual status and trends report to the County, the Data Evaluation Team or the Agent of the County

Cost-Effectiveness

The Load Allocations outlined in the Action Plan require reduction of sediment delivery from all controllable sources. Controllable sources are defined as those which are associated with human activity and will respond to mitigation or altered land management practices or restoration. The Load Allocations are not intended to apply to natural sources of sediment or to human-caused sources which will not respond to intervention. Nonetheless, this is an ambitious plan requiring significant landowner commitment and funding. As such, the Regional Water Board is concerned that available funds be spent in the most cost-effective manner. That is, available funds should first be spent to reduce the sources of sediment which cause the most significant environmental harm.

1. *Prioritizing Sites*

After conducting road, skid trail, and landing inventories and unstable slope, hillslope and riparian zone assessments, landowners are encouraged to prioritize sediment delivery source reduction activities based on the relationship between the cost of the activity and the environmental benefit to be realized from the activity. Landowners might, for example, categorize sites or activities into high, medium and low priorities. Such a prioritization scheme should consider the degree to which any individual tributary or reach of stream provides habitat for cold water fish. Hagans and Weaver (1996) recommend that initial expenditures should be aimed at protecting the best remaining refuge watersheds: those areas with the best habitat and healthiest, highest numbers and most diverse populations of fish and other forms of aquatic life, or where special at-risk populations are present.

2. *Landowner Consortia*

As an additional method of reducing overall costs, landowners are encouraged to form landowner groups through which property assessment, source control, and/or monitoring efforts can be conducted collectively, thereby enjoying some economies of scale. The Garcia River Watershed Advisory Group may be a good forum through which landowners can share ideas, training, and otherwise offer help to one another. The Garcia River Watershed Agricultural

Landowners Group may also be a good forum for such exchange. The California Farm Bureau and California Forestry Association may be entities capable of assisting in organizing landowners in such a fashion as might the Mendocino County Resource Conservation District. The Regional Water Board, too, can lend assistance in organizing and training landowner groups, where necessary.

Margin of Safety

The regulations at 40 CFR 130.7 state 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." A discussion of the margin of safety as it applies to the development of the TMDL for the Garcia River watershed is included in several locations, including the Loading Capacity Calculation section of the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan). For ease of review, a discussion of the margin of safety is summarized here.

The TMDL, as described in this section, is understood to include the problem statement, numeric targets, source analysis, loading capacity, and load allocation. The margins of safety included in the Garcia River Watershed TMDL are as follows:

- Existing instream and hillslope data from the Garcia River watershed were assessed in the hopes of deriving site specific numeric targets. Site specific numeric targets would provide a numeric expression of the specific conditions in the Garcia River watershed necessary to support a cold water fishery, most notably the coho salmon fishery. The existing data, however, were generally insufficient to derive site specific numeric targets. As such, a conservative approach was employed by which many of the numeric targets were extracted from the scientific literature. The studies used as the basis for numeric targets included laboratory studies in which fish had unlimited food supplies and constant environmental conditions. They included field studies in basins in which little or no significant landuse was occurring. The result is a set of numeric targets that largely represent the conditions necessary not just to prevent impairment but to allow for the on-going success of salmonids.
- The source analysis is primarily based on aerial photo interpretation and road density data analysis rather than on extensive field analyses. With regard to the aerial photo interpretation, mass wasting features were identified on a sequence of aerial photos from 1965 to 1996. In addition to identifying mass wasting features, the technician determined whether or not the features were associated with land management activities. For example, a mass wasting feature with a road running above it was said to be associated with the road. For the purpose of estimating sediment delivery rates from various landuse categories (e.g., roads and timber harvest units), a conservative approach was employed by which all mass wasting features which were associated with land management activities were assumed to be caused by the land management activity in question.
- The loading capacity calculation and TMDL are derived from USEPA's TMDL and include an explicit 8% margin of safety. The 8% margin of safety is applied to account for

uncertainties in the data and differences between the Garcia River watershed and the Caspar Creek watershed.

- The loading capacity calculation and TMDL are based on an estimate of the lowest possible average annual sediment delivery rate. This is because the sediment budget from which the average annual sediment delivery rate is derived is based on a limited data set. It does not include, for example, estimates of background sources of fluvial and surface erosion. It does not include estimates of fluvial and surface erosion from timber harvest units. And, it does not include estimates of erosion from agricultural activities. The sediment budget is judged to be adequate even in the absence of these estimates since the missing components are likely to be less than the included components. Nonetheless, a sediment budget including an estimate for each of the noted components would demonstrate that the average annual sediment delivery in the basin is greater than the 1,380 tons/mi^2/yr currently estimated. A reduction by 60% of the under-estimated average annual sediment delivery rate, then, results in a conservative TMDL of 552 tons/mi^2/yr.
- The load allocation directs landowners "to identify and control all existing and future controllable discharges of sediment." Controllable discharges are defined as discharges resulting from human activities that can influence the quality of waters of the State and that can be reasonably controlled by prevention or mitigation. Thus, while there is flexibility created by the phrase "reasonably controlled," the load allocation nonetheless presents a conservative approach to sediment delivery control that is intended to reduce hillslope delivery to a level approaching that which existed prior to the steep decline in the salmonid fishery. The conservative nature of this approach also accounts for the fact that sediment delivery is only one component of the sedimentation problem identified in the Garcia River watershed. The remobilization of instream stored sediment is another unquantified and largely uncontrollable component of the problem. Controlling all sites that can be "reasonably controlled" provides better assurance that the stream channel system will be left in a condition more conducive to imminent, natural recovery.

As is repeated throughout the Reference Document, 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 Reference Document in the future will result in less stringent requirements as the margin of safety is reduced.

Annual and 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 Load 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 in the Action Plan, 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 Load Allocations have been achieved.

Normal winter rains and larger storms will nonetheless have an effect on the assessment of Load Allocations. Storm events which occur after mitigations have been achieved will provide a test of the success of the mitigation. For this reason, follow-up inventories are required and storm-related hillslope targets are proposed which will help assess post-mitigation success.

VI. IMPLEMENTATION PLAN

Overview

The Implementation Plan can be found in the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan). The Implementation Plan identifies a program for implementing the requirements necessary to reduce and control the existing and future human-related sediment load delivered to the Garcia Watershed, and move towards attainment of the numeric instream targets. An implementation plan, while not strictly a requirement of the Total Maximum Daily Load as described by the Clean Water Act and associated regulations, is required under section 13242 of the California Water Code to be included in the Basin Plan. The Implementation Plan further provides the practical purpose of informing the public of the way in which the Regional Water Board intends to implement the TMDL.

The Problem Statement section of the Reference Document sufficiently demonstrates impacts to the cold water fishery from sedimentation. Further, the Source Analysis section of the Reference Document sufficiently demonstrates that land management activities on the hillslope and in the riparian zone play a role in the delivery of sediment to the stream system. Finally, the Load Capacity Calculation and the Technical Rationale of the Load Allocation sections of the Reference Document identifies potential linkages between hillslope activities and instream conditions. As such, the Reference Document adequately demonstrates the need for mitigation of existing and potential sources of sediment delivery on the hillslope and in the riparian zone; modification of current land management activities which can perpetuate the delivery of sediment to the stream system; and consideration of restoration by which to improve instream conditions, particularly in potential salmonid refuge streams.

The data submitted to the Regional Water Board for consideration in the development of this Reference Document, however, does not identify the exact mechanisms for sediment delivery in each tributary system. Nor does it identify the exact locations of sediment delivery sites across the basin. It provides, instead, general substantiation for concern (e.g., sedimentation is impacting cold water fish habitat), as well as the identification of specific areas and issues of concern (e.g., roads are contributing a large proportion of the sediment which is delivered to the stream system). Landowners engaged in activities with the potential to deliver sediment to the watershed include, for example: timber operators, ranchers, farmers, and county roads.

Because the information submitted to the Regional Water Board to date does not offer a clear basis for establishing allowable sediment loads in each tributary sub-basin, the Regional Water Board has opted to encourage landowners (or a consortia of landowners as described in the Load Allocation section of the Reference Document) to collect baseline information (described in the Elements of an Erosion Control Plan section of the Implementation Plan) from which to apply load reduction requirements and from which landowners can design altered land management practices. This is viewed as a less arduous and more accurate way of reducing sedimentation in the basin than allocating specific load reductions to individual landowners based on the limited data now available. In particular, landowners are encouraged to develop and implement their own Site-Specific Management Plans designed not only to collect the necessary baseline information, achieve the necessary sediment delivery reductions, and move towards the numeric targets, but also to establish a land management scheme which protects the beneficial uses in a manner which is most appropriate to their own specific situation.

Background

The twelve months of discussion at the Garcia River Watershed Advisory Group (WAG) meetings and subcommittee meetings resulted in the development of a considerable amount of qualitative and quantitative information regarding the status of the Garcia River watershed. It also resulted in the significant generation of ideas regarding the best methods for controlling the sedimentation problems now confronting the basin. Many landowners who participated in the Garcia River WAG meetings expressed an interest in being allowed flexibility in identifying and designing control strategies appropriate for their own properties. In particular, many landowners argued that they should be allowed, on a voluntary basis, to develop such plans.

The result of the assessment contained in the body of this Reference Document indicates that conditions in the watershed are indeed quite poor for cold water fish. In fact, coho salmon have been listed by the National Marine Fisheries Service as threatened in this area, precisely because of the dramatic decline in their populations and loss of adequate freshwater habitat. Thus, while the Reference Document and Action Plan encourages voluntary efforts by landowners-- and acknowledges the voluntary efforts already undertaken by many-- the Reference Document and Action Plan also provide a framework for ensuring that progress is made in improving instream habitat before the complete loss of the species.

The strength of the Garcia River WAG, despite the arguments which are inherent in groups of varying perspectives, is that the members and their supporters all share a concern about the health of the salmonid fishery. It is the Regional Water Board's hope that this concern will be translated into action through cooperation and implementation of sediment delivery reduction measures, as described in the Implementation Plan of the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment.*.

Implementation Enforcement

As described in the discussion of the *Nonpoint Source Management Plan* (1988) in the Introduction section of the Reference Document, the Regional Water Board is constrained by the Porter-Cologne Act from specifying the manner of compliance with water quality standards. Two methods, however, are identified in the *Nonpoint Source Management Plan* (1988) by which the Regional Water Boards can use their regulatory authorities to encourage implementation of conservation measures. One is to waive adoption of waste discharge requirements on condition that the dischargers implement conservation practices. A corollary to this method is to waive applicability of discharge prohibitions on the same condition as described above. The second method is to enter into a Management Agency Agreement (MAA) with another agency that has authority to require implementation of conservation measures.

Both of these methods are included in the *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan). The Regional Water Board has already entered into an MAA with the California Department of Forestry and Fire Protection (CDF). Through the MAA, CDF approves timber harvest plans (THP) only after considering the impacts on water quality. Following approval by the State Water Resources Control Board and Office of Administrative Law of the adoption of the Action Plan as an amendment to the Basin Plan, the requirements therein will be considered by CDF prior to their approval of individual THPs, Sustained Yield Plans, and other relevant enforceable timber-related planning documents.

Similarly, the Basin Plan already includes two prohibitions against discharges associated with logging, construction and other related activities, as described in the Implementation section of the Action Plan. Again, in order to encourage voluntary efforts to develop and implement Site Specific Management Plans, the Regional Water Board will not apply the existing prohibitions for logging, construction, and associated activities against landowners who are implementing an approved Site-Specific Management Plan or the Garcia River Management Plan (together referred to as a Management Plan). If significant discharges or placement of sediment occurs despite the implementation of a Management Plan, the Regional Water Board will consider the need to revise the Management Plan, and will address the discharge or placement of sediment through the issuance of a Cleanup and Abatement Order, if necessary, but will not enforce the violations of the prohibitions against any landowner who is implementing an approved Management Plan.

Further, the application to land management activities in the Garcia River watershed of the prohibitions now contained in the Basin Plan will be clarified and expanded. In particular, given the watershed's impaired status, any measurable discharge of sediment shall be considered deleterious to beneficial uses and the prohibition will be expanded to apply to all land uses and all waters of the State within the watershed.

All landowners engaged in land management activities which result in the discharge of sediment to the stream are encouraged to collect the necessary baseline information, mitigate or control existing and potential sediment delivery sites, and implement fish-friendly land management practices. However, most important to the success of the Action Plan is the cooperation and involvement of the largest landowners in the basin, including the 10 largest landowners each owning greater than 1000 acres of property in the basin. Without the cooperation and participation of these larger landowners, the overall success of the Action Plan and improvements to the instream environment will be significantly lessened.

VII. MONITORING PLAN

Overview

Monitoring is intended to provide information regarding the effectiveness of sediment control efforts in attaining the Numeric Targets over time. Instream and hillslope monitoring parameters, monitoring protocols, and frequency of monitoring are described in the Monitoring Plan section of the Action Plan. Instream and hillslope monitoring by landowners (except for the Sediment Delivery Site monitoring described in the Erosion Control Plan in the Implementation Plan section of the Strategy) is on a voluntary basis. Regional Water Board staff will coordinate instream monitoring efforts of the landowners, other regulatory agencies, academic institutions and members of the public and shall set a goal of establishing at least one instream monitoring point in each of the twelve Planning Watersheds in the Garcia River watershed. In addition, Regional Water Board staff will work together with the University of California Cooperative Extension to assist landowners in developing voluntary monitoring plans.

The Monitoring Plan is an important component to the overall Action Plan because it will provide the information necessary to make adjustments to the overall assessment as site-specific data are generated and more definitive relationships among hillslope conditions, hillslope activities, and instream conditions are revealed and to assess progress towards attainment of the desired future conditions as expressed by the Numeric Targets.

Instream and hillslope monitoring by landowners that is not required by the Erosion Control Plan is on a voluntary basis and is strongly encouraged by the Regional Water Board. Individual monitoring plans can be combined to form a comprehensive basin-wide monitoring plan, including monitoring conducted by conservation groups and agencies. For example, the Department of Forestry in conjunction with the Mendocino County Resource Conservation District and two of the industrial timber companies have developed an instream monitoring plan to test the success of the Forest Practice Rules in protecting water quality. That plan could serve as the basis for the instream monitoring desired under the Action Plan, as well. As a general matter, landowners, conservation groups, and agencies are encouraged to cooperate with one another in the development of their own individual plans or in a comprehensive basin-wide plan, as appropriate.

Parameters

The parameters and the protocols for measurement are described in the Action Plan.. Ideally, all of the listed parameters would be measured regularly at established sampling locations.

Sampling Locations

For instream parameters, there should be at least one attainment point in each Planning Watershed of the Garcia River watershed. This is a minimum of 12 monitoring stations. Individual landowners are encouraged to choose to establish monitoring points above and below any significant land management activity on their own property to ensure that upstream contributions are not attributed to their operations. The habitat-related parameters (barriers, percent fines, pool characteristics, etc.) should be measured in fish-bearing and historically fish-bearing streams and should be measured on an annual basis. V* and d_{50} should be measured in third order streams with gradients between 1-4%, also on an annual basis. The thalweg profile, width-to-depth ratio, and pool-forming elements should be measured in Class I, II and III streams at least once every three years and during the summer following storm events with a recurrence interval of 20 years of greater. Open stream channels should be measured by a modified RAPID analysis using aerial photographs. This analysis is intended to be conducted by the Regional Water Board every ten years.

For hillslope parameters, monitoring in accordance with an approved Erosion Control Plan will be conducted on individual roads, landings, skid trails, and agricultural facilities as sediment delivery sources are identified and control mechanisms are implemented. Sediment delivery reductions associated with roads, landings, and skid trails can be measured, as described by Pacific Watershed Associates, or estimated as described by Coastal Forestlands, Ltd, as examples. Any defensible method for measuring or estimating can be used but must be submitted as part of the Erosion Control Plan to the Regional Water Board staff for review prior to its implementation. Similarly, sediment delivery reductions associated with agricultural activities can be measured (e.g., sediment trap) or estimated (e.g., via a relationship to residual dry matter). Again, any defensible method for measuring or estimating can be used but must be submitted as part of the Erosion Control Plan to the Regional Water Board prior to its implementation. Mass wasting is intended to be evaluated by Regional Water Board staff via aerial photographs once every ten years.

Sampling Schedule

For instream monitoring, habitat-related parameters should be measured on an annual basis so as to discern an improving trend over time. Stream channel stability-related parameters should be measured once every 3 years and in years when there has been a storm event with a recurrence interval of 20 years or greater. The less rigorous sampling frequency for stream channel stability-related parameters is proposed since channel stability is predicted to change very slowly over time and is most clearly demonstrated as a result of large storm events. In addition, Knopp (1993) demonstrated that the relationship between stream channel stability and hillslope disturbance takes as long as 40 years to discern. The modified RAPID analysis should be conducted at least once every ten years.

For hillslope monitoring, road, landing and skid trail mitigation will occur on an annual basis with corresponding measurements or estimates of sediment delivery reductions. The effects on stream crossings of storm events with recurrence intervals in excess of 20 years should be measured or estimated during the summer following such events. For agriculture-related activities on hillslopes and in the riparian zone, sediment delivery reduction activities will be measured or estimated on an annual basis. Average sediment delivery reductions over 4 year periods must be reported. Aerial photograph interpretation is intended to occur at least once every ten years to assess mass wasting associated with timber harvest units. Timber Harvest Plan review will occur regularly, as they are submitted.

Figure 31: Summary of Monitoring Parameters and Protocols

Parameter	**Protocol**	**Brief Description** (Protocol should be consulted for detailed methodology)	**Frequency**
		INSTREAM MONITORING	
Sediment-related barriers	Any defensible method	Stream survey; identification of sediment deltas, underground stream sections, shotgun culverts, reaches with water depths less than 0.18 meters, etc.; measurement or estimate of extent of barrier and mapping of location	Annual
Embeddedness	Flosi and Reynolds (1994), Burns (1984)	Identify at least 5 riffle habitat units in Class I streams. Randomly select at least 50 cobbles from each habitat unit and measure or estimate the percent of each cobble which is covered or surrounded by fines. This will be obvious from a dark ring around the cobble indicating its exposure to stream flow. Rate each cobble 1, 2, 3, or 4 as follows: score of 1=cobbles 0-25% surrounded or covered by fines; 2=26-50%; 3=51-75%; 4=76-100%	Annual
% fines, gravel composition	McNeil protocol, Valentine (1995)	Identify at least 5 riffle habitat units in Class I streams. Collect at least 2 bulk core samples of sediment in each habitat unit in the first at the pool/riffle break immediately downstream of pool crests. Measure the of volume sediment associated with each size class in the field. Bag at least 5 samples to be weighed in the laboratory to establish a correlation between weight and volume.	Annual
Pool characteristics	Flosi and Reynolds (1994)	Identify at least 10 pool habitat units within a reach that is 20-30 bankfull widths long in Class I streams. Measure habitat unit length, characterize habitat types in each unit, and measure mean width of low flow channel. Measure maximum length, width and depth of all pools in each unit. Measure depth of each pool tail crest.	Annual
Frequency of primary pools	Flosi and Reynolds (1994)	Within each reach (as described above), identify the maximum length of all pools which are >3 feet deep, > in width than 1/2 width of low flow channel, and > in length than width of low flow channel.	Annual
V*	Lisle and Hilton (1992), Knopp (1993)	Identify at least 10 survey units within a reach of 20-30 bankfull widths in length in 3rd order streams with slopes 1-4%. Measure the residual volume of each pool within the unit with a graduated rod along transects, as described by Lisle and Hilton.	Annual
D50	Wolman (1954), Knopp (1993), Rosgen (1996)	Identify at least 5 survey units within a reach of at least 20-30 bankfull channel widths long in 3rd order streams with slopes 1-4%. Lay out transects, as described by Rosgen, and collect at least 100 particles in each reach. Measure the particle, as described, and tally for later graphing.	Annual
Volume of large woody debris	Shuett-Hames (1994) for Timber, Fish and Wildlife Watershed Assessment Manual (Level 2 analysis)	Identify at least 10 survey units of at least 500 feet long within Class I, II and III streams. Identify and measure all pieces of large woody debris, including logs at least 4 inches in diameter and 72 inches long and root wads. Note the location of the LWD in the channel, the channel length, wood type, stabilizing factors, pool formation function and orientation and decay class.	At least once every three years

Parameter	Protocol	Brief Description (Protocol should be consulted for detailed methodology)	Frequency
Cross-section	Rosgen (1996)	Identify at least 1 survey unit within a reach of 20-30 bankfull widths long in each Class I and II streams. Establish at least 3 transects across the bankfull channel in each survey unit and collect evenly spaced measurements of the depth to channel along each transect. The transect should be marked for return at subsequent samplings.	At least once every three years
Thalweg profile	Trush (1997), Dunne and Leopold (1976)	Identify at least 1 survey unit within a reach of at least 20-30 bankfull widths long in each Class I and II streams. Survey units must be no less than 30 times the bankfull channel width with 3-4 meanders within the survey unit.	At least once every three years
Miles of open stream channel	Grant (1988)	Modified RAPID analysis measuring linear distance of open stream channels from aerial photographs	At least once every ten years
Flow and/or stage height	Gordon, et. al. (1992)	Measurements or estimates determined during instream sampling. Continuous measurements are desirable but require sophisticated equipment that is vulnerable to damage. Point measurements of stage height during storm event and routinely through the year are more manageable.	Ongoing
Rainfall		Daily measurement using a gage with a sensitivity of 0.1 inch.	Ongoing
HILLSLOPE MONITORING			
Landslides, fluvial, and surface erosion associated with roads, landings and skid trails	Pacific Watershed Associates or similar method	Road inventory; identification of existing and potential sediment delivery sites; measurement or estimation of volume of sediment associated with each site.	Annual
Landslides associated with harvest units	Timber, Fish and Wildlife (Washington State)	Aerial photographs; identification of landslide features associated with timber harvest units; measurement of the area of the landslide feature; estimate of the volume of sediment delivered to the stream from each feature.	Annual
Landslides, fluvial, and surface erosion associated with agricultural activities	Any defensible method	Property survey; identification of existing and potential erosion problems; measurement or estimation of volume of sediment associated with each site or situation	Annual
Stream crossing failures	Pacific Watershed Associates or similar method	Road survey after storms with a 20 year recurrence interval or greater; identify location of failed or partially failed crossings; measurement or estimation of volume of sediment associated with failure	Once in summer of years having storms with a 20 year recurrence interval, or greater
Density of unpaved roads	Any defensible method	GIS and/or THP data review; cumulative tally of miles of road per tributary or Planning Watershed, the average width of the road system, and the density of unpaved roads.	At least once every ten years

VIII. ESTIMATED TOTAL COST AND POTENTIAL SOURCES OF FUNDING (EDUCATION AND ASSISTANCE OPPORTUNITIES)

The *Garcia River Watershed Water Quality Attainment Action Plan for Sediment* (Action Plan) calls for landowners to conduct assessments of erosion and erosion potential on their properties, including an inventory of existing and potential sediment delivery sites associated with roads, skid trails, landings, and agriculture-related facilities. In addition, it encourages landowners to developed Site Specific Management plans by which to address the erosion on their property and reduce the delivery of sediment to waters of the State. That is, rather than impose generic measures on landowners' properties, the Action Plan encourages landowners to identify their own measures which are particularly well suited for the site-specific conditions of their properties.

The tack taken in the Action Plan is based on the notion that landowners are most familiar with their own property and are best suited to identify the measures appropriate for the issues confronting them. Further, it is based on the notion that landowners have a stake in ensuring that the soil on their properties remain on site and that their facilities remain in functioning order. However, not every landowner will have the training, tools or finances to conduct the assessments, inventories, and mitigations or identify the improved land management practices most appropriate for the conditions confronting them. Thus, the following is a list of potential training and financing resources available to landowners as assistance in this process.

Funding Programs

An estimated cost to implement the sedimentation reduction efforts described in the Action Plan is $5 million plus unquantified costs which include inventory costs and the opportunity cost of the volume of unharvested timber, up to an additional $2 million. Potential training and financing resources available to landowners include but are not limited to the Wildlife Habitat Incentive Program (WHIP), the Environmental Quality Incentives Program (EQUIP), the Conservation Reserve Program (CRP), the Salmon and Steelhead Restoration Program (SSRP), the Forestry Incentive Program (FIP), the Salmon and Steelhead Restoration Account (SSRA), and Clean Water Act Section 205 (j) and Section 319(h) funding.

<u>Wildlife Habitat Incentive Program (WHIP)</u>

WHIP is a voluntary program for people who want to develop and improve wildlife habitat primarily on private lands. It provides both technical assistance and cost-share payments to help establish and improve fish and wildlife habitat. Participants who own or control land agree to prepare and implement a wildlife habitat development plan. The U.S. Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS) offers participants technical and financial assistance for the establishment of wildlife habitat development practices. In addition, if the landowner agrees, cooperating State wildlife agencies and nonprofit or private organizations may provide expertise or additional funding to help complete a project. USDA and the participant enter into a cost-share agreement for wildlife habitat development. The agreement generally lasts from 5 to 10 years. Under the agreement, the landowner agrees to install and maintain the WHIP practices and allow NRCS or its agent access to monitor the effectiveness of the practices while the USDA agrees to provide technical assistance and pay up to 75 percent of the cost of installing the wildlife habitat practices.

Contact Tom Schott of NRCS in Ukiah at (707) 468-9223 for more information. Information is also available on NRCS's World Wide Web site at *http://www.nrcs.usda.gov*.

Environmental Quality Incentives Program (EQIP)

EQIP is a program designed to address significant natural resources needs and objectives including: soil erosion and water pollution prevention, farm and ranch land production, agricultural water conservation, and wildlife habitat preservation and development. EQIP provide cost sharing as well as technical and education assistance. It will fund up to 75% of a given project, as determined by a local working group. EQIP is a program available to agricultural producers and provides no more than $10,000 per year to landowners with a conservation plan approved by the Resource Conservation District. The funds are available every year and are offered through a contract which can last for up to 5 years.

Contact Tom Schott of NRCS in Ukiah at (707) 468-9223 for more information. Information is also available on NRCS's World Wide Web site at *http://www.nrcs.usda.gov.*

Conservation Reserve Program (CRP)

The National Conservation Initiative Program is an attempt to use grass and trees to protect and enhance streams. The buffer strips installed through this program aid in the permanent protection of water bodies by trapping runoff pollutants such as sediment, fertilizers, pesticides, bacterial and viral pathogens, and heavy metals. Farmers benefit from the installation of these strips which protect the stream while helping to maintain highly productive land. The USDA pays up to 50% of the cost to establish buffers; the agency also makes an annual rental payment on the land being conserved for the life of the CRP contract (10-15 years). An additional 20% incentive payment over the rental can be paid for certain buffers such as field windbreaks, riparian forest buffers, filter strips, and grass waterways. The program allows for continuous sign-up through the USDA's Farm Service Agency under the Conservation Reserve Program.

Contact Tom Schott of NRCS in Ukiah at (707) 468-9223 for more information. Information is also available on NRCS's World Wide Web site at *http://www.nrcs.usda.gov.*

Stewardship Incentive Program (SIP)

SIP is a federally funded forest assistance program. Qualifying landowners can be reimbursed up to 75 percent of their expenses for performing a broad range of resource management activities. Potentially funded projects include: preparation of a property, neighborhood or watershed management plan; tree planting; tree thinning; fuels management; erosion control; stream bank restoration; riparian/wetland restoration; fish and wildlife habitat improvement; or protection of archaeological or historical sites. At a minimum, the property musts contain 20 to 1000 acres of forestland to qualify for the program. The application process generally takes a minimum of two months with SIP contracts valid for 12 months. A SIP contract can only include one stewardship practice and reimbursement will be for no more than $10,000 per federal fiscal year.

Contact Jill Butler of the California Department of Forestry Coast-Cascade Region in Santa Rosa, CA at (707) 576-2935 or call 1-800-738-TREE.

Forestry Incentive Program (FIP)

FIP is a federal funded forest assistance program aimed at improving the productivity of timberland. Qualifying landowners can be reimbursed up to 65% of their expenses for tree planting, thinning, pruning, or slash disposal. At a minimum, the property must consist of 10 to 1000 acres of land capable of growing at least 70 cubic feet of wood per acre each year. Private individuals, groups, organizations, associations, Native American tribes, and closely held corporations are all potentially eligible for funding. A FIP project must be maintained for at least ten years and is paid no more than $10,000 in a federal fiscal year. FIP contracts are good for a period of one year. Additional extensions can be arranged on request.

Contact Jill Butler of the California Department of Forestry Coast-Cascade Region in Santa Rosa, CA at (707) 576-2935 or call 1-800-738-TREE.

Salmon and Steelhead Restoration Account (SSRA)

SSRA provides funding for restoration and watershed planning in coastal streams outside of the Central Valley drainage. Potentially funded projects include: instream habitat restoration, watershed and riparian habitat restoration, watershed planning, project maintenance and monitoring, watershed organization, technical training and education, cooperative fish rearing, and public education. A project proposal must be submitted to the Department of Fish and Game for consideration.

Contact Mary Brawner of the Department of Fish and Game in Sacramento at (916) 654-5628 for more information.

319(h) Grant Program

The 319(h) grant program offers funds to non-profit organizations, government agencies including special districts, and education institutions. Specific non-point source activities that are eligible for 319(h) funds may include, but are not limited to: the implementation of best management practices for agricultural drainage, acid mine drainage, physical habitat alteration, channel stabilization, sediment control, hydrologic modification, dredging, silvicultural practices, septic systems, marina and boating activities, urban runoff, livestock grazing, irrigation water management, and confined animal facilities management. Other eligible activities include technology transfer, ground water protection, pollution prevention, technical assistance, facilitation of citizen monitoring and facilities of education elements of projects.

Contact Ken Harris at (916) 657-0876 or John Ladd at (916) 657-1016 of the State Water Resources Control Board for further information.

205(j) Grant Program

The 205(j) grant program offers funds to public agencies and special districts to conduct planning activities. Eligible activities include development of watershed plans or other planning functions designed to resolve actual or potential water quality issues. Proponents must show that a coordinated approach with relevant agencies and stakeholders will be employed.

Contact Paul Lillebo of the State Water Resources Control Board at (916) 657-1031.

Appendix D includes a summary of additional cost share and technical programs which may be of use to landowners and organizations.

Informal Technical Assistance

Informal technical assistance may be obtained through a variety of sources. The following is a list of organizations and agencies which may be able to provide assistance in the form of personal communication, participation in a classroom training event, participation in a field training event, or other kinds of assistance as requested.

California Department of Fish and Game-- Rick Macedo at (707) 928-4369
California Department of Forestry and Fire Protection-- Brad Valentine, Biologist at (707) 576-2937 or Pete Cafferata, Hydrologist at (916) 653-9455
California Division of Mines and Geology-- Tom Spittler at (707) 576-2949
California Farm Bureau-- Tess Dennis at (916) 561-5656
California Forestry Association-- Mark Rentz at (916) 444-6592
Garcia River Watershed Advisory Group-- Craig Bell at (707) 882-2150
Garcia River Watershed Agricultural Landowners Group-- Carol Caughey at (707) 882-3622
Mendocino County Resource Conservation District-- Teri Barber at (707) 964-0171
Mendocino County Water Agency-- Dennis Slota at (707) 463-4589
National Marine Fisheries Service-- Kristi Young at (707) 575-6067
Natural Resource Conservation Service-- Tom Schott at (707) 468-9223
North Coast Regional Water Quality Control Board-- Dave Evans, Watershed Unit, Holly Lundborg, Engineering Geologist, or Frank Reichmuth, Timber Harvest Division at (707) 576-2220
U.C. Cooperative Extension-- John Harper at (707) 463-4495
U.C. Davis-- Ken Tate at (916) 752-4301
U.S. Environmental Protection Agency-- David Smith, TMDL Coordinator at (415) 744-2012 or Doug Ederhardt, Forestry Team Leader at (415) 744-1280

The U.C. Cooperative Extension and the California Farm Bureau organized training specifically designed for landowners who are interested in learning methods for conducting property assessment and road, skid trail and landing inventories. Contact John Harper at the U.C. Cooperative Extension, (707) 463-4495 for additional information.

The Regional Water Quality Control Board can provide training in assessment, inventory, mitigation, or monitoring, as necessary. Please contact Dave Evans, Holly Lundborg, or Frank Reichmuth at (707) 576-2220 to request Regional Water Board participation in training events.

IX. PLAN FOR FUTURE REVIEW AND REVISION OF THE REFERENCE DOCUMENT AND ACTION PLAN

Public participation was a key element in the development of the Reference Document and the Action Plan, and will continue to be an essential component in the implementation of the Action Plan. Interested persons will have the opportunity to comment on the progress of the Action Plan, at watershed meetings, and to the Regional Water Board at least once every 3 years, at which time the Regional Water Board shall determine if there is sufficient progress toward implementation of erosion control and management activities, as well as movement towards attainment of the Numeric Targets described in the Action Plan. If sufficient progress as described above is not documented, the Regional Water Board will consider revising the Action Plan through a Basin Plan amendment. If the Regional Water Board concludes that the Numeric Targets are being attained throughout a Planning watershed, it may consider suspending or terminating some or all of the Action Plan for landowners within that Planning watershed.

Throughout the Reference Document, there is mention of the need to update the Reference Document and the Action Plan and the assumptions it is based on as new, site-specific data is collected and submitted. This section describes the review and revision process associated with the Reference Document and the Action Plan and the submittal of information. As mentioned throughout the document, the assumptions upon which the Reference Document and the Action Plan are based are conservative assumptions which are intended to overcome the fact that the existing data for the Garcia River watershed, though voluminous, is not sufficient to comprehensively and accurately describe either the instream or hillslope conditions throughout the basin. Thus, as site-specific data is developed and submitted, it is likely that the accuracy of the assessment will be greatly improved. As the accuracy of the assessment improves and assumptions are replaced with scientific fact, the requirements associated with the Action Plan can be revised to better reflect those facts. Given the conservative nature of the assumptions used in the current phase of the Action Plan, future revisions are likely to result in the need for less stringent requirements. It will be to landowner's benefit, then, to collect and submit data associated with the improvements they make on their property and the changes they observe in the instream environment.

The Regional Water Board staff is committed to review (and revise the Reference Document and/or ask the Regional Water Board to amend the Action Plan, as necessary) on a regular schedule as set forth below. It is clear that some elements will require a longer time than others before the data reflects a trend in which reviewers have confidence. These elements are unlikely to be revised in the short term. Other elements , however, can be updated upon the first submittal of site-specific data. Figure 32, below, identifies the periods in which specific kinds of changes will be likely. These, however, are only predictions and may change over time.

As a general matter, the Regional Water Board staff will review data regularly as it is submitted. The Regional Water Board intends to consider whether any revisions to the Action Plan are appropriate every three years. Staff consideration of revision to the Reference Document can be requested at any time. Requesters will be asked to submit data which supports their request. Where the data is compelling, revisions to the Reference Document can be made outside of the schedule listed below.

Several specific elements of the Reference Document and/or Action Plan are particularly suited for future revision. For example:

- **Numeric Targets:** The numeric targets are currently based on a review of the scientific literature and the identification of optimal conditions for salmonid success. Data indicating the conditions specific to the Garcia River watershed which adequately support salmonid success can be used to revise the numeric targets in the future.
- **Source Analysis:** The sediment budget contained in the Source Analysis section is preliminary in nature and does not currently include several potential sediment inputs, such as: surface erosion on skid trails, sediment yield from road cutbanks and ditches, stream bank erosion caused by fluvial processes, the movement of instream stored sediment, and sediment yield from agricultural activities. In addition, the preliminary sediment budget only includes estimates for sediment yield from haul road and skid trail crossings, sediment yield from gullies due to diversions on roads and skid trails, and road surface erosion. The sediment budget can be revised as data is submitted which helps to quantify and/or update any of these potential sediment inputs.
- **Load Allocations:** The Load Allocations are based on assumptions related to the degree to which that landslides identified in aerial photographs actually delivery sediment to a watercourse and the degree to which they are caused by land management activity. The Load Allocations can be modified as field data is collected which identifies a more exact relationship between landslides, sediment delivery, and cause.
- **Load Allocations:** The Load Allocations are also based on an estimate of how successful known mitigation and control measures are likely to be at reducing sediment delivery. The Load Allocations can be modified as data is submitted which indicates that the true success of diligently applied mitigation and control measures is different than what was predicted.

Figure 32: Schedule for review and potential revision of the Reference Document.

Time period	Types of data to be reviewed	Potential areas of revision
Year 3	Baseline inventories Baseline property assessments Baseline monitoring data	Problem Statement Source Analysis
Year 8	5 years of instream, hillslope, and sediment delivery reduction data	Problem Statement Source Analysis
Year 13	10 years of instream, hillslope and sediment delivery reduction data	Problem Statement Source Analysis Load Allocation Sedimentation Reduction Plans Monitoring Plan

REFERENCES

Bachman, R. W. 1958. The ecology of four north Idaho trout streams with reference to the influence of forest road construction. M.S. thesis, University of Idaho, Moscow. 97 p.

Bartsch, A. F. 1960. Settleable solids, turbidity, and light penetration as factors affecting water quality. Biological Problems in Water Pollution, Trans. 1959 Seminar. U.S. Dep. Health, Educ. and Welfare, Tech Rep. W60-3, R. A. Taft Sanit. Eng. Cent. Cincinnati, Ohio.

Bjornn, T. C., M. A. Brusven, M. P. Monau, J. H. Milligan, R. A. Klamt, E. Chacho, and C. Schaye. 1977. Transport of granitic sediment in streams and its effects on insects and fish. For. Wildlife and Range Exp. Stn., Completion Rep. Water Resource. res. Inst. Proj. B-036-IDA. Univ. Idaho, Moscow. 43 p.

Brown, L. R., P. B. Moyle, and R. M. Yoshiyama. 1994. Historical decline and current status of coho salmon in California. N. Am. J. Fish. Mgt. 14(2): 237-261.

Burns, J. W. 1970. Spawning bed sedimentation studies in north California streams. Pages 253-279 *in* California Fish and Game 56 (4).

Burns, D. C. 1984. An inventory of embeddedness of salmonid habitat in the South Fork salmon River drainage, Idaho. UnPubl. Report, Payette and Boise National Forests. McCall, Idaho: 30 pp.

California Department of Conservation, Division of Mines and Geology, 1984, Geology and Geomorphic Features related to Landsliding. Compiled by Clifton W. Davenport. OFR-84-47 SF.

Cederholm, C. J., L. M. Reid, and E. O. Salo. 1981. Cumulative effects of logging road sediment on salmonid populations in the Clearwater River, Jefferson County, Washington. In: Proceedings from the conference on salmon spawning gravel: a renewable resource in the Pacific Northwest. Washington State University, Washington Water Research Center, Report 39, Pullman. Pages 38-74.

Chapman, D. W. 1962. Effects of logging upon fish resources of the west coast. J. For. 60(8): 533-537.

Chapman, D. W. 1988. Critical review of variables used to define effects of fines in reds of large salmonids. In: Transactions of the American Fisheries Society 117. Pages 1-25

Circuit Riders Production, Inc. See Philip Williams & Associates. 1996.

Coastal Forestlands, Ltd., 1997, Watershed and Aquatic Wildlife Assessment

Cooper, A. C. 1956. A Study of the Horsefly River and the effect of placer mining operations on sockeye spawning grounds. Int. Pac. salmon Fish. Comm. Publ. 3. 58 p.

Cordone, A. J., and D. W. Kelley. 1961. The influence of inorganic sediment on the aquatic life of streams. California Fish and Game 47 (2):189-228.

Critical Sites Erosion Study. See Durgin, et. al. 1988.

Davies, P. E. and M. Nelson. 1994. Relationships between riparian buffer widths and the effects of logging on stream habitat, invertebrate community composition and fish abundance. Australian Journal Marine Freshwater Resources. 45:1289-1305.

Department of Water Resources. 1976. Rainfall analysis for drainage design, volume II-- long-duration precipitation frequency data. Bulletin No. 195.

Dunne, T. and L.B. Leopold. 1978. Water in Environmental Planning. W.H. Freeman and Company, San Francisco. 818 pp.

Durgin, P. B., R. R. Johnston, and A. M. Parson. 1988. Critical sites erosion study: a cooperative investigation by the California Department of Forestry and the United States Forest Service. Vol. I, Causes of erosion on private timberlands in northern California. Arcata, Ca.

Dyrness, C. T. 1967. Mass soil movement in the H. J. Andrews Experimental Forest, USDA, Forest Service, PNW Research Station, Portland, Oregon, PNW-42, 12 pages.

Ellis, M. M. 1936. Erosion silt as a factor in aquatic environments. Ecology 17(1):29-42.

Everest. F. H., and D. W. Chapman. 1972. Habitat selection and spatial interaction by juvenile chinook salmon and steelhead trout in two Idaho streams. J. Fish. res. Board Can. 29(1):91-100.

Farrington, R. L. and M. E. Savina. 1977. Off-site effects of roads and clearcut units on slope stability and stream channels, Fox Planning Unit, USDA Forest Service, Six Rivers National Forest, Eureka, California.

Fiksdal, A. J. 1974. A landslide survey of the Stequalehoe Creek watershed. University of Washington, Fish Research Institute. FRI-UW-7404.

Flosi, G. and F. L. Reynolds. 1994. California salmonid stream habitat restoration manual. Inland Fisheries Division, California Department of Fish and Game, The Resources Agency

Forest Ecosystem Management Assessment Team (FEMAT). 1993. Forest ecosystem management: an ecological, economic, and social assessment. Prepared by the USDA, National Marine Fisheries Service, Bureau of Land Management, U.S. Fish and Wildlife Service, National Park Service, and the Environmental Protection Agency.

Forest, Soil and Water, 1997, The Garcia river: watershed assessment and instream monitoring plan

Frissell, C. A. and W. J. Liss. 1986. Classification of stream habitat and watershed systems in south coastal Oregon, and an assessment of land use impacts. Progress report prepared for Oregon Department of Fish and Wildlife, Oak Creek Laboratory, Oregon State University, Corvallis, Oregon. 51 pages.

Fugro West, Inc. 1994. Gualala Aggregates sand and gravel project draft environmental impact report. Prepared for the Mendocino County Planning and Building Services Department

Gordon, N. D., T. A. McMahon, and B. L. Finlayson. 1992. Stream Hydrology - An Introduction for Ecologists. J. Wiley & Sons: 526 pp.

Grant, G. 1988. The RAPID technique: a new method for evaluating downstream effects of forest practices on riparian zones. USDA Forest Service, Pacific Northwest Forest Research Station, Gen. Tech. Report PNW-GTR-220, Portland, OR.

Hagans, D. K., W. E. Weaver and M. A. Madej. 1986. Long-term on-site and off-site effects of logging and erosion in the Redwood Creek basin, northern California. In: Papers presented at Amer. Geophys. Union meeting on cumulative effects (9-13 Dec. 1985, San Francisco, Ca.). Tech. Bull. 490, pp. 38-66, National Council of the Paper Industry (NCASI), New York, New York.

Hall, J. D., and R. L. Lantz. 1969. Effects of logging on the habitat of coho salmon and cutthroat trout in coastal streams. In: Proceedings from Symposium on Salmon and trout in Streams. T. G. Northcote, editor. University of British Columbia. H.R. MacMillan Lectures in Fisheries. Pages 355-375

Humiston, G. 1995. California Rangeland Water Quality Management Plan, administered by the Range Management Advisory Committee in cooperation with the State Water Resources Control Board

Hanson, D. L. 1977. Habitat selection and spatial interaction in allopatric and sympatric populations of cutthroat and steelhead trout. Ph.D. thesis, Univ. Idaho, Moscow. 66 p.

Johnson, A. W. and D. M. Ryba. 1992. A literature review of recommended buffer widths to maintain various functions of stream riparian areas. King County Surface Water management Division, Seattle, WA.

Keller, E. A., and W. N. Melhorn. 1995. Rhythmic spacing and origin of pools and riffles. In: Geological Society of America Bulletin, v. 89. Doc. no. 80509. Pages 723-730

Kemp, H.A. 1949. Soil pollution in the Potomac River basin. In: American Water Works Association Journal 41(9). Pages 792-796

Klamt, R. R. 1976. The effects of coarse granitic sediment on the distribution and abundance of salmonids in the central Idaho batholith. M.S. thesis, Univ. Idaho, Moscow. 85 p.

Knopp, C. 1993. Testing indices for cold water fish habitat. Final Report for the North Coast Regional Water Quality Control Board.

Kondolf, G. M. Unpublished. Assessing salmonid spawning gravel quality.

Koski, K. V. 1966. The survival of coho salmon (*Oncorhynchus kisutch*) from egg deposition to emergence in three Oregon coastal streams. M.S. Thesis, Oregon State Univ., Corvallis: 84 pp.

LaHusen, R. G. 1984. Characteristics of management-related debris flows, northwestern California. In: Symposium on effects of forest land use on erosion and slope stability. Eds., C. L. O'Loughlin and A. J. Pearce. IUFRO, May 1984.

Ledwith, T. 1996. The effects of buffer strip width on air temperature and relative humidity in a stream riparian zone. Summer 1996:6-7.

Lisle, T. E. 1993. The fraction of pool volume filled with fine sediment in northern California: relation to basin geology and sediment yield. Final Report to the California Division of Forestry and Fire Protection.

Lisle, T. and S. Hilton. 1992. The volume of fine sediment in pools: an index of sediment supply in gravel-bed streams. Water Resources Bulletin, American Water Resources Association.

Lisle, T. E. and J. Lewis. 1992. Effects of sediment transport on survival of salmonid embryos in a natural stream: a simulation approach. Reprinted from Canadian Journal of Fisheries and Aquatic Sciences, Volume 49, Number 11, pages 2337-2344.

Lotspeich, F. B., and F. H. Everest. 1981. A new method for reporting and interpreting textural composition of spawning gravel. U.S. Forest Service Research Note PNW-139.

Louisiana-Pacific Corporation. 1997. Sustained Yield Plan for Coastal Mendocino County

Lynch, J. A., E. S. Corbett, and K. Mussellem. 1985. Best management practices for controlling non-point source pollution on forested watersheds. Journal of Soil and Water Conservation. Jan-Feb 164-167.

Madej, M. A. and V. Ozaki. 1996. Channel response to wave propagation and movement, Redwood Creek, CA, USA. Earth Surface Processes and Landforms, v. 21, 911-927p.

Mangelsdorf, A. T. 1997. Assessment of aquatic conditions in the Garcia River watershed, prepared for the North Coast Regional Water Quality Control Board

McCuddin, M. E. 1977. Survival of salmon and trout embryos and fry in gravel-sand mixtures. Masters Thesis, University of Idaho Graduate School.

McDade, M. H., Swanson, F. J., McKee, W.A., Franklin, J. F. and Van Sicle, J. 1990. Source distances for coarse woody debris entering small streams in western Oregon and Washington. Ca. J. Fish. Aquat. Sci. 20:326-330.

McNeil, W. J., and W. H. Ahnell. 1964. Success of pink salmon spawning relative to size of spawning bed materials. U.S. Fish and Wildlife Service Special Scientific Report--Fisheries 469.

Mendocino County Resource Conservation District. 1992. Garcia River watershed enhancement plan. Prepared for the California State Coastal Conservancy

Moffat & Nichol Engineers. 1995. Garcia estuary feasibility study, Point Arena, California, phase 1. Prepared for the Mendocino County Resource Conservation District, Ukiah, Ca. 76 pages + appendices.

Moring, J.R., and R. L. Lantz. 1974. Immediate effects of logging on the freshwater environment of salmonids. Oregon Wildl. Comm. Res. Div. Final Rep. Project AFS-58. 101 pp.

Moring, J. R. 1982. Decrease in stream gravel permeability after clear-cut logging: indication of intragravel conditions for developing salmonid eggs. Hydrobiologia 88:295-298.

Murphy, M. L. and K. V. Koski. 1989. Input and depletion of woody debris in Alaska streams and implications for streamside management. North America Journal of Fisheries Management. 9:427-436.

National Marine Fisheries Service. 1996. Coastal salmon conservation: working guidance for comprehensive salmon restoration initiatives on the Pacific coast.

Nickelson, T. E., and R. R. Reisenbichler. 1977. Streamflow requirements of salmonids. Prog. Rep. Oreg. Dep. Fish and Wildl. AFS-62. Contract 14-16-0001-4247, Portland. 24 p.

O'Connor Environmental, Inc. See Forest, Soil and Water, Inc. 1997

Pacific Watershed Associates. 1994a. Dumont Creek watershed assessment report: an erosion inventory and plan of action for erosion prevention and erosion control, Dumont Creek, Umpqua National Forest, Oregon. Prepared for the U.S. Forest Service, Umpqua National Forest, Roseburg, Oregon and the Pacific Rivers Council, Eugene, Oregon. 85 pages + appendices.

Pacific Watershed Associates. 1994b. Action plan for restoration of the South Fork Trinity River watershed and its fisheries. Prepared for the U.S. Bureau of Reclamation and the Trinity River Task Force, Weaverville, Ca. 388 pages.

Pacific Watershed and Associates. 1997. Sediment production and delivery in the Garcia River watershed, Mendocino County, California: an analysis of existing published and unpublished data. Prepared for Tetra Tech, Inc. and the U.S. Environmental Protection Agency.

Pautzke, C. F. 1938. Studies on the effects of coal washings on steelhead and cutthroat. In: Transactions of the American Fisheries Society 67 (1937).

Peterson, N. P., A. Hendry, and T. P. Quinn. 1992. Assessment of cumulative effects on salmonid habitat: some suggested parameters and target conditions. Timber, Fish and Wildlife. TFW-F3-92-001.

Philip Williams & Associates, Ltd. 1996. Garcia River gravel management plan. Prepared for the Mendocino County Water Agency

Philips, R. W., R. L. Lantz, E. W. Claire, and J. R. Moring. 1975. Some effects of gravel mixtures on emergence of coho salmon and steelhead trout fry. In: Transactions of the American Fisheries Society 3. Pages 461-466

Platts, W. S., M. A. Shirazi, and D. H. Lewis. 1979. Sediment particle sizes used by salmon for spawning with methods for evaluation. U.S. Environmental Protection Agency Ecological Research Series EPA-600/3-79-043.

Rau, Haydon, Bordessa, Franz, and Associates. 1990. Environmental assessment for gravel bar skimming on the Garcia River, Mendocino County, Ca. Ukiah, CA. Job #89-250.

Regional Water Quality Control Board. 1994. Water Quality Control Plan for the North Coast Region, Santa Rosa, CA

Reid, L. M.1981. Sediment production from gravel-surfaced forest roads, Clearwater basin, Washington. University of Washington, College of Fisheries, Fisheries research Institute, Publication No. FRI-UW-8108, Seattle, WA. 247 p.

Reiser, D. W. and T. C. Bjornn. 1979. Habitat requirements of anadromous salmonids. In: Influence of Forest and Rangeland Management on Anadromous Fish Habitat in the Western United States and Canada, edited by William R. Meehan, USDA Forest Service General Technical Report PNW-96

Rosgen, D. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, Co.

Shirazi, M. A., W. K. Seim, and D. H. Lewis. 1981. Characterization of spawning gravel and stream system evaluation. In: Proceedings from the Conference on Salmon Spawning Gravel: A Renewable Resource in the Pacific Northwest. Washington State University, Washington Water Research Center Report 39, Pullman. Pages 227-278

Shuett-Hames, D., A. Pleus, L. Bullchild, and S. Hall. 1994. Ambient monitoring program manual. Northwest Indian Fisheries Commission. Timber, Fish & Wildlife. TFW-AM9-94-001.

Smith, O.R. 1939. Placer mining silt and its relation to salmon and trout on the pacific coast. In: Transactions of the American Fisheries Society 69. Pages 135-139

State Water Resources Control Board. 1988. Non point source management plan. Sacramento, CA

Swanson, F. J. and F. J. Dyrness. 1975. Impact of clearcutting and road construction on soil erosion by landslides in the Western Cascade Range, Oregon. Geology. Vol 3, No 7. pages 393-396

Swantson, D. N. and F. J. Swanson. 1976. Timber harvesting, mass erosion and steepland forest geomorphology in the Pacific Northwest. In: Geomorphology and Engineering, ed. D. R. Coastes. Dowden, Hutchinson and Ross, Publishers, Stroudsburg, Pennsylvania. pages 199-221.

Tappel P. D. T. C. Bjornn. 1983. A new method of relating size of spawning gravel to salmonid embryo survival. In: North American Journal of Fisheries Management. Volume 3. American Fisheries Society. Pages 123-135

Tarzwell, C. M. 1957. Water Quality Criteria for Aquatic Life. In Biological Problems in Water Pollution. U.S. Dep. Health, Educ. and Welfare, R.A. Taft San Eng. Cent., Cincinnati, Ohio. p. 246-272.

Tebo, L. B., Jr. 1955. Effects of siltation resulting from improper logging on the bottom fauna on a small trout streams in the southern Appalachians. Prog. Fish-Cult. 17(2):64-70.

Tebo, L. B., Jr. 1957. Effects of siltation on trout streams. Soc. Am. For. Proc. 1956 Meeting, p. 198-202.

Tebo, L. B., Jr. 1974. Review of selected parameters of trout stream quality. In: Symposium on Trout Habitat Research and Management. Appalachian Consortium Press. Boone, N.C. p. 20-32.

Thompson, K. 1972. Determining stream flows for fish life. In: Proceedings, Instream Flow requirement Workshop, Pac. Northwest River Basin Comm., Vancouver, Wash. p. 31-50.

Timber, Fish and Wildlife. See Washington Forest Practices Board. 1995.
Trautman, M. B. 1933. The general effects of pollution on Ohio fish life. In: Transactions of the American Fisheries Society 63. Pages 69-72
Trush, W. 1997. Personal communication with Fred Euphrat. 20 August 1997 and October 16, 1997.
U.S. Department of Agriculture. 1993. Determining the risk of cumulative watershed effects resulting from multiple activities.
Valentine, B. E. 1995. Stream substrate quality for salmonids: guidelines for sampling, processing and analysis. Prepared for the California Department of Forestry and Fire Protection, Santa Rosa, Ca.
Wallen, E. I. 1951. The direct effect of turbidity on fishes. Okla. Agric. and Mech. Col., Arts and Science Studies, Biol. Ser. No. 2, 48(2):27.
Washington Forest Practices Board. 1995. Board manual: standard methodology for conducting watershed analysis, version 3.0.
Waters, T. F. 1995. Sediment in Streams: Sources, Biological Effects, and Control. American Fisheries Society Monograph 7.
Weaver W. E. and D. K. Hagans. 1994. Handbook for forest and ranch roads: a guide for planning, designing, constructing, reconstructing, maintaining and closing wildland roads. Prepared for the Mendocino County Resource Conservation District, Ukiah, CA in cooperation with the California Department of Forestry and Fire Protection and the USDA Soil Conservation Service. 149 pages + appendices.
Weaver and Hagans, 1996, Sediment treatments and road restoration: protecting and restoring watersheds from sediment-related impacts. In: Healing the Watershed: A Guide to the Restoration of Watershed and Native Fish in the West., ed. The Pacific Rivers Council, Inc., Eugene, OR. Pages 109-139.
Weaver, W. E., A. V. Choquette, D. K. Hagans and J. Schlosser. 1981a. The effects of intensive forest land use and subsequent landscape rehabilitation on erosion rates and sediment yield in the Copper Creek drainage basin, Redwood National Park. In: Proceedings, Symposium on Watershed Rehabilitation in Redwood National Park and Other Coastal Areas, August 24-28, 1981, Arcata, California. Center for Natural Resource Studies of the John Muir Institute, Berkeley, California, pages 298-312.
Weaver, W. E., D. K. Hagans, and M. A. Madej. 1987b. Managing forest roads to control cumulative erosion and sedimentation effects. In: Proc. of the California Watershed Management Conference. Report 11 (18-20 Nov. 1986, West Sacramento, Ca.). Wildland Resources Center, University of California, Berkeley, Ca. 6 pages.
Wolman, M.G. 1954. A method of sampling coarse river-bed material. Trans. of Am. Geophysical Union, 35: 951-956.
Ziebell, C. D. 1957. Silt and Pollution. Wash. Pollut. Control Comm. Info. Ser. 57-1. 4 p.

GLOSSARY

Abandoned road	The designation of a road following use and completion of abandonment activities. These roads are left in a condition where no sediment sources remain and no maintenance of the road is required. These roads may be reconstructed and used for future land management activities.
Abandonment	The practice of closing a road, landing, skid trail or other facility so that regular maintenance is no longer needed and future erosion is largely prevented.
Aggradation	To fill and raise the elevation of the stream channel by deposition of sediment.
Agricultural facility	Any building, corral, pen, pasture, field, trail, or other feature on the landscape which is attributable to or associated with agricultural operations.
Alevin	A young fish; especially a newly hatched salmon when still attached to the yolk sac.
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.
Best Management Practices (BMPs)	Practices which are designed to lessen environmental impacts from nonpoint sources.

Channel roughness	A numerical value used to describe the relative roughness of a stream channel in relationship to the size of particles on the stream bed. Roughness effects the turbulence of the stream flow.
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 stream include historically fish-bearing streams.
Class II	Watercourses which have fish always or seasonally present offsite within 1000 feet downstream; and/or contain aquatic habitat for non-fish aquatic species. Class II waters do not include Class III waters that are directly tributary to Class I waters.
Class III	Watercourses which do not have aquatic life present, but show evidence of being capable of sediment transport to Class I and II waters under normal high flow conditions during and after completion of land management activities.
Class IV	Man-made watercourses, which usually supply downstream established domestic, agricultural, hydroelectric supply or other beneficial uses.
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.
Creel	A wicker basket for carrying newly caught fish.
Debris torrents	Long stretches of bare, generally unstable stream channel banks scoured and eroded by the extremely rapid movement of water-ladened debris, commonly caused by debris sliding or road stream crossing failure in the upper part of a drainage during a high intensity storm.
Decommission	See obliterate.
Deep seated landslide	Landslides involving deep regolith, weathered rock, and/or bedrock, as well as surficial soil. Deep seated landslides commonly include large (acres to hundreds of acres) slope features and are associated with geologic materials and structures.

Ditch relief	A drainage structure which will move water from an inside road ditch to an outside area, beyond the outer edge of the road fill. Ditch relief structures can include culverts, rolling dips, and/or water bars. Ditches are adequately relieved when there is no downcutting of the inside ditch or gully erosion at the outlet of the relief structure.
Drainage structure	A structure or facility constructed to control road runoff. These structures include but are not limited to fords, inside ditches, water bars, outsloping, rolling dips, culverts or ditch drains.
Flooding	The overflowing of water onto land that is normally dry.
Fry	A young juvenile salmon after it has absorbed its egg sac and emerged from the redd.
Headwater swale	The swale or dip in the natural topography that is upslope from a stream, at its headwater. There may or may not be evidence of overland or surface flow of water in the headwater swale.
Interstices	The space between particles (e.g. space between sand grains).
Inner gorge	A geomorphic feature formed by coalescing scars originating from mass wasting and erosional process caused by active stream erosion. The feature is identified as that area of stream bank situated immediately adjacent to the stream, having a slope generally over 65% and being situated below the first break in slope above the channel.
Inside ditch	The ditch on the inside of the road, usually at the foot of the cutbank.
Landslide	Any mass movement process characterized by downslope transport of soil and rock, under gravitational stress by sliding over a discrete failure surface-- or the resultant landform.
Large woody debris	A piece of woody material having a diameter greater than 30 cm (12 inches) and a length greater than 2 m (6 feet) that is located in a position where it may enter the watercourse channel.
Mass wasting	Downslope movement of soil mass under 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 Reference Document , a numeric target is developed based on the numeric or narrative State water quality standards which are needed to recovered the impaired beneficial use.
Obliterated road	The designation of a road following use and completion of decommission activities. These road are left in a condition where hillslope drainage is returned to its natural drainage pattern and no slope stability hazards remain. These roads will not be reconstructed and used for future land management activities.
Obliteration	To remove those elements of a road, landing, skid trail, or other facilities that unnaturally reroute hillslope drainage or present slope stability hazards.
Permanent drainage structure	A road drainage structure designed and constructed to remain in place following active land management activities while allowing year round access on a road.
Permanent road	A road which is planned and constructed to be part of a permanent all-season transportation system. These roads have a surface which is suitable for hauling forest and ranch products throughout the entire winter period and have drainage structures, if any, at watercourse crossings which will accommodate the fifty-year flood flow, including debris. Permanent roads receive regular and storm period inspection and maintenance.
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.
Riffle	A shallow extending across a streambed and causing broken water.
Riparian Management Zone (RMZ)	The strip of land along both sides of a watercourse where conservation measures are required for the protection of the quality and beneficial uses of water, fish and riparian habitat and for controlling erosion.

Rolling dip	A shallow, rounded dip in the road where the road grade reverses for a short distance and the surface runoff is directed in the dip or trough to the outside or inside of the road. Rolling dips are drainage facilities constructed to remain effective while allowing passage of motor vehicles at reduced road speed.
Seasonal road	A road which is planned and constructed as part of the permanent transportation system where most hauling and heavy use may be discontinued during the winter period and whose use is restricted to periods when the surface is dry. Most seasonal roads are not surfaced for winter use, but have a surface adequate for hauling of forest and ranch products in the non-winter period, and in the extended dry periods or hard frozen conditions occurring during the winter period. Seasonal roads have drainage structures at watercourse crossings which will accommodate the fifty-year flood flow and associated debris.
Sediment	Fragmented material that originates from weathering of rocks and decomposed organic material that is transported by, suspended in, and eventually deposited by water or air.
Sediment budget	An accounting of the sources, movement, storage and deposition of sediment produced by a variety of erosional processes, from its origin to its exit from a basin.
Sediment delivery	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.

Sensitive areas	Any area, particularly in the riparian zone, which when altered by land management activities results in a loss or reduction in ecological functioning.
Shallow seated landslide	A landslide produced by the failure of the soil mantle (typically to a depth of one or two meters, sometimes includes some weathered bedrock), on a steep slope. It includes debris slides, soil slips and failure of road cut-slopes and sidecast. The debris moves quickly (commonly breaking up and developing into a debris flow) leaving an elongated, concave scar.
Sidecast	The excess earthen material pushed or dumped over the side of roads and landings.
Skid trail	Constructed trails or established paths used by tractors or other vehicles for skidding logs. Also known as tractor roads.
Smolt	A young salmon at the stage at which it migrates from fresh water to the sea.
Steep slope	A hillslope, generally greater than 50% that leads without a significant break in slope to a watercourse. A significant break in slope is one that is wide enough to allow the deposition of sediment carried by runoff prior to reaching the downslope watercourse.
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.
Temporary drainage structure	A road drainage structure designed and constructed to allow access during active land management activities. The temporary structure will be removed following active land management.
Thalweg	The deepest part of a stream channel at any given cross-section.
Thalweg profile	Change in elevation of the thalweg as surveyed in an upstream-downstream direction against a fixed elevation.
Timber Harvest Plan	A plan, prepared by a registered professional forester and submitted to the California Department of Forestry for approval, which provides specific information regarding commercial timber operations to be undertaken by a landowner.
Unstable areas	Characterized by slide areas, gullies, eroding stream banks, or unstable soils. Slide areas include shallow and deep-seated landslides, debris flows, debris slides, debris torrents, earthflows and inner gorges and hummocky ground. Unstable soils include unconsolidated, non-cohesive soils and colluvial debris.
V*	A numerical value which represents the proportion of fine sediment that occupies the scoured residual volume of a pool.
Watercourse	Any well-defined channel with a distinguishable bed and bank showing evidence of having contained flowing water indicated by deposit of rock, sand, gravel, or soil.
Watercourse and lake protection zone	As used in the Forest Practice Rules, the strip of land, along both sides of a watercourse or around the circumference of a lake or spring, where additional practices may be required for the protection of the quality and beneficial uses of water, fish and riparian wildlife habitat, other forest resources and for controlling sediment.
Waters of the state	Any surface water or groundwater, including saline water, within the boundaries of the state.

Watershed	Total land area draining to any point in a watercourse, as measured on a map, aerial photo or other horizontal plane. Also called a basin, drainage area, or catchment area.
Water quality objective	Limits or level of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area.
Water quality standard	Consist of the beneficial uses of water and the water quality objectives as described in the Water Quality Control Plan for the North Coast Region.
Yarding	The movement of forest products from the point of felling to a landing