Assessment of Aquatic Conditions in the Garcia River Watershed

Prepared in support of the
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INTRODUCTION

Introduction

The *Assessment of Aquatic Conditions in the Garcia River Watershed* is a compilation of several subject-specific assessments conducted, for the most part, on a Planning Watershed basis and contained in the following four chapters: General Description, Limiting Factors Assessment, Resource Assessment, and Synthesis. The *Assessment of Aquatic Conditions in the Garcia River Watershed* evaluates the data currently existing for the Garcia River watershed while applying office-based tools such as aerial photograph interpretation. There is no field work associated with this assessment. The General Description chapter includes a discussion of the land use, geology, soil/vegetation regions, and hydrology of the watershed. The Limiting Factors Assessment includes discussion of the channel morphology and aquatic habitat, including water quality. The Resource Assessment includes discussion of the geomorphology, riparian functioning, hydrologic change, and active erosional processes in the watershed. And, the Synthesis includes the preliminary sediment budget and overall discussion of the data in the watershed.

The Limiting Factors Assessment was conducted by a consortium of technical experts from the Mendocino County Water Agency, Mendocino County Resource Conservation District, California Department of Forestry and Fire Protection, California Department of Fish and Game, Division of Mines and Geology, North Coast Regional Water Quality Control Board, U.S. Environmental Protection Agency, and the Natural Resource Conservation Service. The Resource Assessment is a compilation of the work of Wendy Melgin of the U.S. Environmental Protection Agency who assessed the hydrologic change in the basin; Matt O'Connor of O'Connor Environmental under contract through Forest, Soil and Water, Inc. with the Mendocino County Resource Conservation District and the California Department of Forestry and Fire Protection who assessed the mass wasting and surface erosion potential in the basin [see The *Garcia River: Watershed Assessment and Instream Monitoring Plan* (1997)]; and other existing sources of information such as the riparian assessment conducted by Circuit Rider Productions under contract through Philip Williams & Associates with the Mendocino County Water Agency to produce the *Garcia River Gravel Management Plan* (1996). The Synthesis is a compilation of the work of Dr. Fred Euphrat of Forest, Soil, and Water, Inc. and Kallie Kull of East-West Forestry under contract with the Mendocino County Resource Conservation District and California Department of Forestry and Fire Protection who assessed the existing information for the purpose of developing a forestry-related monitoring plan [*The Garcia River: Watershed Assessment and Instream Monitoring Plan* (1997)] and other material assessed by staff at the Regional Water Quality Control Board. The Synthesis also includes a preliminary sediment budget for the watershed developed by Pacific Watershed Associates under contract through Tetra Tech, Inc. with the U.S. Environmental Protection Agency.

The *Assessment of Aquatic Conditions in the Garcia River Watershed* is intended to provide the technical basis for the *Garcia River Watershed Water Quality Attainment Strategy* *for Sediment* (1997) by identifying past conditions of the basin as possible, the current conditions of the basin, and the factors which appear to be currently limiting the success of previously successful salmonid species, namely coho salmon and steelhead.

Method

Development of the *Assessment of Aquatic Conditions in the Garcia River Watershed* began with the compilation of the data currently existing for the Garcia River watershed. The California Resources Agency, through U.C. Davis, developed a web page on CERES (http://ceres.ca.gov) which includes metadata describing the currently existing data for the Garcia River watershed as collected by the North Coast Regional Water Quality Control Board with assistance from the Garcia River Watershed Advisory Group. The Garcia River Watershed Advisory Group was comprised of land owners; land managers; environmentalists; local, state, and federal agencies representatives; and other interested members of the public. Reports, articles, and unpublished data were augmented by interviews with many of the various landowners, interest group representatives, and agency personnel. A four volume set of material was compiled which excerpts the critical data, information, and observations from the original information sources.

Limiting Factors Assessment

The Limiting Factors Assessment includes consideration of channel morphology and aquatic habitat, including water quality. A consortium of technical experts from various county, state and federal agencies (as identified above) discussed the existing data in a two-day workshop drawing conclusions about the potential factors limiting the success of salmonids in the Garcia River watershed. The group's findings were presented over the course of three evening meetings to the Garcia River Watershed Advisory Group for their discussion and augmentation. A summary of the conclusions of the Limiting Factors Assessment Team as augmented by the Garcia River Watershed Advisory Group are reported in the Limiting Factors Assessment chapter. Appendices 1-12 (contained in a separate volume) outline the existing data considered in each Planning Watershed.

Resource Assessment

The Resource Assessment includes consideration of hydrologic changes, riparian functioning, and active erosional processes in the watershed. The hydrologic change analysis was conducted by the U.S. Environmental Protection Agency (as identified above) by reviewing the existing hydrologic data and evaluating it in relation to numerous scientific articles on the subjects of forestry and hydrologic change. An assessment of riparian functioning in the watershed was conducted by staff at the Regional Water Board, particularly relying on information developed by Circuit Rider Productions, as identified above.

A mass wasting and surface erosion analyses were conducted by a consultant (as identified above) in accordance with guidelines of the Washington Department of Natural Resources Standard Methodology for Conducting Watershed Analysis, Version 3.0 (1995). A level 1 analysis was conducted using aerial photographs of the basin dating from 1966 through 1996 provided by the Mendocino County Resource Conservation District and the U.S. Environmental Protection Agency. The analysis also included use of data regarding roads, stream classes, Planning Watershed boundaries, and topography provided as Geographical Information System (GIS) data by the California Department of Forestry and Fire Protection (CDF). The GIS data provided by CDF primarily originated from Timber Harvest Plans submitted to the agency from 1987 through 1997.

Synthesis

The Synthesis includes overall consideration of the existing data and a preliminary sediment budget. A synthesis of the existing data was performed by Forest, Soil and Water (as identified above) and augmented by staff at the Regional Water Board. The synthesis of existing data attempts to draw connections, as possible, between instream conditions and hillslope activities or characteristics.

A preliminary sediment budget was developed by a consultant (as identified above) by reviewing data from the Resources Assessment, the *Sustained Yield Plan for Coastal Mendocino County* (1997) prepared for Louisiana-Pacific Corporation, *the Watershed and Aquatic Wildlife Assessment* (1997) prepared for Coastal Forestlands, Ltd., the *Garcia River Gravel Management Plan* (1996) prepared for the Mendocino County Water Agency, the *Garcia River Watershed Enhancement Plan* (1992) prepared for the Mendocino County Resource Conservation District, and other various data collected as part of the existing data inventory. Existing information for the Garcia River watershed was compared to sediment budgets in other similar watersheds, including Caspar Creek, the Navarro River, and Redwood Creek in Humboldt County.

Summary

The *Assessment of Aquatic Conditions in the Garcia River Watershed* is a compilation and assessment of the existing data for the Garcia River watershed. It serves as the technical basis for the *Garcia River Watershed Water Quality Attainment Strategy* (1997) and represents the collaborative effort of many parties, including: local citizens, landowners, agency representatives, and technical consultants.

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 tanoak 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. (See Figure 1, the map of northern California for the location of the Garcia River watershed within this region).

The California Department of Forestry and Fire Protection has divided the basin into 12 separate sub-basins or Cal Water Planning Watersheds (Planning Watersheds). (See Figure 2, the map of the Garcia River watershed with Planning Watershed boundaries).

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

Figure 1, map of northern CA., unavailable for this edition of this document

Figure 2, map of watershed, unavailable for this edition of this document 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. (See Figure 3, the map identifying the acreage under Timber Harvest Plan in each year from 1987 to 1997 and Figure 4, the map identifying the area under each silvicultural practice in this same time period).

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 cutover timberland was put into range land by 1912. Slashing camps were started, with axmen cutting all young virgin and second growth trees. In 1915 the White Lumber Company sold all of its holdings and much of the timbered land in the Point Arena area 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 three industrial timber companies who own a total of 52% of the basin: Coastal Forestlands, Ltd. with 34%; Louisiana-Pacific Corporation with 16%; and Georgia-Pacific Corporation with 2%. 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 Figure 5, the Ownership Statistics by Planning Watershed, Land Holdings Greater than 1000 Acres in the Garcia River Watershed and Figure 6, 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

Figure 3, THP history, unavailable for this edition of this document

Figure 4, Silvicultural practices, unavailable for this edition of this document

Figure 5, ownership statistics, unavailable for this edition of this document

Figure 6, land ownership map, unavailable for this edition of this document

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 south west 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. (See Figure 7, the soil map and accompanying classification key and Appendix 13 for a description of the physical and chemical properties of each soil type). 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. (See Figure 8, the vegetation types map).

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 9 summarizes the stream density information.

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

Figure 7, soil map, unavailable for this edition of this document

Figure 7b, key to soil map, unavailable for this edition of this document

Figure 8, Vegetation map, unavailable for this edition of this document

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.

Figure 9: 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 greater than average values.

Planning Watershed	Predominant Stream	Square miles	Class I (mi/mi^2)	Class II (mi/mi^2)	Class III (mi/mi^2)	Unclass. Perennial (mi/mi^2)	Unclass. 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

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 10 provides a summary of the estimated bankfull flows associated with each Planning Watershed and some individual tributary systems. (See Figure 11, the map identifying the sub-basin boundaries associated with the estimate of bankfull flows).

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.

Figure 10: 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

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

Figure 11, map of bankfull calculation points, unavailable for this edition of this document

October 31st. The other permittees are allowed to divert water on a year-round basis. (See Appendix 15 for water rights on the Garcia River).

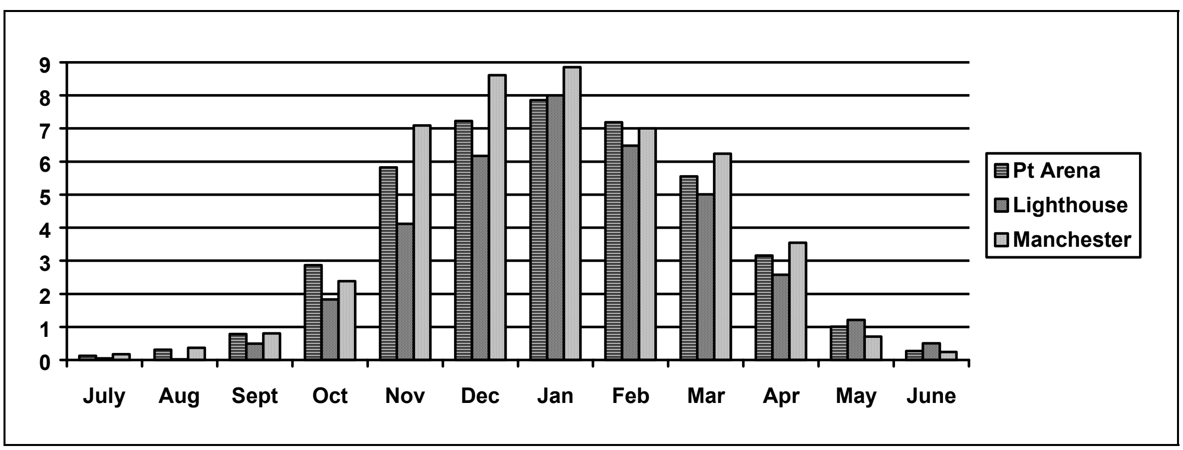
Precipitation

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. (See Figure 13, the annual precipitation map).

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. (See Appendix 14 for an excerpt of the DWR bulletin).

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 12: Average annual rainfall distribution in the vicinity of the Garcia River estuary.



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.

Figure 13, Precipitation map, unavailable for this edition of this document

Flooding

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 14 summarizes the flood frequencies.

Figure 14: 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 15 summarizes the peak flow discharges recorded at the USGS gaging station on the Garcia River at Connor Hole.

Figure 15: 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-- 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.

LIMITING FACTORS ASSESSMENT

Introduction

This chapter includes a review of all of the available data for the Garcia River watershed related to channel morphology and aquatic habitat, including water quality. The data is primarily evaluated with respect to the success of coho salmon in individual sub-basins within the watershed. It is used to determine what factors, if any, appear to be limiting the success of coho in individual sub-basins.

The data is evaluated with respect to coho salmon because of the coho's recent listing by the National Marine Fisheries Service as a threatened species and because of its relative sensitivity to changes in environmental conditions. As such, the coho salmon is used as an indicator species-- an indicator of overall watershed health. Another species included in this review is the steelhead which is currently proposed by the National Marine Fisheries Service for listing on the endangered species list. Steelhead appear to thrive under a somewhat broader range of environmental conditions than do the coho. Various amphibian species may also be appropriate indicator species and warrant greater consideration in the future.

In this chapter, potential limiting factors are identified for each sub-basin within the Garcia River watershed. The degree of certainty with regard to the identified limiting factors varies widely due to the wide variation in the availability of quality data. This evaluation relies on conservative assumptions and estimates where abundant, quality data is currently lacking.

Defining Limiting Factors

Limiting factors are those factors which prevent a species from achieving a self-sustaining, viable population. Limiting factors can be related to human activities such as over-fishing. Or, they can be related to natural events such as drought. They also can be related to a combination of human and natural events. For example, the natural rate of erosion may be increased on a hillside when it is heavily roaded. Should such accelerated erosion lead to an increase in the rate at which sediment is delivered to a stream, such delivered sediment may fill in pools or bury gravels. Pools are necessary as habitat for rearing and over-wintering. Clean gravels are necessary as spawning habitat.

What follows is a list of the factors which may potentially limit the success of coho in the Garcia River watershed. This list does not include factors which are exclusively related to natural events or events outside of the basin.

Spawning Habitat

- Excess fine sediment can fill in the interstices of gravels, cementing them in place and reducing their viability as a spawning substrate
- Excess fine sediment can fill in the interstices of redds thus:

    - reducing the oxygen which is available to the fish embryos,
    - reducing the transport of waste material from the interior of the redd, and/or
    - impairing the fry in its emergence from the redd

- Removal or burial of coarse sediment reduces the area available for spawning
- Excess coarse sediment reduces the depth of the stream channel causing stream channel widening, bank erosion, and increased flood potential thus reducing pool habitat and increasing the vulnerability of redds
- Increased peak flows scour redds and deter winter spawners

Rearing/Overwintering Habitat

- Excess coarse sediment can fill in pools thus reducing the volume of available rearing and/or overwintering habitat
- Excess fine sediment can fill in pools thus reducing the volume of available rearing and/or over-wintering habitat
- Removal, burial or scouring of large woody debris and/or other roughness elements reduces the habitat complexity and pool formation
- Excess coarse sediment reduces the depth of the stream channel causing stream channel widening, bank erosion, and increased flood potential thus reducing pool habitat
- Increased peak flows scour stream channels potentially impacting overwintering fish

Water temperature

- Elevated water temperatures increase the metabolic rate, reduce growth and reduce survivability
- Removing or reducing riparian vegetation increases solar radiation thus increasing summer water temperatures
- Increasing sediment delivery to a stream beyond its ability to transport it decreases the channel depth and causes channel widening which increases the area of solar gain

Instream cover

- Removal or burial of cover elements such as large woody debris or boulders increases vulnerability to predation and decreases channel structure and habitat diversity
- Stream bank erosion reduces the area of undercut bank available for cover thus increasing vulnerability to predation
- Removal of riparian vegetation reduces the volume of overhanging vegetation available as cover thus increasing vulnerability to predation. It also reduces bank stability.

Barriers

Log jams, poorly-designed culverts, fishing nets, or low flow conditions can prevent fish from migrating upstream to spawning grounds, within the basin to refugia, or downstream to the ocean

Food supply

Removal of riparian vegetation can reduce the amount of leaf litter necessary to support the macroinvertebrate food supply
Excess fine sediment can reduce the area necessary to support the macroinvertebrate food supply
Contaminants such as ammonia, nutrients, or pesticides can reduce macroinvertebrate populations

Water quality

Contaminants such as ammonia, nutrients, or pesticides can effect both vertebrate and invertebrate populations
Contaminants such as excessive Biological Oxygen Demand can reduce the dissolved oxygen levels necessary for proper metabolism

Physical disturbance

Instream activities involving the movement of equipment in the stream (including off-road vehicles, trucks, dozers, etc.) increases the potential for direct harm to fish and/or their redds
An increase in the volume, velocity and/or duration of winter floods increases the potential for direct harm to fish and/or their redds

Methods

This Limiting Factors Assessment was conducted in four stages. In the first stage, all of the available data and other relevant information was collected and compiled into a four-volume *Existing Information Inventory* (1997). Descriptions of the data are contained on the California Resource Agency's CERES web page at http://ceres.ca.gov. In the second stage, a group of technical experts drawn from participating agencies met in 2 all-day meetings to discuss the data and draw tentative conclusions regarding potential limiting factors. Members of the group represented the Natural Resources Conservation Service, the U.S. Environmental Protection Agency, the North Coast Regional Water Quality Control Board, the California Department of

Forestry and Fire Protection, the California Division of Mines and Geology, the California Department of Fish and Game, the Mendocino County Resources Conservation District, and the Mendocino County Water Agency. In the third stage, a summary of the data was presented to the Garcia River Watershed Advisory Group where further discussion and refinements of the data and conclusions were made. The Garcia River Watershed Advisory Group was comprised of land owners; land managers; environmentalists; local, state and federal agency representatives; and other interested members of the public. In the fourth stage, staff at the North Coast Regional Water Quality Control Board summarized the data, compiled the meeting notes, and further refined the data analysis.

The available data for the Garcia River watershed related to channel morphology and aquatic habitat is divided into the categories described in the outline below. Appendices 1 through 12 in the accompanying volume include a summary of all of the available data for each Planning Watershed, also organized into these categories. Below is a description of the sources of data which were used in the Limiting Factors Assessment, as well as a summary of the findings.

Channel Morphology

Slope

Channel slopes were calculated by GIS by overlapping hipsography (topographic lines) with hydrography (streams). A stream gradient map was developed and is contained in the Geographic Information System operated by CDF. (See Figure 16, the Stream Gradients-- Class I and Class II Watercourses map). The stream gradient map illustrates that 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 from 3% up to greater than 20%. There is suitable steelhead habitat in many of these moderate to steep regions.

Louisiana-Pacific Corporation (L-P) has produced a similar map for 6 of the planning watersheds which make up its Garcia River Watershed and Wildlife Assessment Area. L-P has divided stream slopes into source reaches (greater than 20% gradient), transport reaches (3-20% gradient) and storage reaches (<3% gradient). Field observation in the Garcia River watershed suggests that in smaller tributaries, storage reaches may be found at steeper gradients than generally expected, perhaps up to 8% (Jack Monschke, personal communication). Louisiana-Pacific Corporation describes the mainstem as a storage reach, along with much of the North Fork Garcia, South Fork Garcia, and Signal Creek. The mainstems of other tributaries are generally described as transport reaches with first and second order streams identified as source reaches.

Figure 16, Stream gradient map unavailable for this edition of this document

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 17 summarizes these estimates.

Figure 17: 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 18 summarizes the existing McNeil data.

Figure 18: 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 19 summarizes the substrate data collected as part of the habitat typing conducted by the Mendocino County Resource Conservation District.

Figure 19: 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.

Width/depth ratio

Numerous channel cross-sections have been measured throughout the lower mainstem Garcia in relation to the gravel mining operations centralized at the end of Buckridge Road at the confluence with the North Fork Garcia River. Dennis Jackson, a hydrologist formerly with the

Mendocino County Water Agency, reported several conclusions in his *Analysis of the 1996 Garcia River Cross Sections* (1997) in which he reviewed the cross sections from the lower river collected from 1991 to 1996. He concluded , for example, he concluded that a wave of sediment has moved past the Conner Hole gaging station in the lower river beginning in 1969 and peaking in 1975. (See Figures 20 and 21, excerpts from Jackson's report which indicate cross section locations and summarize the data, respectively).

Jackson further concluded that seven of the eleven cross sections in the lower river from Eureka Hill bridge down showed a decline in water surface elevation relative to 1991. The decline in water surface ranged from -0.7 to -1.4 feet. Three of the cross sections showed a change of less than 0.5 feet and are judged to be unchanged. One cross section (Baxman-6) showed a rise in the water surface elevation of 2.1 feet.

Five of the eleven cross sections showed a decrease in the thalweg elevation. The decrease in thalweg elevation ranged from -1.4 to -2.1 feet. Four of the cross sections showed less than 0.5 feet of change in the thalweg elevation. Two of the cross sections showed an increase in the thalweg elevation. The increase in thalweg elevation ranged from 1.4 feet (at the downstream Kendall cross section) to 2.3 feet (at the Baxman-6 cross section). Jackson noted that the downstream Kendall cross section traverses a failed bank and is downstream of a reach that suffered significant bank failure in 1995.

Jackson concluded that the overall trend at the eleven cross sections is a decline in both water surface elevation and thalweg elevation relative to 1991. The tendency for the water surface elevation to decline indicates that the downstream control riffles are being eroded. The drop in thalweg depth shows that the bed is scouring. The erosion of the control riffles and scouring of the bed may be an indication that less bedload is being supplied from above Eureka Hill Bridge. Jackson concluded that the river appears to be in "dynamic equilibrium" in this lower reach.

The Mendocino County Resource Conservation District (RCD) measured cross-sections in various locations in relation to restoration work funded through the RCD. Similarly, Coastal Forestlands, Ltd. (CFL) measured cross-sections in locations throughout its ownership in association with its *Watershed and Aquatic Habitat Assessment* (1997). In each case, cross-sections were only measured for one year, 1995 and 1996, respectively. Figure 22 summarizes width/depth ratios calculated for these other cross-sections measured in the watershed.

Figure 20: Map of Cross Section Endpoints in the Lower Garcia River as excerpted from Jackson's "Analysis of the 1996 Garcia River Cross Sections" (1997)

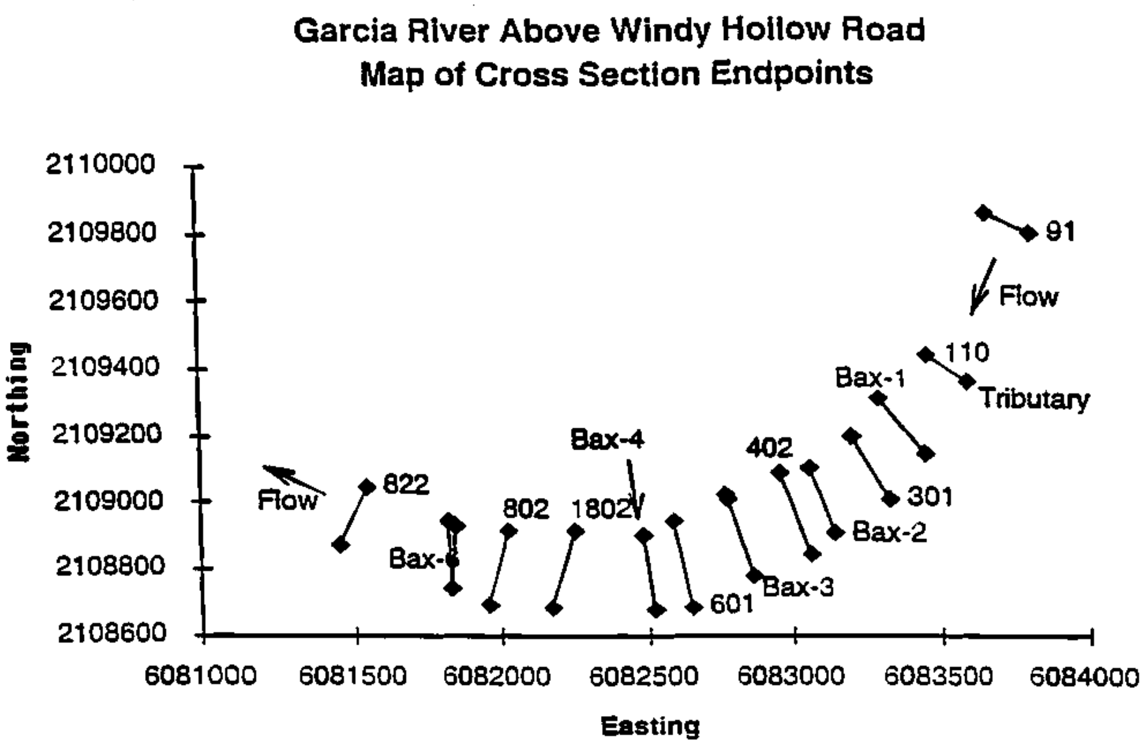


Figure 21: Cross Section Data for the Lower Garcia River as excerpted from Jackson's "Analysis of the 1996 Garcia River Cross Sections" (1997)

Garcia River
Water Surface and Thalweg Elevations Relative to 1991 or 1993 Values

	1991		1993		1994		1995		1996	
Cross Section	Water	Thalweg	Water	Thalweg	Water	Thalweg	Water	Thalweg	Water	Thalweg
Bentonite										
92			0.0	0.0	0.0	0.2			0.0	0.0
110			0.0	0.0	-0.3	1.3			-0.3	1.5
Baxman-1	0.7	0.9	0.0	0.0	-0.4	0.1	-0.2	0.7	-0.3	-0.8
302			0.0	0.0	-0.4	0.2	-0.4	0.9	-0.3	1.6
Baxman-2	0.4	0.2	0.0	0.0	-0.4	-1.2	-0.5	-2.3	-0.3	-1.2
402			0.0	0.0	-0.4	-0.2	-0.3	-0.2	-0.3	-2.0
Baxman-3	0.4	0.2	0.0	0.0	-0.4	-1.7	-0.4	-1.7	-0.3	-1.8
602			0.0	0.0	-0.4	-0.8	-0.2	-1.1	-0.1	-0.6
Baxman-4	-1.3	-1.3	0.0	0.0	-0.5	-2.3	-0.3	-3.2	-0.4	-0.8
1802			0.0	0.0	-0.1	-2.1			1.8	-0.4
802			0.0	0.0	-0.2	0.4			1.8	0.4
Baxman-6	-1.5	-0.9	0.0	0.0	-0.5	-2.1			0.9	1.7
812			0.0	0.0	-0.5	-2.4			0.9	2.1
822			0.0	0.0	-0.3	0.3			-0.3	
Kendall										
Upstream	0.0	0.0	-0.6	-0.8					0.2	0.2
Downstream	0.0	0.0	-0.7	0.2					0.2	1.4
Hooper										
MCWA-1	0.0	0.0	-0.3	0.3					-1.1	-1.4
MCWA-2	0.0	0.0	0.5	-0.1						
MCWA-3	0.0	0.0	0.1	-0.4						
MCWA-4	0.0	0.0	-0.7	-0.9						
Conner Hole										
Cableway	0.0	0.0	1.3				0.8	-0.5	-0.8	-0.4
Footbridge	0.0	0.0							-0.7	-0.3
Downstream	0.0	0.0	1.3	-1.0					-1.4	-1.6
Eureka Hill										
Upstream										
Downstream										

Figure 22: Summary of width/depth ratios calculated for cross-sections collected in various locations throughout the watershed.

Planning Watershed	Stream	Data Collector	Width/depth ratio
113.70010	Pardaloe Creek	RCD	11
113.70013	Blue Waterhole Creek	RCD	10
	Garcia River	CFL	12
113.70014	Inman Creek #1	CFL	12.6
	Inman Creek #2	CFL	12.2
	Inman Creek #3	CFL	7.6
113.70020	Signal Creek #1	CFL	7.0
	Signal Creek #2	CFL	13.5
	Signal Creek #3	CFL	10.9
113.70021	Garcia River	CFL	12.9
113.70022	Garcia River	CFL	20
113.70025	North Fork #1	CFL	17.0
	North Fork #2	CFL	11.3
	North Fork #3	CFL	23.1

<u>Confinement</u>

Confinement has been measured for the Garcia River mainstem using aerial photographs. A floodplain width to channel width which is greater than 4 is defined as unconfined. A floodplain width to channel width which is between 2 and 4 is defined as moderately confined. A floodplain to channel width which is less than 2 is defined as confined. Confinement has been estimated for various individual tributaries from field observations. (See Figure 23, the Main Stem- Garcia River Channel Confinement map). Louisiana-Pacific Corporation has measured confinement for streams within its Watershed and Wildlife Assessment Area. Louisiana-Pacific Corporation's confinement map generally, but not perfectly, agrees with the attached map.

<u>Stream Channel Opening</u>

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. Figure 24 provides a summary of the results. 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,

Figure 23, Channel confinement map unavailable for this edition of this document 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.

Figure 24: 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[4] North Fork	106.0	0.7	5.5	2.8	1%	5%	3%
113.70026[1] Hathaway	34.0	0.0	0.0	0.0	0%	0%	0%

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

[4] 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.

(113.70014). Stansbury/Whitlow Creeks (113.70012) has nearly recovered (within 25%) its 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 Creek (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.

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 25 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 25: 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 26 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 26: Summary of estimates of the percentage of pools, riffles and runs from Department of Fish and Game Stream Surveys

Planning Watershed	Stream	Date	Pools (%)	Riffles (%)	Runs (%)
113.70010	Mill	06/24/94	40	20	40
	Pardaloe	06/24/94	0	100	0
113.70011	None				
113.70012	None				
113.70013	Blue Waterhole	08/20/87	30	40	30
113.70014	None				
113.70020	Signal	08/19/87	30	60	10
		11/06/95	70	15	15
113.70021	None				
113.70022	None				
113.70023	South Fork	08/17/87	40	50	10
		10/13/88	40	50	10
		10/19/89	25	65	10
		10/08/91	25	65	10
		10/06/92	20	80	0
	Fleming	08/17/87	50	30	20
		10/13/88	30	50	20
		10/19/89	15	75	10
		11/09/90	20	60	20
		10/08/91	50	40	10
113.70024	Rolling Brook	08/18/87	15	65	20
	Lee	10/19/89	15	84	1
113.70025	North Fork	10/27/83	60	0	40
113.70026	Hathaway	09/25/86	75	5	20
	Garcia	08/18/87	30	20	50
		08/20/87	30	20	30
		11/11/87	5	2	93

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 27 summarizes the Department's data.

Figure 27: 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
		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.

Stream Temperature

There are several sources of temperature data in the Garcia basin. Year-round temperatures were recorded from 1964 to 1979 at Connor Hole, 0.9 miles downstream from the North Fork on the mainstem Garcia. Since then, the Friends of the Garcia have collected summer temperature data from 1993 through 1996 at various locations in the basin. Figure 28 summarizes the basin wide temperature data collected by Friends of the Garcia based on whether or not data at individual stations have exceeded the short-term maximum temperature of 23.7C, the maximum weekly average temperature of 17.4C or fluctuated outside of the preferred temperature range of coho salmon (11.8-14.6C).

Figure 28: Summary of Stream Temperatures collected by Friends of the Garcia

Planning Watershed	Stream	Does the daily temperature exceed 23.7C?	Does the weekly average temperature exceed 17.4C?	What % of the time are daily temps between 11.8 & 14.6C?
113.70010	Pardaloe Creek	Unknown	Unknown	Unknown
	Redwood Creek	No	Unknown	<20
	Mill Creek	No	Unknown	<20
113.70011	Garcia River	No	Unknown	<20
113.70012	Stansbury Creek	Unknown	Unknown	Unknown
113.70013	Blue Waterhole Creek	Yes	Yes	<5
113.70014	Inman Creek	Yes	Unknown	<20
113.70020	Signal Creek	Unknown	Unknown	Unknown
113.70021	Graphite Creek	Unknown	Unknown	Unknown
113.70022	Garcia River	No	Yes	<15
113.70023	Garcia River	Yes	Yes	0
	South Fork Garcia	No	No	<50
113.70024	Mill Creek	No	No	>95
	Rolling Brook	No	No	>90
	Lee Creek	No	No	>95
	Hutton Gulch	No	No	>95
	Garcia @ Louie’s Pool	No	Yes	<1
	Garcia @ Eureka Hill Bridge	No	Yes	0
113.70025	Olsen Gulch	No	No	>85
	Garcia @ Oz Hole	No	Yes	<2
113.70026	Hathaway Creek	No	No	>90
	Garcia @ Minor Hole	No	Yes	0

In addition, the 3 industrial timber owners and 1 non-industrial timber owner have collected summer temperature data on their individual properties. These later sources of data have all been collected using continuous data loggers. Based on this data, the following stream reaches potentially suffer stream temperatures which limit the success of cold water fish: the entire mainstem Garcia from Pardaloe Creek to the estuary, Pardaloe Creek, and Planning Watersheds 113.70011-113.70022.

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.

Mendocino Watershed Services, a non-profit restoration organization and New Growth Forestry, a forestry consulting firm have identified the location of several potential barriers in various locations throughout the watershed as a result of their stream restoration efforts. These have either been modified through stream restoration or are planned for such modification in the future.

The Department of Fish and Game has kept track of anadromous fish barriers on streams in the Garcia River basin as it has conducted stream surveys over the years. The general location of many of these barriers are recorded on the following map. These primarily represent natural barriers such as bedrock falls. (See Figure 29, Anadromous Fish Migration Barriers map).

Figure 29, Anadromous fish barriers, unavailable for this edition of this document

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. 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. 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 stream reaches of approximately 100 meters. Figure 30 summarizes the Department's data.

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.

Figure 30: 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		

Planning Watershed	Stream	Date	Steelhead density (fish/m^2)	Steelhead biomass (kg/hectare)	Coho density (fish/m^2)	Coho biomass (kg/hectare)
		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		
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		

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 31 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 31: 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 then 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 standard. Figure 32 summarizes the water quality data collected at Highway 1 and Buckridge Road.

Figure 32: 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.

<u>Physical Disturbance</u>

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 the year. Other comments included mention of the potential for physical disturbance to fish, redds and habitat by gravel mining activities.

Potential 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 Watersheds throughout the Garcia River basin. Figure 33 summarizes the instream data and compares it to numeric targets derived from the literature. Figure 28 augments Figure 33 by providing a summary of the temperature data for the watershed. Where data did not exist, but members of the team had personal familiarity with the Planning Watershed in question, the conclusions were qualified. Figures 28 and 33 can be interpreted to conclude the following:

- Where instream summer temperatures exceed the daily maximum temperature, maximum weekly average temperature or regularly exceed the preferred range for coho salmon, growth
- 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 40%, 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

<u>Summary of Potential Limiting Factors in each Planning Watershed</u>

1. *Planning Watershed 113.70010-- Pardaloe Creek Sub-basin*

The Pardaloe Creek Planning Watershed, prior to the late 1960s when the Department of Fish and Game blew up a waterfall on the mainstem Garcia River, supported only resident trout and other non-anadromous aquatic species. Since being opened up to anadromous fish, however, both the Pardaloe and Mill Creek sub-basins have supported abundant salmonid populations. Even today, these sub-basins contain some of the highest densities of steelhead redds of anywhere in the basin. Coho, however, have not recently been seen here.

a. Pardaloe Creek

At the April 17, 1997 Limiting Factors meeting, the agency group identified the following limiting factors for Pardaloe Creek: elevated summer temperatures, minimal pool depth, and minimal overwintering habitat. Watershed Advisory Group members confirmed that larger fish often must compete in Pardaloe for limited hiding places. Further, the *Garcia River Watershed Enhancement Plan* (1992) states that "while pools were abundant, mean maximum depth was only just over 2 feet...Cover in all habitat units averaged less than 25%...Lack of flows and decreased depth due to aggradation prevent almost any use of riffles during low flow conditions. High water temperatures may have prevented use of run and step run units...Pardaloe Creek is only in the early stages of recovery from past sediment incursions and lacks sufficient shade and riparian cover...The quality of gravel and cobble was classified as fair to poor throughout the reach." (Page 3-44). Currently available information indicates the following as potential limiting factors:

- Growth-- due to elevated summer temperatures related to insufficient shade/riparian cover and reduced channel depth/low summer flows
- Rearing/Overwintering-- due to minimal pool depth and frequency, related to aggradation and limited stream complexity
- Spawning-- due to elevated embeddedness

b. Mill Creek

At the April 17, 1997 Limiting Factors meeting, the agency group discussed the possibility of de-listing the Mill Creek sub-basin from the 303(d) Impaired Waters list. While one McNeil sample and observations at the mouth of the stream gave some pause, it was noted that Mill and Redwood Creeks have some of the best, locally defined, functional floodplain of anywhere in the basin. Further, the habitat, cover, complexity, and riparian condition imply a functioning system. As such, the group suggested that a field survey be conducted to more closely understand the current condition of the sub-basin, consider it for de-listing, and consider it as a potential reference stream for the rest of the basin.

2. *Planning Watershed 113.70011-- Larmour Creek Sub-basin*

Grant's Camp Creek, Larmour Creek and the upper Garcia River mainstem, prior to the late 1960s when the Department of Fish and Game blew up a waterfall downstream on the mainstem Garcia River, supported only resident trout and other non-anadromous aquatic species. Since being opened up to anadromous fish, however, these streams have supported anadromous species, as well. Grant's Camp Creek was rated as moderately to severely damaged in 1996 while Larmour Creek and the mainstem Garcia River were rated as undamaged and lightly damaged, respectively.

a. Grant's Camp Creek

The information for Grant's Camp Creek is generally over 30 years old. Only the channel slope data, as derived from topographical maps, has its origins in a more modern era. The mainstem Grant's Camp Creek is about 3%, the west-side tributary about 7% and the east side tributary about 5% in slope. Older information suggests that Grant's Camp Creek, though small, has in the past had suitable habitat for salmonids despite its rating as moderately and severely damaged. Assessing the potential limiting factors is not possible from the existing information.

b. Larmour Creek

As with Grant's Camp Creek, there is little current data available which describes the condition of the sub-basin. The channel slope ranges from 7-8% in the first mile to 5-6% thereafter with a 75 foot falls identified at the slope break. As such, its value as an anadromous fishery appears limited. Assessing the potential limiting factors is not possible from the existing information.

c. Garcia River

Historic information indicates that the mainstem Garcia River in this Planning Watershed has supported abundant steelhead populations. Currently available information indicates the following as potentially limiting factors:

- Rearing-- due to limited pool depths related to sedimentation and limited instream complexity
- Growth-- due to elevated summer stream temperatures

3. *Planning Watershed 113.70012-- Stansbury Creek Sub-basin*

Stansbury Creek used to be the upper most stream available to anadromous fish before the Department of Fish and Game blew up a 12 foot falls on the Garcia River just upstream of its confluence with Stansbury. Salmonids, including Chinook salmon, used to pool up on the Garcia River below these falls.

a. Stansbury Creek

There is very little available information on Stansbury Creek, besides notes on the location of log jams and poorly-maintained roads. The stream channel is approximately 6-8% in slope in its lower to mid reaches. Its upper tributaries steepen considerably. It was mentioned at the April 28, 1997 Watershed Advisory Group meeting that the lower reach of Stansbury is defined by a rock gorge. The canopy in Stansbury is reported as fairly good.

Given the steepness of slope, the value of Stansbury Creek as a spawning stream is in question. However, given its relatively good canopy and local bedrock, Stansbury may provide potential habitat for summer rearing. In fact, there were sitings of young-of-year steelhead in 1995. Nonetheless, assessing the potential limiting factors is not possible from the existing information.

b. Whitlow Creek

Whitlow Creek is described mostly through timber harvest plans. THPs in this stream indicate that Whitlow Creek is "lacking sinuosity, large woody debris and a good pool to riffle ratio." Water temperatures, are also suspected of being elevated due to the poor to moderate shade canopy. Currently available information indicates the following as potential limiting factors:

- Rearing/Overwintering-- due to limited pool depth and frequency and limited instream complexity

c. Garcia River

According to historical reports from the Department of Fish and Game, the Garcia River used to be comprised of a "good combination of excellent spawning riffles and deep pools and stretches of rough, boulder- and rubble-strewn water." This habitat apparently supported an abundant salmonid fishery. There is little current data or information available which describes the conditions of this stretch of the Garcia River. However, what does exist suggests the following potential limiting factor:

- Growth-- due to elevated summer stream temperatures

4. *Planning Watershed 113.70013-- Blue Waterhole Creek Sub-basin*

The 1952 aerial photographs indicate that a substantial amount of logging had already occurred in the Blue Waterhole sub-basin by the 1950s. By 1966, the Department of Fish and Game rated Blue Waterhole Creek and severely damaged. Blue Waterhole Creek is particularly noted for its good summer flows which exceed many other Garcia River tributaries. Currently available information indicates the following potential limiting factors:

- Growth-- due to elevated summer stream temperatures related to poor shade canopy
- Rearing/Overwintering-- due to limited pool depth and frequency related to excess sediment
- Embryo development in the Garcia River mainstem-- due to elevated fines < 0.85 mm
- Emergence in the Garcia River mainstem-- due to elevated fines < 6.5 mm

5. *Planning Watershed 113.70014-- Inman Creek Sub-basin*

Inman Creek has a gentle channel slope, ranging from 0-3% up to its first fork and 2-3% in the lower reaches of most of its tributaries. It has a fair among of cobble and boulder in the stream. Further, steelhead are regularly seen in Inman Creek. Coho have been seen periodically, as well. Currently available information indicates the following as potential limiting factors:

- Growth-- due to elevated summer stream temperatures related to poor canopy cover
- Rearing/Overwintering-- due to limited pool depth, pool frequency, related to sedimentation and lack of large woody debris
- Emergence-- due to elevated fines < 6.5 mm

6. *Planning Watershed 113.70020-- Signal Creek Sub-basin*

The stream channel in Signal Creek slopes from 3-4% in the first 3 miles and then ranges from 5-6% for the next mile before steepening to 10-15%. The stream has lots of good boulder and cobble in the stream and appears to have a sufficient number of pools and riffles. The slopes appear to be quite stable, here, even following a fire in the early 1990s. Summer water temperatures appear to be moderate to good. Steelhead are regularly seen here. Coho are seen periodically, as well. Currently available information indicates the following potential limiting factors:

- Rearing-- due to limited pool depth related to a lack of large woody debris
- Excessive flow velocities

7. *Planning Watershed 113.70021-- Graphite Creek Sub-basin*

Neither Casper Creek nor Graphite Creek have been extensively studied. Only the geology is relatively well understood. Casper Creek defines a border between the Coastal Belt Franciscan material on the southwestern side of the basin and Franciscan Melange on the northeastern side. The Division of Mines and Geology notes that in Franciscan Melange, 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.

a. Casper Creek

Casper Creek has a low to moderate channel slope with very steep tributaries. There is a short, steep slope at its mouth which may be impeding fish migration. Louisiana-Pacific Corporation conducted a stream survey in Casper Creek and found no fish present. However, the surveyor did note adequate summer temperatures and the presence of pools. Thus, Casper may provide adequate habitat for summer rearing were there is adequate access. Currently available information suggests that the following is a potential limiting factor:

- Access-- due to limited channel depth at the mouth

b. Graphite Creek

Graphite Creek is somewhat more steep than Casper Creek. It too has a short, steep section at its mouth. There is very little information regarding Graphite Creek. However, the currently available information suggests the following as a potential limiting factor:

- Access-- due to limited channel depth at the mouth

c. Garcia River

The stream is shallow and wide in this section and flows with a low gradient. Steelhead fry have been observed here, as well as measured in 1987. Currently available information indicates the following is a potential limiting factor:

- Growth-- due to elevated summer stream temperatures

8. *Planning Watershed 113.70022-- Beebe Creek Sub-basin*

a. Beebe Creek

Beebe Creek is relatively steep, with a slope generally greater than 12%. A potential bedrock barrier has been noted just above the Garcia Haul Road. However, the Department of Fish and Game has electrofished above the Garcia Haul Road and counted 1,901 steelhead per linear mile. Whether or not these might have been resident trout is unknown. Currently available information indicate the following as potential limiting factors:

- Access-- due to limited channel depth at the mouth
- Rearing-- due to limited pool depth and instream cover

b. Garcia River

Judging by confinement measurements, it appears as if the Garcia River is destabilizing its banks at meanders where confinement is measured as moderate. It has also been noted that the river is warm and wide in this stretch. Many observers have noted the presence of redds in this stretch. Currently available information indicates the following as a potential limiting factor:

- Growth-- due to elevated summer stream temperatures related to stream width

9. *Planning Watershed 113.70023-- South Fork Garcia Sub-basin*

According to "old timers," the South Fork used to be a big producer of coho salmon. The Department of Fish and Game began stocking the South Fork and Fleming Creek with coho in the 1980s to help improve the standing crop. Abundant steelhead are still seen in the South Fork Garcia, as are periodic coho.

a. South Fork Garcia River

The South Fork Garcia River has a low gradient through its low and mid reaches. It changes course mid way up where it steepens and then become more gentle in slope before steepening again at its headwaters. The substrate is predominantly gravel and cobble, the canopy cover is dense, and the pool density has decreased over the years. Currently available information indicates the following as potential limiting factors:

- Access-- due to limited channel depth at the mouth
- Embryo survival-- due to elevated fines < 0.85 mm
- Emergence-- due to elevated fines < 6.5 mm
- Rearing/Overwintering-- due to limited pool depth and frequency related to sedimentation and limited instream complexity

b. Fleming Creek

Fleming Creek is moderately sloped in its lower reach-- approximately 6%. The substrate is composed predominantly of gravel and rubble, the canopy closure is good, summer water temperatures appear adequate, and the proportion of pools to riffles appears to have decreased over time. Currently available information indicates the following as potential limiting factors:

- Access-- due to improper culvert placement
- Embryo survival-- due to elevated fines < 0.85 mm
- Emergence-- due to elevated fine < 6.5 mm
- Rearing/Overwintering-- due to limited pool depth and frequency related to sedimentation

c. Garcia River

There has been spawning observed on the mainstem below the South Fork Garcia. In fact, fish sometime pool up below the South Fork waiting for higher flows to allow them up this smaller tributary. Currently available information indicates the following potential limiting factors:

- Growth-- due to elevated summer stream temperatures
- Rearing-- due to limited pool depth related to a lack of sufficient instream complexity

10. *Planning Watershed 113.70024-- Rolling Brook Sub-basin*

Mill Creek, Rolling Brook, Lee Creek and Hutton Gulch all have good summer water temperatures-- generally within the preferred summer range for coho salmon, and never exceeding the maximum weekly average temperature. They also are all fairly steep with a more gently sloping channel at the mouths of each tributary. As such, these streams provide fine habitat for steelhead, but questionable habitat for coho spawning. Nonetheless, these streams may provide summer rearing and overwintering habitat for coho. In particular, the cooler flows may attract juvenile fish who during the summer will seek refuge from elevated mainstem temperatures.

a. Mill Creek

The lower reach of Mill Creek ranges from 1-3% in slope. It steepens to 10-15% then become more gentle with a series of ever-steepening cascades. In 1967, Mill Creek was noted as a very good spawning and nursery stream. Gravels were noted in the lower reach and pools a short distance upstream. Summer temperatures were measured as adequate, as they are today. Steelhead have been counted in Mill Creek as recently as 1996. Currently available information indicates the following potential limiting factors:

- Access-- due to limited channel depth at the mouth

b. Rolling Brook

The lower reach of Rolling Brook ranges from 3-5% in slope and then steepens in stretches from 7-10%, to 10-15% and greater than 20%. The substrate is predominantly gravel in the lower reach. Louisiana-Pacific Corporation rated the pools as "poor", the cover as "good," the amount of large woody debris as "good," the spawning gravels as "poor" to "fair," and the overwintering habitat as "good." Currently available information indicates the following potential limiting factors:

- Embryo survival-- due to elevated fines < 0.85 mm
- Emergence-- due to elevated fines < 6.5 mm
- Rearing/Overwintering-- due to limited pool depth and frequency related to sedimentation

c. Lee Creek

The lower reach of Lee Creek ranges from 5-6% in slope. The mid and upper reaches form a series of slope steps ranging alternately from 10-15%, 7-10%, 10-155, >20%, 10-15%, 7-10%, and >20% at the upper perennial reach. The substrate is predominantly rubble, as predicted by Louisiana-Pacific Corporation's particle size model. It is comprised mostly of riffles and the cover is only fair. Currently available information indicates the following potential limiting factors:

- Rearing/Overwintering-- due to limited pool depth and frequency

d. Hutton Gulch

The lower reach of Hutton Gulch ranges from 1-3%. It steepens to >20% and then flattens out again to slopes ranging from 5-10%. The mouth of Hutton Gulch used to be the site of Save Our Salmon's fish rearing ponds in the 1970s and 1980s. The Department of Fish and Game planted coho salmon there in the 1970s and 1980s, as well. There has been much discussion, over the years, about the degree to which upslope timber practices have impacted the downstream rearing ponds due to sedimentation. Currently available information indicates the following as potential limiting factors:

- Access-- due to limited channel depth at mouth
- Rearing/Overwintering-- due to limited pool depth and frequency

e. Garcia River

Cross sections in this reach of the Garcia River watershed suggest that in the period from 1993 to 1996, the river is in a state of “dynamic equilibrium.” The channel has a low gradient, < 1%. Currently available information indicates the following as a potential limiting factor:

- Growth-- due to elevated summer stream temperatures

11. *Planning Watershed 113.70025-- North Fork Garcia Sub-basin*

The North Fork Garcia River has a low channel gradient up to a bedrock waterfall about 4 miles from the mouth. The Garcia River mainstem, too, has a low channel gradient. There is the potential for coho and steelhead habitat.

a. North Fork Garcia River

Stream temperatures are unknown in the North Fork, but information on barriers, embeddedness, fines, pools and large woody debris exists. Currently available information suggests the following as potential limiting factors:

- Access--due to underground flows near the mouth
- Spawning-- due to elevated embeddedness
- Embryo survival-- due to elevated fines < 0.85 mm
- Emergence-- due to elevated fines < 6.5 mm
- Rearing/Overwintering-- due to limited pool depth and frequency related to sedimentation and a lack of sufficient large woody debris

b. Garcia River

Limited data is available for the mainstem Garcia River in this reach with the exception of cross sections collected in relation to gravel mining operations. Currently available information suggest the following as a limiting factor:

- Growth-- due to elevated summer stream temperatures

12. *Planning Watershed 113.70026-- Hathaway Creek Sub-basin*

The Hathaway Creek sub-basin includes the lower reaches of the Garcia River and its estuary. It is predominantly an alluvial reach with very low channel gradients. The riparian zone was probably composed of a complex, mature redwood forest prior to logging before the turn of the century.

a. Hathaway Creek

Hathaway Creek is described by "old timers" and others as having supported steelhead and coho in the past. The mouth of the stream is characterized by a wetlands which is influenced by tidal action. Currently available information suggests the following as limiting factors:

- Embryo development-- due to elevated fines < 0.85 mm potentially related to the alluvial nature of the lower river
- Emergence-- due to elevated fines < 6.5 mm potentially related to the alluvial nature of the lower river
- Rearing/Overwintering-- due to limited pool frequency

b. Garcia River

The Garcia River is described by "old timers" and others as having supported an abundance of steelhead and coho in the past which used to bring numerous sports fishermen and locals to the lower mainstem for fishing. Currently available information suggests the following as limiting factors:

- Spawning-- due to elevated embeddedness potentially related to the alluvial nature of the lower river
- Rearing-- due to limited instream complexity
- Growth-- due to elevated summer stream temperatures

Figure 33: 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
113.70024										Yes
Mill	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?
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

RESOURCE ASSESSMENT

Introduction

The Resource Assessment is primarily an assessment of upslope conditions as they relate to watershed functioning. It includes discussion of the geomorphology, riparian functioning, hydrologic change, and active erosional processes in the watershed.

Methods

The discussion of geomorphology comes primarily from the work of the Division of Mines and Geology which is compiled on three USGS quadrangles entitled "Geology and Geomorphic Features related to Landsliding" data 1984. Geologic and geomorphic features were mapped from aerial photographs with limited field truthing. This is augmented with erosion hazard rating conducted by timber companies as part of Timber Harvest Plans from 1987 to 1997 and as part of Louisiana-Pacific Corporation's *Sustained Yield Plan for Coastal Mendocino County* (1997).

The discussion of riparian functioning comes primarily from the work of Pacific Watershed Associates entitled *Sediment Production and Delivery in the Garcia River Watershed, Mendocino County, California: An Analysis of Existing Published and Unpublished Data* (1997) and Circuit Rider Productions, Inc. which is included in the *Garcia River Gravel Management Plan* (1996) developed by Philip Williams and Associates. Pacific Watershed Associates conducted an analysis of changes in stream channel opening throughout Garcia River watershed from 1952 through 1996 using a modified RAPID analysis. Circuit Rider Productions, Inc. mapped and analyzed the riparian zone associated with the lower Garcia River based on its potential for impact from gravel mining in that region. This information is augmented by soils/vegetation data, habitat typing data, and instream cover data collected by the Natural Resource Conservation Service, the Mendocino County Resource Conservation District, and the California Department of Fish and Game, respectively.

The discussion of hydrologic change was developed by Wendy Melgin of the U.S. Environmental Protection Agency. Melgin assessed the existing hydrologic data and developed hypotheses and recommendations based on her review of current scientific literature.

The discussion of active erosional processes comes primarily from the work of Pacific Watershed Associates entitled *Sediment Production and Delivery in the Garcia River Watershed, Mendocino County, California: An Analysis of Existing Published and Unpublished Data* (1997) which in turn relies heavily on the work of O'Connor Environmental, Inc. included in *The Garcia River: Watershed Assessment and Instream Monitoring Plan* (1997) developed by Forest, Soil and Water, Inc.

O'Connor Environmental, Inc. conducted a mass wasting and surface erosion analysis in accordance with guidelines of the Washington Department of Natural Resources Standard Methodology for Conducting Watershed Analysis, Version 3.0 (1995). A level 1 analysis was conducted using aerial photographs of the basin dating from 1966 through 1996 provided by the Mendocino County Resource Conservation District and the U.S. Environmental Protection Agency. The analysis also included use of data regarding roads, stream classes, Planning Watershed boundaries, and topography provided as Geographical Information System (GIS) data by the California Department of Forestry and Fire Protection (CDF). The GIS data provided by CDF primarily originated from Timber Harvest Plans submitted to the agency from 1987 through 1997.

Pacific Watershed Associates developed a preliminary sediment budget for the watershed using existing data and comparing it to more complete data sets in other similar watersheds, including the Navarro River, Caspar Creek and Redwood Creek in Humboldt County.

Geomorphology

1. Division of Mines and Geology

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 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 semi-viscous, 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. <u>Erosion Hazard Ratings</u>

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 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. (See Figure 34, Erosion Hazard Ratings).

Figure 34,-- Erosion Hazard Ratings unavailable for this edition of this document

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) (SYP) that Planning Watersheds 113.70020 through 113.70025 are predominated by high EHRs. Extreme EHRs are recorded in Olson 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 L-P'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 Limiting Factors Assessment section 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. <u>Lower Garcia River</u>

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. (See Figure 35, Riparian Vegetation in the Lower Garcia River). 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

Figure 35, Riparian Vegetation in the Lower Garcia River unavailable for this edition of this document 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 36 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 36: 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. <u>Instream Cover Data</u>

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 Limiting Factors section of the strategy. 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. <u>Summary of Riparian Functioning</u>

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.

Hydrologic Change

In a review of the existing flow data, Wendy Melgin of U.S. Environmental Protection Agency concluded that there is not sufficient existing data to determine the degree to which the hydrologic regime has changed as a result of land use activities in the basin. However, she stated that the development of impervious surfaces, such as roads, or compacted soil areas would tend to decrease infiltration and percolation to ground water. These activities decrease the amount of stored water and decrease baseflow during non-runoff periods, such as summer and early fall. The combination of decreased baseflows and increased sediment loads may contribute to the loss of aquatic habitat, such as pools. Appendix 18 contains Melgin's complete assessment.

Erosional Processes Active in the Basin

1. <u>Overview</u>

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 20. 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 road and skid trails approaches deeply incised stream channels. (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, Humboldt County comprehensively evaluates the proportion of sediment delivered from a variety of sources.

2. Mass Wasting Analysis

O'Connor Environmental, Inc. (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. OCEI's work is contained in Appendix 17.

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 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 37 provides a summary of the mass wasting analysis results, including the modified estimates.

a. *Sediment Production in Individual Planning Watersheds*

As outlined in Figure 37, 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
- 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

Figure 37: 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
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

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 ($tons/mi^2/yr$)
113.700	TOTAL	114.5	145 (avg)	664,500	311,200	466,800	423,960	961,900	1,852,660	405

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. 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; Navarro River, Mendocino; Redwood Creek, Humboldt) PWA has estimated that 26-45% of the overall sediment budget is attributable to fluvial erosion from roads and skid trails. See the Synthesis section 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. Landuse 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 38 estimates the miles of stream which have experienced stream bank erosion based on the stream channel opening data.

Figure 38: 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.

There are no specific estimates of sediment production due to fluvial erosion associated with stream banks. See the Preliminary Sediment Budget section below 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.

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* (1997), and 3) the Louisiana-Pacific Corporation *Sustained Yield Plan for Coastal Mendocino County* (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 40 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 39, 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 39: 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 40 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 40: 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 landuse 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 in the Synthesis section.

5. Summary

Figure 41 summarizes the data presented in the Resource Assessment. 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.

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.

Figure 41: 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/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 density (mi/mi^2)	3.63	2.60	4.54	4.43	5.16	5.54	4.01	5.18	3.58	4.66	4.96	3.01
Riparian Functioning												
% of stream corridor with soils which support conifer	>75M >50P	>75	>75	>75	>75	100	>75	100	>75	>75	>75	<25
Riparian zone canopy density	71 M 18P	?	?	?	?	?	?	?	?	?	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

SYNTHESIS

Introduction

The Synthesis chapter attempts to assess both the Limiting Factors Assessment and Resource Assessment together to determine the interactions, as possible, between the hillslope and instream environments. The Synthesis primarily relies on the work of Forest, Soil & Water, Inc. and Pacific Watershed Associates. Their work is contained in Appendices 19 and 20, respectively.

Method

Pacific Watershed Associates evaluated existing sediment delivery and transport data to develop a sediment budget for the Garcia River watershed. Because the existing data for the Garcia River was limited, Pacific Watershed Associates compared the existing data to that of other basins where more complete sediment budgets have already been developed. On this basis, a preliminary sediment budget for the basin was developed.

Forest, Soil & Water, Inc. evaluated the sensitivity of given Planning Watersheds to impact by first establishing the presence of the resource to be protected and then determining if that resource was responding negatively to land management. Their assessment is augmented here in summary form.

A master table is produced which summarizes all of the information contained in the Limiting Factors Assessment and Resource Assessment, divided by Planning Watershed. It is contained in Figure 43. From this summary, a table is developed which identifies those Planning Watersheds in which salmonids have been measured or seen, the condition of the aquatic habitat, and the production of fine and coarse sediment. It is contained in Figure 44. A series of hypotheses are made regarding the likely relationships between instream conditions and hillslope characteristics or activities. These hypotheses are tested in each Planning Watershed to determine if the predicted relationship exists. It is important to note that while plentiful throughout the watershed, the existing data is generally not specific enough nor plentiful enough in specific sub-basins to be able to draw statistically significant conclusions.

Preliminary Sediment Budget

1. <u>Sediment Inputs</u>

PWA (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 SYPs 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, 1,400 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 coastal 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, and erosion, sediment yield from road cutbanks and ditches, streambank 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 streambank 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 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. Instream Stored Sediment

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 42 summarizes the data collected by LP.

Figure 42: Summary of instream stored sediment data collected by L-P as presented by PWA 1997.

Inferred Stream Order	Length of inventoried stream (mi)	Sediment stored in terraces and floodplains (yd3/mi)	Sediment stored in terraces and floodplains (%)	Sediment stored in the active channel (yd3/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. Sediment Output

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. Overall Sediment Budget

The assessments conducted by PWA (1997) and Philip Williams & Associates (1996) indicate that at a minimum 1,400 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 174 ton/mi^2/year may be associated with:

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

Figure 43: Summary of Preliminary Sediment Budget for the Garcia River Watershed

Sediment Movement Mechanism	**Percentage of overall budget**	**Estimated average annual sediment yield (tons/mi^2/year)**
SEDIMENT INPUTS		
Mass wasting	40 to 60%	560 to 840
Fluvial erosion	26 to 45%	364 to 630
Surface erosion	10 to 21%	140 to 294
Total		1,400*
MOVEMENT OF STORED SEDIMENT		
Gravel extraction	77%	586
Background erosion	23%	174*
SEDIMENT OUTPUTS		
Bedload and suspended sediment	100%	2,160*

* 174 tons/mi^2/year have not been specifically accounted for in the sediment budget. They may be part of the natural erosion of instream stored sediment as depicted here or represent inaccuracies in the sediment input or output estimates.

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.

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 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.

Observations

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.

Figure 44. Summary of all the data and information contained in the Limiting Factors Assessment and Resource Assessment

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

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
Annual sediment delivery rate due to surface erosion (tons/yr)	7,283	19,405	13,381	15,204	19,446	14,342	12,409	9,088	16,189	24,015	36,942	5,876
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 density (mi/mi^2)	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	>75M >50P	>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

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
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*
% change from 1 952 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 I	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
Does daily temperature exceed 23.5C?	No	No	?	Yes	Yes	?	?	No	Yes	No	No	No
Does weekly average temperature exceed 17.4C?	?	?	?	Yes	?	?	?	Yes	Yes	Yes	Yes	Yes
How often is daily temperature in 11.8 - 14. 6C range? (%)	<20	<20	?	<5	<20	?	?	<15	<50	0	<2	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
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	?	?	?
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=Stometta

Predominant vegetation type
- ME=Mixed evergreen
- OW=Oakwoodland
- 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

Predominant panicle 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

Figure 45. Summary of Instream and Hillslope Data

PARAMETER	**113. 70010**	**113. 70011**	**113. 70012**	**113. 70013**	**113. 70014**	**113. 70020**	**113. 70021**	**113. 70022**	**113. 70023**	**113. 70024**	**113. 70025**	**113. 70026**
PRESENCE OP SALMONIDS												
Salmonids present	Yes	?	?	Yes	Yes	Yes	?	?	Yes	Yes	Yes	Yes
Coho present since 1988	No	?	?	No	Yes	Yes	?	?	Yes	No	No	No
INSTREAM												
> average Class I, II and unclassified perennial streams	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No
Pools <50% of habitat units	Yes	?	?	Yes	?	No	?	?	Yes	Yes	? Garcia	Yes Garcia
Elevated fines	Yes	?	?	Yes	Yes Garcia	?	?	?	?	?	Yes	?
> average increase in stream channel opening	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	No	No	No
Elevated temperatures	Yes	Yes	?	Yes	Yes	?	?	Yes Garcia	Yes Garcia	Yes Garcia	Yes Garcia	Yes Garcia
HILLSLOPE												
> average mass wasting (coarse sediment)	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	No	No
> average surface erosion (fine sediment)	No	Yes	No	No	Yes	No	No	No	Yes	Yes	Yes	No
> average road densities (fluvial erosion potential)	No	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	No

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. 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 appears to have had an impact on instream conditions, including pool and spawning gravel characteristics in some Planning Watersheds. Further, the condition of the riparian zone also appears to have had an impact on instream conditions, including pool and spawning gravel characteristics, availability of large woody debris and habitat niches in some Planning Watersheds. The hypotheses identified above require further testing through the development and assessment of additional data.

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Volume II
Appendices

Assessment of Aquatic Conditions in the Garcia River Watershed

Prepared in support of the
Garcia River Watershed Water Quality Attainment Strategy for Sediment
December 9, 1997

for the

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North Coast Region
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Existing Data for
Planning Watershed 113.70010
Mill and Pardaloe Creeks

General Setting

Location

Pardaloe Creek is the headwater stream of the Garcia River Basin. It originates at Pardaloe Peak which reaches an elevation of 2,470 feet. Mill Creek joins Pardaloe Creek to form the beginning of the mainstem Garcia River. Planning Watershed 113.70010 is contained on the Ornbaun Valley and Gube Mountain quadrangles of the U.S. Geological Survey's 7.5 minute topographic maps. The sub-basin is further described by Township 12 North and Range 13 West, Sections 3 through 10 and 15 through 22

Soils

The soils contained in Planning Watershed 113.70010 include:

- Casabonne-Wohly complex, 9-30%, 30-50%, and 50-75% slopes
- Squawrock-Garcia-Witherell complex, 15-50% and 50-75% slopes
- Pardaloe-Woodin complex, 30-50% slopes
- Ornbaun-Zeni complex, 30-50% and 50-75% slopes
- Squawrock-Witherell complex, 15-50% slopes
- Bigriver loamy sand, 0-5% slopes
- Garcia-Snook-Gube complex, 30-50% and 50-75% slopes
- Hopland-Wohly complex, 30-50% and 50-75% slopes
- Hopland-Witherell-Squawrock complex, 30-50% slopes
- Maymen-Etsel-Snook complex, 30-75% slopes
- Hopland-Squawrock association, 50-75% slopes
- Yorkville-Hopland association, 30-50% slopes
- Yorkville-Yorktree-Squawrock complex, 15-30% slopes

Personnel at the Natural Resources Conservation Service reviewed these soil complexes and associations and organized them into vegetative types. These types are described below.

Predominant Vegetation

Soils identified in Planning Water 113.70010 support a mixture of oak woodland/grassland, mixed evergreen, patches of chaparral (primarily in the Pardaloe sub-basin), and patches of redwood forest (primarily in the Mill Creek sub-basin).

At the April 17, 1997 Limiting Factors meeting, it was noted that Mill Creek still contains a lot of residual redwood. At the April 28, 1997 Watershed Advisory Group meeting it was noted that much of the Mill Creek redwood is in late seral stage. It was further noted that though this planning unit supports some livestock, it is predominantly forested.

Land Use

Major Land Owners

According to County Tax Assessor's roll, Planning Watershed 113.70010 is owned by 4 large landowners (>1000 acres), none of them industrial timber owners. Another 8 landowners are identified who own properties ranging from 50 to 1000 acres. These parcels are primarily operated as ranches, including non-industrial timber harvesting.

Historic Land Use

The 1952 aerial photographs indicate that parcels of land in Planning Watershed 113.70010 were cleared prior to 1952. It also indicates that small-scale logging had occurred by that date, leaving behind remnant skid trails and roads. The County encouraged and issued land conversion permits in the 1950s and 1960s. Records indicate that by 1964, the families under the County program had received permits to convert to grazing land a total of approximately 1780 acres, approximately 890 acres of it timber land.

In 1966, the California Department of Fish and Game published its "Stream Damage Surveys - 1966" in which it rated the tributaries of the Garcia River as severely damaged, moderately damaged, lightly damaged or undamaged. The upper and lower reaches of the mainstem of Pardaloe Creek were rated as lightly damaged. The mid-reach was rated as moderately damaged. Box Canyon Creek and Monahan Creek, tributaries of Pardaloe Creek, were rated as severely damaged. The lower reaches of Mill Creek were rated as moderately damaged. And, but with a small mid-reach stretch rated as lightly damaged, the rest of Mill Creek and Redwood Creek, a tributary to Mill Creek, were rated as undamaged.

Hydrology

Drainage Area

1. *Acres*

Planning Watershed 113.70010 contains 10,473 acres. Runoff from this sub-basin drains into the mainstem Garcia River where it originates at the confluence of Mill and Pardaloe Creeks. The Pardaloe Creek sub-basin drains approximately 5,634 acres whereas the Mill Creek sub-basin drains approximately 4,839 acres.

2. *Flows*

The are no flow measurements available for Planning Watershed 113.70010. However, if the discharge with a 2-year recurrence interval, as measured at the USGS gaging station at Connor Hole is 14,000 cfs, and the area of Planning Watershed 113.70010 is 16.7.0% of the area above the USGS gaging station, and area is roughly proportional to flow, then the discharge with a 2-year recurrence interval in Planning Watershed 113.70010 is roughly 2,335 cfs. The estimated bankfull discharge in the Pardaloe Creek sub-basin is 1,256 cfs and in the Mill Creek sub-basin, 1,079 cfs.

The U.S. Geological Survey recommends, in Water-Resources Investigations 77-21, using the following equation to estimate flow with a 2-year recurrence interval: $Q_u=Q_g(A_u/A_g)^b$ where Q_g is the discharge at a nearby gaging station, A_u is the drainage area in square miles of the ungaged basin, A_g is the drainage area in square miles of the gaged basin, and b is a coefficient equal to 0.9 for the North Coast Region. This equation results in an estimate for the discharge with a 2-year recurrence interval of 2,793 cfs when Qg is equal to 14,000 cfs, Au is equal to 16.36 square miles, and Ag is equal to 98.10 square miles.

3. *Diversions*

Pardaloe Creek has been dammed at a location approximately 1.5 miles from the headwaters. There are no other known water diversions in Planning Watershed 113.70010.

<u>Precipitation</u>

The precipitation patterns in Planning Watershed 113.70010 are divided approximately along the ridge that divides the Pardaloe Creek sub-basin from the Mill Creek sub-basin. According to Fire Resource Assessment Program of CDF, the Pardaloe Creek sub-basin receives an average annual rainfall of 65.0 inches. The Mill Creek sub-basin receives an average annual rainfall of 55.0 inches.

According to the Department of Water Resources, the annual rainfall of record at the Yorkville weather station was in 1941 with 94.7 inches. This same source records the annual rainfall with a 2-year return period as 48.84 inches. The intensity of rainfall over 1 to 10 days ranges from 4.41 inches to 11.56 inches, during events with a 2-year recurrence interval.

Geology

Geologic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program. However, it's program did not include mapping in this planning unit.

Geomorphic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program. However, it's program did not include mapping in this planning watershed.

Pardaloe Creek

Channel Morphology

1. *Slope*

According to measurements collected from the Ornbaun Valley and Gube Mountain U.S. Geological Survey 7.5 minute topographic map, the channel slope in Pardaloe Creek is less than 2% for the lower 4 miles of its length. It then steepens to 8-10% just past Monahan Creek. At the peak, the channel slope is greater than 20%.

There are four perennial tributaries identified on the U.S. Geological Survey topographic maps. The channel of the first tributary, Box Canyon Creek, ranges from 0-4% slope with steep upper reaches greater than 20% in slope. The channel of the second tributary, an unnamed south-side tributary, ranges from 8-10% slope. Monahan Creek ranges from 2-3% slope through most of its course. Steeper first order streams, ranging from 10 to greater than 20% slope, flow into Monahan. The Newton Creek tributary system has a 4-5% slope at its confluence with Pardaloe. Newton Creek itself has a slope ranging from 8-10%. The slope of the upper reaches range from 10 to greater than 20%

2. *Substrate Composition*

In 1991, as part of the *Garcia River Watershed Enhancement Plan*, sub-contractors to the Mendocino County Resource Conservation District conducted habitat typing on Pardaloe Creek. Their findings indicate that in a 20,224 foot stream reach, bedrock was the dominant bank substrate. In 10% of the reach, embeddedness was measured as <25%. In 53% of the reach, embeddedness was measured between 25-50%. In 30% of the reach, embeddedness was measured between 50-75%. And, in 6% of the reach, embeddedness was measured as greater than 75%.

In 1994, the California Department of Fish and Game conducted a stream survey. The survey reach was 102 meters long with an area of 1,025 square meters. The surveyor estimated that the substrate was 1% silt, 10% sand, 30% gravel, 45% rubble, and 15% boulder.

3. *Width/depth ratio*

In its review of restoration work conducted on Pardaloe Creek, the Mendocino County Resource Conservation District measured the cross-section of the new stream channel at two locations. The cross sections do not demonstrate a break in slope on the south bank which would be indicative of bankfull flows. As such, it is difficult to determine the width/depth ratio of the stream at these locations.

The habitat typing conducted by subcontractors to the Mendocino County Resource Conservation District indicated a riffle/flatwater mean width of 10.0 feet and a total pool mean depth of 0.9 feet for a width/depth ratio of 11.

4. *Confinement*

Confinement has not been measured for Pardaloe Creek.

Aquatic Habitat

1. *Habitat Types and Distribution*

In September of 1991 as part of the *Garcia River Watershed Enhancement Plan*, sub-contractors to the Mendocino County Resource Conservation District conducted habitat typing of Pardaloe Creek. As part of their survey, they identified the type, length, width, and depth of individual habitat units. The *Garcia River Watershed Enhancement Plan* states "While pools were abundant, mean maximum depth was only just over two feet. Pools where bedrock upcrops or boulders constricted the channel were where maximum depths were achieved. Pools formed around large woody structure comprised approximately 10% of all habitat types...Habitat typing surveys showed that fish habitat on Pardaloe Creek appears to have greatly diminished as a result of sedimentation and riparian alteration. Lack of flows and decreased depth due to aggradation prevent almost any use of riffles during low flow conditions. Flows often go underground in riffles of this stream...Scoured areas around bedrock were the areas supporting the highest concentrations of steelhead juveniles." (Page 3-44)

The RCD's data indicates that pools cover 32% of the 20,224 foot stream reach surveyed with 18% of the pools having depths greater than 3 feet. Five percent of the stream reach contained large woody debris.

During the California Department of Fish and Game's 1994 stream survey, the habitat of the study reach was estimated to be 100% in riffles.

2. *Instream Cover*

In September of 1991 as part of the *Garcia River Watershed Enhancement Plan*, sub-contractors to the Mendocino County Resource Conservation District conducted habitat typing of Pardaloe Creek. As part of their survey, they rated the shelter within each habitat unit. Further, they estimated the dominant components of the stream bank and the degree to which it was vegetated. The *Garcia River Watershed Enhancement Plan* states "Cover in all habitat units averaged less than 25%." The dominant shelter identified in 20,224 feet of stream was boulder with a mean pool shelter rating of 48.

During the California Department of Fish and Game's 1994 stream survey, instream objects were given a cover rating of 80. Turbulence was given a cover rating of 60. And, overhanging vegetation was given a cover rating of 30. No undercut banks were noted.

At the April 28, 1997 Watershed Advisory Group meeting, it was noted that 2+ steelhead have been seen competing for hiding places in Pardaloe Creek. It was generally noted that Pardaloe Creek might be a good candidate for restoration work involving the placement or creation of more instream cover.

3. *Water Temperature*

In September of 1991 as part of the *Garcia River Watershed Enhancement Plan*, sub-contractors to the Mendocino County Resource Conservation District conducted habitat typing on Pardaloe Creek. The *Garcia River Watershed Enhancement Plan* states "While steelhead were present in most of the stream reaches surveyed, stream temperatures in Pardaloe Creek ranged from 60-72 ^{o} F, the highest of any reach of the Garcia River measured (during this study)...High water temperatures may have prevented use of run and step run units in this stream during fish surveys." (Page 3-44)

On June 24, 1994, during the California Department of Fish and Game's fish population surveying, the water temperature was 73F.

There is no known continuous temperature monitoring on Pardaloe Creek.

4. *Barriers*

As part of the four potential barriers were identified in the Pardaloe Creek sub-basin. The first was noted in a south-side tributary immediately upstream of the confluence with Mill Creek. Two potential barriers were noted on the lower reach of Pepperwood Creek. And, the fourth was noted on a south-side tributary approximately 0.8 miles upstream of Pepperwood Creek. There has been no known modification of these barriers.

5. *Population Composition and Distribution*

Live population survey results:

In September of 1991 as part of the *Garcia River Watershed Enhancement Plan*, sub-contractors to the Mendocino County Resource Conservation District conducted aquatic vertebrate population sampling on Pardaloe Creek. As shown in Figure 1, a total of 2,301 young-of-year steelhead were counted in a total of 62 separate habitat units. A total of 213 one-plus steelhead were counted in a total of 28 habitat units. And, a total of 57 two-plus steelhead were count in a total of 15 habitat units. Crawdads, newts, salamanders, sticklebacks, and suckers were also seen. A total of 62 habitat units was surveyed.

On June 24, 1994, the California Department of Fish and Game conducted a stream survey. The survey reach was 102 meters long with an area of 1,025 square meters. A total of 158 young-of-year trout and 4 one-plus steelhead were counted in the study reach. Crayfish, salamanders and frogs were also noted. Steelhead density was calculated at 1.78 fish per square meter. Steelhead biomass was calculated at 53.87 kg per hectare.

During the winter of 1995-96, Salmon Trollers Association conducted a spawning survey in Pardaloe Creek. As part of their survey they noted 5.2 live fish per mile of stream. They surveyed 1.5 miles of stream starting at the mouth. In the winter of 1996-97, Salmon Trollers Association noted 8.6 live fish per mile. Again, they surveyed 1.5 miles of stream starting at the mouth.

At the April 28, 1997 Watershed Advisory Group meeting it was noted that old timers often talk of the large numbers of coho which used to make their way up to Pardaloe Creek after the mainstem bedrock waterfall was blasted by the California Department of Fish and Game.

Redd survey results:

In September of 1991 as part of the *Garcia River Watershed Enhancement Plan*, sub-contractors to the Mendocino County Resource Conservation District conducted habitat typing in Pardaloe Creek. During this survey, 33 old redds left over from the 1990-91 spawning season were noted.

During the winter of 1995-96, Salmon Trollers Association surveyed Pardaloe Creek for redds. They identified 22.0 redds per mile. They surveyed 1.5 miles of stream starting at the mouth. In the winter of 1996-97, Salmon Trollers Association identified 37.3 redds per mile. Again, they surveyed 1.5 miles of stream starting at the mouth.

Carcass survey results:

At the April 28, 1997 Watershed Advisory Group meeting it was noted that an operator working in the Pardaloe sub-basin saw a coho carcass in 1994.

During the winter of 1995-96, Salmon Trollers Association surveyed Pardaloe Creek for redds. As part of their survey, they noted and tagged 2 steelhead carcasses. During the winter of 199697, Salmon Trollers Association noted no carcasses at all.

6. *Food Supply*

There is no known food supply data for Pardaloe Creek.

7. *Water Quality*

There is no known water quality data for Pardaloe Creek.

Miscellaneous Observations

At the April 28, 1997 Watershed Advisory Group meeting it was noted that approximately one timber harvest plan has operated in Pardaloe Creek since the passing of the Forest Practice Act. As such, there has been little disturbance in the basin in the last 25 years. But, too, there has been little corrective action such as that which is often required under a timber harvest plan.

Mill Creek

Channel Morphology

1. *Slope*

According to measurements collected from the Ornbaun Valley U.S. Geological Survey 7.5 minutes topographic map, the channel slope in Mill Creek is less than 2% for most of its length. North Mill and Sled Creeks, tributaries to Mill Creek, have a channel slope ranging from 5-6%. Redwood Creek, also a tributary to Mill Creek, has a channel slope which is less than 3%.

Cabin Creek, a tributary of Redwood Creek, has a channel slope ranging from 2-3% in its lower reaches and 15-20% in its upper reaches.

2. *Substrate Composition*

In 1991, as part of the *Garcia River Watershed Enhancement Plan*, sub-contractors to the Mendocino County Resource Conservation District conducted habitat typing on Mill Creek. Their findings indicate that in a stream reach of 601 feet, the dominant bank substrate was cobble and gravel. Measurements for embeddedness indicated that 33% of the particles measures were <25% embedded, 33% were between 25-50% embedded, and 33% were between 50-75% embedded.

On June 24, 1994, the California Department of Fish and Game conducted a stream survey. The survey reach was 126 meters long with an area of 1,123 square meters. In this reach (at a slope <1%), the California Department of Fish and Game estimated that the substrate was 2% silt, 5% sand, 90% gravel, 1% rubble, 1% boulder, and 1% bedrock.

In September 1994, a consultant to the Mailliard family measured the particle size distribution of the substrate from two study reaches in Redwood Creek, a tributary to Mill Creek. In the upper reach of Redwood Creek (exact location unknown), the contractor found that the substrate was composed of 32.2% fines <0.85 mm (very fine sand). She found that 47% of the substrate material was less than or equal to 2 mm (sand). The geometric mean particle size ranged from 2.7 to 6.3 mm (very fine to fine gravel) with an average of 4.2 mm (fine gravel). In the lower reach of Redwood Creek (exact location unknown), the contractor found that the substrate was composed of 19.4% fines <0.85 mm (very fine sand). She found that 36.6% of the substrate material was less than or equal to 2 mm (sand). The geometric mean particle size ranged from 4.2 to 6.2 mm (very fine to fine gravel) with an average of 5.1 mm (fine gravel).

At the April 17, 1997 Limiting Factors meeting, it was noted that Mill Creek generally has a good gravel substrate suitable for salmonid spawning. At the April 28, 1997 Watershed Advisory Group meeting, it was suggested that the McNeil data collected on Redwood Creek may represent unconfined flows across pasture land rather than from a true, well-defined stream channel.

3. *Width/depth ratio*

There are no known cross-sections or other data from which to determine the width/depth ratio of the streams in the Mill Creek sub-basin. However, the 1991 habitat typing conducted by sub-contractors to the Mendocino County Resource Conservation District indicates a mean riffle/flatwater width of 17.8 feet and a total pool mean depth of 1.6 feet for a width/depth ratio of 11.

4. *Confinement*

Confinement has not been measured for the Mill Creek sub-basin. However, at the April 17, 1997 Limiting Factors meeting, it was noted that Mill Creek has some of the best locally defined, functional floodplain of anywhere in the basin. It was further noted that Redwood Creek, a tributary to Mill Creek, also had a good floodplain.

Aquatic Habitat

1. *Habitat Types and Distribution*

On June 24, 1994, the California Department of Fish and Game conducted a stream survey. The habitat within the survey reach was estimated to be 40% in pools, 20% in riffles, and 40% in runs.

The habitat typing conducted in 1991 by subcontractors to the Mendocino County Resource Conservation District indicated that the 601 foot stream reach surveyed contained 24% pools with 67% of the pools having a depth greater than 3 feet. Twenty-six percent of the stream reach had large woody debris.

2. *Instream Cover*

The habitat typing conducted in 1991 by subcontractors to the Mendocino County Resource Conservation District indicated that the dominant shelter in 601 feet of stream was boulders. The mean pools shelter rating was 50.

During the California Department of Fish and Game's 1994 stream survey turbulence was given a rating of 5. Instream objects were given a rating of 30. Undercut banks were given a rating of 2. And, overhanging banks were given a rating of 30.

At the April 17, 1997 Limiting Factors meeting it was noted that there is a lot of large woody debris in Redwood Creek, a tributary of Mill Creek.

At the April 28, 1997 Watershed Advisory Group meeting, it was noted that the large woody debris in the lower reaches of Mill Creek is limited. It was further noted that there was a lot of large woody debris in the mid reaches of Mill Creek.

3. *Water Temperature*

During its 1994 stream survey, the California Department of Fish and Game measured the water temperature as 67F (19C).

On August 3, 1994, a consultant to the Mailliard family placed Hobo Temps in Mill Creek and Redwood Creek, a tributary of Mill Creek so as to measure water temperature. The Hobo Temps were collected from their sampling locations on October 18, 1994. Temperature data was collected from pools. Temperatures in Mill Creek ranged from 45 to 65 F (7 to 20C) with a 3-month average of approximately 57F (14C). Temperatures in Redwood Creek ranged from 47 to 63F (8 to 17C) with a 3-month average of approximately 58F (14C).

4. *Barriers*

At the April 17, 1997 Limiting Factors meeting, it was noted that the limits of anadromy in the Mill Creek and Redwood Creek sub-basin to extend to within one mile of the their respective headwaters. No other barriers were noted.

5. *Population Composition and Distribution*

Live population survey results:

On June 24, 1994, the California Department of Fish and Game conducted a stream survey. of Mill Creek. The study reach was 126 meters long with an area of 1,123 square meters. A total of 129 young-of-year trout and 1 one-plus steelhead were counted in the study reach. Crayfish, salamanders, and frogs were also noted. Steelhead density was calculated at 1.31 fish per square meter. Steelhead biomass was calculated at 22.33 kg per hectare.

Also in 1994, a consultant to the Mailliard family estimated fish and amphibian species population densities for Redwood Creek. She found 0.35 steelhead per square meter, 0.04 Pacific Giant Salamander per square meter, 0.06 yellow-legged frogs per square meter, and 0.04 rough-skinned newts per square meter.

During the winter of 1995-96, Salmon Trollers Association surveyed Mill Creek for redds. As part of their survey, they noted 1.5 live fish per mile. They surveyed 3.6 miles up from the mouth of Mill Creek. In the winter of 1996-97, Salmon Trollers Association noted 4.3 live fish per mile. Again, they surveyed 3.6 miles up from the mouth of Mill Creek.

Redd survey results:

During the winter of 1995-96, Salmon Trollers Association surveyed Mill Creek for redds. They identified 20.5 redds per mile. They surveyed 3.6 miles up from the mouth of Mill Creek. From December 1996 to January 1997 they noted 1.7 redds per mile. From February to

April 1997 they noted 24.2 redds per mile. Again, they surveyed 3.6 miles up from the mouth of Mill Creek.

Carcass survey results:

During the winter of 1995-96, Salmon Trollers Association surveyed Mill Creek for redds. As part of their survey, they counted and tagged 2 steelhead carcasses. In the winter of 1996-97, they counted and tagged 1 carcass of an unknown species.

6. *Food Supply*

There is no known food supply data for Mill Creek.

7. *Water Quality*

There is no know water quality data from the Mill Creek sub-basin.

Existing Data for
Planning Watershed 113.70011
Larmour Creek Sub-basin

General Setting

Location

Planning Watershed 113.70011 contains the upper portion of the Garcia River mainstem from where it originates with the confluence of Mill and Pardaloe Creeks to the Garcia's confluence with Larmour Creek. Grant's Camp, East End and Larmour Creeks are tributaries which flow into the Garcia River from the north side. There are several south-side tributaries, as well. Planning Watershed 113.70011 is contained on the Zeni Ridge quadrangle of the U.S. Geological Survey's 7.5 minute topographic map. The sub-basin is further described by Township 12 North and Range 14 West, Sections 1-4, 10-14. The upper reaches of Larmour Creek are contained in T 13 N, R 15 W, Sections 25-26 and T 13 N, R 14 W, Sections 30-32.

Soils

The soils contained in Planning Watershed 113.70011 include:

- Gube-Garcia-Snook complex, 30-50% and 50-75% slopes
- Casabonne-Wohly complex, 9-30% and 30-50% slopes
- Squawrock-Garcia-Witherell complex, 15-50% and 50-75% slopes
- Ornbaun-Zeni complex, 9-30%, 30-50% and 50-75% slopes
- Squawrock-Witherell complex, 15-50% slopes
- Pardaloe-Woodin complex, 30-50% slopes
- Yorkville-Yorktree-Squawrock complex, 30-50% slopes

Personnel at the Natural Resource Conservation Service reviewed these soil complexes and organized them into vegetative types. These types are described below.

Predominant Vegetation

The soils identified in Planning Watershed 113.70011 predominantly support a mixed evergreen forest. They also support a long strip of oak woodland/grassland on the southwestern facing slope. A strip of the mainstem Garcia on the northeastern facing slope support redwood forest. Small patches of chaparral are supported in the headwaters of Larmour Creek and Grant's Camp Creek.

Land Use

Major Land Owners

According to the County Tax Assessor's rolls, Planning Watershed 113.70011 is owned by 5 major landowners. Coastal Forestlands, Ltd. and Louisiana-Pacific Corporation are industrial timber owners. The Mailliards, Hanes and Aldens own private ranches. The Mailliards own 45% of the sub-basin. The Hanes own 34% of the sub-basin. CFL owns 10% of the sub-basin. The Alden's own 4% of the sub-basin. And, L-P owns 1+% of the sub-basin.

Historic Land Use

The 1952 aerial photographs indicate that much of ridge property in the Larmour Creek and East End Creek sub-basins had already been cleared prior to 1952. Several ridge roads are visible Also in the area, the County encouraged and issued land conversion permits in the 1950s and 1960s. Records indicate that by 1965, family ranches under the County program had received permits to convert to grazing land a total of approximately 1,768 acres, approximately 1,412 acres of it timber land.

The industrial timber lands on the south side of the mainstem Garcia appear in the 1952 photos to be actively logged. A 1959 map of Hollow Tree Lumber's ownership in the basin indicates that they owned several sections of property on the south side of the Garcia mainstem in 1959. Presumably, the logging activities seen in the 1952 aerial photographs are theirs.

In 1966, the California Department of Fish and Game published its "Stream Damage Surveys - 1966" in which it rated the tributaries of the Garcia River as severely damaged, moderately damaged, lightly damaged or undamaged. Larmour Creek was identified as undamaged. East End Creek was identified as severely damaged in its lower reaches, moderately damaged in its mid reach, and undamaged in its upper reaches. Grant's Camp Creek was identified as moderately damaged in its lower reaches and severely damaged in its upper reaches. The mainstem Garcia River from Mill to Larmour Creeks was identified as lightly damaged.

Hydrology

Drainage Area

1. *Acreage*

Planning Watershed 113.70011 contains 6,550 acres. Runoff through this unit originates in both Planning Watershed 113.70010 and Planning Watershed 113.70011 and includes a total drainage area of 17,023 acres.

2. *Flows*

On September 2, 1948, the California Department of Fish and Game conducted a stream survey on the Garcia River from Zeni Ranch to the Garcia River falls, then located above Stansbury Creek. The surveyor recorded an estimated flow of 4 cfs about 0.5 miles below the falls. Though the former falls were technically located in Planning Watershed 113.70012, the flow estimate is for the mainstem Garcia River immediately downstream of Planning Watershed 113.70011 and upstream of tributary discharges from Planning Watershed 113.70012. There are no other known flow measurements available for this planning watershed.

As an estimate, however, if the discharge with a 2-year recurrence interval, as measured at the USGS gaging station at Connor Hole, is 14,000 cfs, and the total drainage area of Planning Watershed 113.70011 is 27.1% of the are above Connor Hole, and area is roughly proportional to flow, then the discharge with a 2-year recurrence interval in Planning Watershed 113.70011 is roughly 3,796 cfs. By a similar calculation, the estimated bankfull flow for Larmour Creek itself is 1,079 cfs.

The U.S. Geological Survey recommends, in Water-Resources Investigations 77-21, using the following equation to estimate flow with a 2-year recurrence interval: $Q_u=Q_g(A_u/A_g)^b$ where Q_g is the discharge at a nearby gaging station, A_u is the drainage area in square miles of the ungaged basin, A_g is the drainage area in square miles of the gaged basin, and b is a coefficient equal to 0.9 for the North Coast Region. The equation results in an estimate for the discharge with a 2-year recurrence interval of 4,324 cfs when Q_g is equal to 14,000 cfs, A_u is equal to 26.59 square miles, and A_g is equal to 98.10 square miles.

3. *Diversions*

There are no known water diversions in Planning Watershed 113.70011.

Precipitation

According to the Fire Resource Assessment Program of the California Department of Forestry and Fire Protection, the average annual rainfall in Planning Watershed 113.70011 is 65 inches on the southwestern facing slopes, 75 inches on the northeastern facing slopes, and 55 inches in the headwaters of the Larmour Creek.

Geology

Geologic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program. However, it's program did not include mapping in this planning watershed.

Geomorphic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program. However, it's program did not include mapping in this planning watershed. Nonetheless, the Division of Mines and Geology have attended preharvest inspections in this Planning Watershed and made notes of the geomorphic features observed. The following are excerpts of preharvest inspections.

1. *THP 1-90-149*

The plan was located at T12N, R14W, Sections 11 and 14. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- Several shallow debris slides within rocky soils and bedrock along steep sideslopes.
- Two slides resulting from significant concentration of runoff from Fish Rock Road. One of the slopes extends for more than 1000 feet as a gully which has caused the second 100 foot slide. Runoff from this paved road was directed onto the sidecast.

The Regional Water Board inspector concluded that these slides were not related to the County Road.

2. *THP 1-96-519*

The plan was located at T12N, R14W, Sections 3, 4 and 10. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- Widespread old debris flows and several deep seated translational/rotational landslides were noted in the 1988 aerial photographs and during the field inspection.
- The hillslopes affected by debris flows were generally well vegetated and stable.
- A crossing was obliterated by a debris flow occurring during the previous winter.
- A failed Humboldt crossing is causing erosion.
- An instream landing was identified.

Grant's Camp Creek

Channel Morphology

1. *Slope*

According to measurements collected from the Zeni Ridge U.S. Geological Survey 7.5 minute topographic map, the channel slope in Grant's Camp Creek is about 3% in its mainstem. The west-side tributary slope is about 7%. And, the east-side tributary slope is about 5%.

On August 28, 1967, the California Department of Fish and Game conducted a stream survey of Grant's Camp Creek. The surveyor described the watershed as a steep, V-shaped canyon.

2. *Substrate Composition*

On August 28, 1967, the California Department of Fish and Game conducted a stream survey in Grant's Camp Creek. The surveyor described the substrate as being approximately 30% bedrock, 10% boulders, and 60% rubble and gravel.

3. *Width/depth ratio*

There are no cross-sections or other data from which to calculate the width to depth ratio for Grant's Camp Creek. However, on August 28, 1967, the California Department of Fish and Game conducted a stream survey of Grant's Camp Creek. The surveyor estimated the width of the stream to be an average of 1.5 feet with a range of 1 to 4 feet.

4. *Confinement*

Confinement has not been measured for Grant's Camp Creek. However, on August 28, 1967, the California Department of Fish and Game conducted a stream survey of Grant's Camp Creek. The surveyor described the watershed as a steep, V-shaped canyon implying that there is little available floodplain. As such, the channel can likely be described as well-confined.

5. *Bankfull discharge*

The bankfull discharge of Grant's Camp Creek is currently unknown. However, on August 28, 1967, the California Department of Fish and Game conducted a stream survey of Grant's Camp Creek. The surveyor estimated the August flows at 1 cfs at the mouth and 0.75 cfs at the stream's fork. He went on to say that "judging by (the) debris on (the) canyon walls and (the) size of (the) streambed, the stream appears to be about 10 times as large during the winter runoff."

Aquatic Habitat

1. *Habitat Types and Distribution*

On August 28, 1967, the California Department of Fish and Game conducted a stream survey of Grant's Camp Creek. The surveyor concluded that the lower 0.75 miles of the stream was used as spawning and nursery habitat. He judged that the spawning area was generally "very good for such a small stream." He went on to say that "at least 50% of the entire stream is suitable for spawning." He then concluded that there was "very limited development of pools (25% of stream)." He said "most are small and shallow: no larger than 3 feet by 3 feet and no deeper than 2 feet."

2. *Instream Cover*

On August 28, 1967, the California Department of Fish and Game conducted a stream survey of Grant's Camp Creek. The surveyor concluded that the shelter was generally good: many undercut banks, logs, and boulders.

3. *Water Temperature*

On August 28, 1967, the California Department of Fish and Game conducted a stream survey of Grant's Camp Creek. The surveyor measured the August water temperatures as 75F at the mouth and 70F at the stream's fork.

4. *Barriers*

On August 28, 1967, the California Department of Fish and Game conducted a stream survey of Grant's Camp Creek. The surveyor observed a lot of debris over the stream, particularly in the region bracketing the stream's fork. He concluded, though, that none of the debris appeared to be blocking the stream's flow. He did note that larger fish might have trouble moving upstream to spawn.

5. *Population Composition and Distribution*

Live Population Survey Results

There are no known population survey's for Grant's Camp Creek. However, on August 28, 1967, the California Department of Fish and Game conducted a stream survey of Grant's Camp Creek. While the surveyor did not make specific mention of fish, he did note the presence of frogs and California newts. Further, he identified habitat sufficient for anadromous fish species. There are no known redd or carcass survey results for this tributary.

6. *Food Supply*

On August 28, 1967, the California Department of Fish and Game conducted a stream survey of Grant's Camp Creek. The surveyor estimated an average of 20 organisms per square foot of rock area, including caddis worm and mayfly larvae.

7. *Water Quality*

There is no known water quality data on Grants' Camp Creek.

Larmour Creek

Channel Morphology

1. *Slope*

According to measurements collected from the Zeni Ridge U.S. Geological Survey 7.5 minute topographic map, the channel slope in Larmour Creek is 7-8% in the first mile and 5-6% there after. At the April 17, 1997 Limiting Factors meeting and again at the April 28, 1997 Watershed Advisory Group meeting it was noted that there is a 75 foot falls on Larmour Creek about 1 mile up from the mouth.

2. *Substrate Composition*

There is no known information which describes the substrate composition of Larmour Creek.

3. *Width/depth ratio*

There are no known cross-sections or other data from which to calculate the width to depth ratio of Larmour Creek. However, assuming Larmour is a Rosgen A-type channel, the width/depth ratio is likely to be low.

4. *Confinement*

Confinement has not been measured for Larmour Creek. However, the V-shaped valley indicates that there is little available floodplain and thus the channel can probably be defined as well-confined.

5. *Bankfull discharge*

The bankfull discharge for Larmour Creek is currently unknown.

<u>Aquatic Habitat</u>

1. *Habitat Types and Distribution*

There is no known data regarding habitat type and distribution on Larmour Creek.

2. *Instream Cover*

There is no known data regarding instream cover on Larmour Creek

3. *Water Temperature*

There is no known data regarding water temperatures on Larmour Creek. However, at the April 28, 1997 Watershed Advisory Group meeting it was noted that the canopy cover on Larmour Creek is poor.

4. *Barriers*

At the April 17, 1997 Limiting Factors meeting and again at the April 28, 1997 Watershed Advisory Group meeting it was noted that there is a 75 foot falls on Larmour Creek about 1 mile up from the mouth.

5. *Population Composition and Distribution*

Live Population Survey Results

There is no known population data for Larmour Creek. However, at the April 28,1997 Watershed Advisory Group Meeting, it was noted that there may be resident trout above the falls on Larmour Creek. There are no known redd or carcass survey results for this tributary.

6. *Food Supply*

There is no known food supply data for Larmour Creek.

7. *Water Quality*

There is no known water quality data for Larmour Creek.

Garcia River from Mill to Larmour Creeks

Channel Morphology

1. *Slope*

According to the measurements collected from the Zeni Ridge U.S. Geological Survey 7.5 minute topographic map, the channel slope on the Garcia River mainstem from Mill Creek just past East End Creek is less than 1%. Just past East End Creek to a location just past Larmour Creek, the channel slope ranges from 1-2%. A 12 foot high bedrock waterfall used to block fish migration at a location on the mainstem just below Larmour Creek until it was blasted by the California Department of Fish and Game sometime in the late 1950s.

3. *Substrate Composition*

There is no known substrate data for the mainstem Garcia from Mill to Larmour Creeks. However, during a review of the 1952 aerial photographs, a lot of sediment was noted in the mainstem channel from about East End Creek to Larmour Creek.

4. *Width/depth ratio*

There are no known cross-sections or other data from which to calculate the width to depth ratio on the mainstem Garcia from Mill to Larmour Creeks.

5. *Confinement*

Confinement was measured using both the 1952 and 1988 aerial photographs. The degree of confinement does not appear to have changed during this period of time. The mainstem channel from the confluence of Mill and Pardaloe Creeks to a location approximately 0.75 miles above the Hollow Tree Road crossing is measured as confined. The section of the mainstem Garcia from approximately 0.75 miles above the Hollow Tree Road Crossing to the crossing itself is measured as moderately confined. (It appears as if logging operations in and around the stream channel immediately above the crossing may have contributed to a loss of confinement). The mainstem Garcia from the Hollow Tree Road crossing to Larmour Creek is measured as confined.

6. *Bankfull discharge*

See Flow, above.

Aquatic Habitat

1. *Habitat Types and Distribution*

There is no known data regarding habitat type and distribution on the mainstem Garcia River from Mill to Larmour Creeks. However, on September 2, 1948, the California Department of Fish and Game conducted a stream survey from Zeni Ranch to the Garcia River falls (then located on the mainstem Garcia River between Larmour and Stansbury Creeks). In his survey, the surveyor noted that the mainstem Garcia River above the falls had good spawning areas.

On July 20, 1995, a consultant to Coastal Forestlands, Ltd., placed a Hobo Temp in a pool on the mainstem Garcia River immediately downstream of the Hollow Tree Road crossing and the confluence with East End Creek. The pool was measured at 30.5 feet long by 13 feet wide with a maximum depth of 2.75 feet.

2. *Instream Cover*

On July 20, 1995 a consultant to Coastal Forestlands, Ltd. placed a Hobo Temp in a pool on the mainstem Garcia River immediately downstream of the Hollow Tree Road crossing and the confluence with East End Creek. The data form describes the cover associated with the chosen sample location as primarily boulders with some aquatic vegetation and a little undercut bank.

3. *Water Temperature*

On September 2, 1948, the California Department of Fish and Game conducted a stream survey from Zeni Ranch to the Garcia River falls (then located on the mainstem Garcia River between Larmour and Stansbury Creeks). The surveyor measured the mid-day temperature at 68.5F (20C).

A consultant to Coastal Forestlands, Ltd. collected, using a Hobo Temp, 1995 summer water temperatures from a pool immediately downstream of the Hollow Tree Road crossing and the confluence with East End Creek. The summer water temperature (from July 21, 1995 to October 23, 1995) ranged from 46 to 80F (8 to 27C) with a summer average of approximately 70F (21C). The diurnal temperature range during the months of July and August reached approximately 15F (9C) and dropped off significantly during the months of September and October. Day time temperatures peaked in late August at 80F (27C) and then declined to a low of 53F (12C) in October. Night time temperatures also peaked in late August but did not precipitously decline until late September.

4. *Barriers*

There is no known data regarding barriers on the mainstem Garcia River from Mill to Larmour Creeks.

5. *Population Composition and Distribution*

Live Population Survey Results:

On September 2, 1948, the California Department of Fish and Game conducted a stream survey from Zeni Ranch to the Garcia River falls (then located on the mainstem Garcia River between Larmour and Stansbury Creeks). The surveyor observed abundant steelhead, including occasional 2-4 inch fish, many 5-6 inch fish, and a few 7-8 inch fish. He also observed crayfish, sticklebacks, and Red-bellied Triturus.

On June 9, 1993, the field notes of a California Department of Fish and Game personnel included mention of a few adult steelhead which had made their way over the mainstem falls during the winter run.

On August 20, 1987, California Department of Fish and Game conducted a population survey at a location approximately 0.25 miles upstream from East End Creek on the mainstem Garcia River. The electroshocking resulted in 82 steelhead per 59 feet or 7,298 steelhead per mile.

Redd survey results:

There is no known redds data for the mainstem Garcia River from Mill to Larmour Creeks. However, on June 9, 1993, the field notes of a California Department of Fish and Game personnel include mention of a few adult steelhead which had made their way over the mainstem falls during the winter run. Their redds were also seen.

Carcass survey results:

There is no known carcass data for the mainstem Garcia River from Mill to Larmour Creeks.

6. *Food Supply*

There is no known food supply data for the mainstem Garcia River from Mill to Larmour Creeks.

7. *Water Quality*

There s no known water quality data for the mainstem Garcia River from Mill to Larmour Creeks.

Existing Data for
Planning Watershed 113.70012
Stansbury Creek Sub-basin

General Setting

Location

Planning Watershed 113.70012 is a unit of the mainstem Garcia River. It is in this unit that the mainstem Garcia River makes one of its three abrupt 90^o bends, flowing predominantly northwest and then southwest. This sub-basin also includes Stansbury Creek on the north and Whitlow Creek on the south. Planning Watershed 113.70012 is contained on the Zeni Ridge U.S. Geological Survey's 7.5 minute topographic map. This unit is further described by Township 12 North and Range 14 West, Sections 5-6; T 12 W, R 15 W, Sections, 1 and 12; and T 13 W, R 15 W, Section 36.

Soils

The soils contained in Planning Watershed 113.70012 include:

- Garcia-Snook-Gube complex, 50-75% slopes
- Ornbaun-Zeni complex, 9-30%, 30-50%, and 50-75% slopes
- Casabonne-Wohly complex, 30-50% slopes
- Squawrock-Garcia-Witherell complex, 30-50% and 50-75% slopes
- Yellowhound-Kibesillah-Ornbaun complex, 30-50% slopes
- Woodin-Yellowhound complex, 30-50% slopes

Personnel at the Natural Resources Conservation Service reviewed the soils complexes and organized them into vegetative types. These types are described below.

Predominant Vegetation

The soils identified in Planning Watershed 113.70012 support a mixture of redwood forest, mixed evergreen, oak woodland/grassland, and chaparral. The south side of the Garcia River mainstem is predominated by redwood forest soils whereas the north side is predominated by mixed evergreen soils. The soils on the ridgetops above Stansbury Creek primarily support chaparral.

Land Use

Major Land Owners

According to the County Tax Assessor's rolls, Planning Watershed 113.70012 is owned by 3 major landowners. Coastal Forestlands is the only industrial timber owner. It owns 26% of the sub-basin. The Bewleys and Hanes own private ranches in this sub-basin, making up 43% and 20% of the sub-basin, respectively.

Historic Land Use

The 1952 aerial photographs of this planning unit indicate that little noticeable landuse activity had occurred in the Stansbury sub-basin prior to 1952. However, extensive operations were clearly underway in the Whitlow Creek sub-basin and along the mainstem upstream of Whitlow Creek, as noted in the 1952 aerial photographs. A 1959 map of Hollow Tree Lumber's ownership in the Garcia River basin indicates that they owned several sections of property on the south side of the Garcia mainstem in 1959. Presumably, the logging activities seen in the 1952 aerial photographs are theirs.

The County encouraged and issued permits to convert timber land to grazing in the 1950s and 1960s. According to records, by 1960 the County had issued permits to clear a total of approximately 665 acres in Planning Unit 113.70012, approximately 515 acres of them timber land.

In 1966, the California Department of Fish and Game published its "Stream Damage Surveys - 1966" in which it rated the tributaries of the Garcia River as severely damaged, moderately damaged, lightly damaged or undamaged. The mainstem Garcia River from Larmour to Blue Waterhole Creeks was rated as lightly damaged. Neither Stansbury nor Whitlow Creeks were rated at all.

Hydrology

Drainage Area

1. *Acreage*

Planning Watershed 113.70012 contains 3,972 acres. Runoff through this unit originates in Planning Watersheds 113.70010, 113.70011 and 113.70012 including a total drainage area of 20,995 acres.

2. *Flows*

There are no known flow measurements available for this planning watershed. However, if the discharge with a 2-year recurrence interval, as measured at the USGS gaging station at Connor Hole is 14,000 cfs, and the drainage area affecting flows in Planning Watershed 113.70012 is approximately 33.4% of the basin area above Connor Hole, and area is roughly proportional to flow, then the discharge with a 2-year recurrence interval in Planning Watershed 113.70012 is roughly 4,682 cfs.

The U.S. Geological Survey recommends, in Water-Resources Investigations 77-21, using the following equation to estimate flow with a 2-year recurrence interval: $Q_u=Q_g(A_u/A_g)^b$ where Q_g is the discharge at a nearby gaging station, A_u is the drainage area in square miles of the ungaged basin, A_g is the drainage area in square miles of the gaged basin, and b is a coefficient equal to 0.9 for the North Coast Region. The equation results in an estimate for the discharge with a 2-year recurrence interval of 5,223 cfs when Qg is equal to 14,000 cfs, Au is equal to 32.80 square miles and Ag is equal to 98.10 square miles.

3. *Diversions*

There are no known water diversions associated with this Planning Watershed.

Precipitation

According to the Fire Resource Assessment Program of the California Department of Forestry and Fire Protection, the average annual rainfall in Planning Watershed 113.70012 is predominantly 65 inches. The average annual rainfall in the headwaters of Stansbury Creek is 55 inches whereas it is 75 inches in the southeastern corner of the Planning Watershed.

Geology

Geologic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program. However, it's program did not include mapping in this planning unit. Coastal Forestlands, Ltd., the industrial timber owner in this planning unit, may have geologic information relevant to this unit contained in the watershed assessment portion of its Sustained Yield Plan. As of this writing, however, neither the Watershed Assessment nor the Sustained Yield Plan has been released for public review.

Geomorphic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program. However, it's program did not include mapping in this planning unit. Nonetheless, the Division of Mines and Geology have attended preharvest inspections in this Planning Watershed and made notes of the geomorphic features observed. The following are excerpts of preharvest inspections.

1. *THP 1-96-196*

The plan was located at T12N, R14W, Section 6 and T12N, R15W, Sections 11-12. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- A review of 1986 and 1992 aerial photographs reveal that the THP area is underlain by large, deep seated, complex rotational landslides and earthflows.
- There is disrupted ground within several large unstable areas.
- There are debris flows associated with roads and skid trails.
- A gully was formed by a diversion of concentrated runoff from a skid trail
- A new road was flagged across a gully 10-12 feet wide and 14 feet deep.
- Numerous road segments were proposed across gullies formed by diversions
- A Class III instream landing has been eroded forming a gully 4-5 feet deep and 6-8 feet wide.

Stansbury Creek

Channel Morphology

1. *Slope*

According to measurements collected from the Zeni Ridge U.S. Geological Survey 7.5 minute topographic map, the channel slope of Stansbury Creek is 6-8% in its lower to mid reaches. The first west-side tributary has a slope ranging from 10-15%. The second west-side tributary has a slope greater than 20%. And, the upper reaches of Stansbury Creek has a slope ranging from 15-20% with the upper headwaters sloping at greater than 20%.

2. *Substrate Composition*

At the April 28, 1997 Watershed Advisory Group meeting it was noted that there is a rock gorge which defines the lower reach of Stansbury Creek. There is no other known substrate data for Stansbury Creek.

3. *Width/depth ratio*

There are no cross-sections or other data from which to calculate the width to depth ratio for Stansbury Creek.

4. *Confinement*

Confinement has not been measured for Stansbury Creek.

5. *Bankfull discharge*

The bankfull discharge of Stansbury Creek is currently unknown.

Aquatic Habitat

1. *Habitat Types and Distribution*

There is no known data regarding habitat type and distribution for Stansbury Creek.

2. *Instream Cover*

There is no known data regarding instream cover for Stansbury Creek.

3. *Water Temperature*

There is no known water temperature data for Stansbury Creek. However, at the April 18, 1997 Watershed Advisory Group meeting it was noted that the canopy cover is fairly good from the mouth of Stansbury up to the upper fork. Temperatures were presumed to be adequate for steelhead.

4. *Barriers*

At the April 28, 1997 Watershed Advisory Group meeting, the presence of a log jam approximately 0.25 mile up from the mouth was noted. This was identified as the extent of the anadromous fishery. The road crossing immediately downstream of the log jam was also identified as a problem site. It was recommended that this crossing be pulled.

5. *Population Composition and Distribution*

Live population survey results:

At April 17, 1997 Limiting Factors meeting it was noted that Stansbury Creek had been the upper most tributary available to anadromous species before the mainstem falls were blasted in the late 1950s. In the winter of 1992, passage in Stansbury Creek was substantially opened to steelhead. There was no sign of spawning during the winter of 1993-94; nor were there any adult fish seen in the winter of 1995. However, young-of-year steelhead were seen in Stansbury Creek in 1995.

Redd survey results:

At the April 17, 1997 Limiting Factors meeting it was noted that no sign of spawning was observed in the winter of 1993-94.

Carcass survey results:

There is no known carcass data for Stansbury Creek

6. *Food Supply*

There is no known data regarding food supply in Stansbury Creek.

7. *Water Quality*

There is no known water quality data in Stansbury Creek.

Whitlow Creek

Channel Morphology

1. *Slope*

According to measurements collected from the Zeni Ridge U.S. Geological Survey 7.5 minute topographic map, the channel slope in Whitlow Creek ranges from 3-4% in its first mile, 5-6% in its second mile, 6-7% in its upper reach, and greater than 20% at its headwaters.

2. *Substrate Composition*

On January 9, 1996, a consultant to Coastal Forestlands, Ltd. walked 0.5 miles of Whitlow Creek within Timber Harvest Plan 1-96-196 MEN. He stated that "this watercourse was heavily impacted by recent sediment (1994-95), as evidenced by the color and angularity of the sediment" (THP 1-96-196 MEN).

At the April 17, 1997 Limiting Factors meeting it was noted that Whitlow Creek generally has lots of fines in the stream channel. Coastal Forestlands, Ltd. is putting in sediment catchment basin as a form of grade control. And, the Division of Mines and Geology has recommended that all permanent culverts be pulled so as reduce the amount of road-related fine material that ends up in the stream as a result of storm flows.

3. *Width/depth ratio*

There are no cross-sections or other data from which to calculate the width to depth ratio of Whitlow Creek. However, at the April 17, 1997 Limiting Factors meeting, it was noted that Whitlow Creek generally has a wide, flat channel with vertical , unprotected banks.

4. *Confinement*
The channel confinement of Whitlow Creek has not been measured.

5. *Bankfull discharge*

The bankfull discharge of Whitlow Creek is estimated based on area as 1,222 cfs.

<u>Aquatic Habitat</u>

1. *Habitat Types and Distribution*

There is no known data regarding habitat types and distribution in Whitlow Creek. However, as part of Timber Harvest Plan 1-96-196 MEN, a consultant to Coastal Forestlands, Ltd. states that the Whitlow Creek watercourse appears simplistic, lacking sinuosity, large woody debris and a good pool to riffle ratio. At the April 17, 1997 Limiting Factors meeting it was noted that Whitlow Creek is generally lacking pools.

2. *Instream Cover*

There is no known data regarding instream cover in Whitlow Creek. However, as part of Timber Harvest Plan 1-96-196 MEN, a consultant to Coastal Forestlands, Ltd. states that the instream structure of Whitlow Creek appears simplistic and lacks pool forming elements such as large woody debris.

3. *Water Temperature*

There is no known water temperature data for Whitlow Creek. However, at the April 17, 1997 Limiting Factors meeting it was noted that canopy cover in Whitlow Creek is moderate at best with a high of 65% canopy closure along the lower reaches of the stream.

4. *Barriers*

There are no known barriers on Whitlow Creek.

5. *Population Composition and Distribution*

Live population survey results:

On January 9, 1996 a consultant to Coastal Forestland, Ltd. walked 0.5 miles of Whitlow Creek within Timber Harvest Plan 1-96-196 MEN. He observed "a number of juvenile fish in the deeper holes, but no sign of redds." (THP 1-91-196 MEN)

Redd survey results:

See Live Population Survey Results for Stansbury Creek, above.

Carcass survey results:

There is no known carcass data on Whitlow Creek.

6. *Food Supply*

There is no known data regarding food supply on Whitlow Creek.

7. Water Quality

There is no known water quality data on Whitlow Creek.

Garcia River from Larmour Creek to Blue Waterhole Creek

Channel Morphology

1. *Slope*

According to measurements collected from the Zeni Ridge U.S. Geological Survey 7.5 minute topographic map, the channel slope of the mainstem Garcia from Larmour to Bluewater Hole Creek is less than 1% with the exception of a short segment above the former mainstem falls which ranges from 1-2 %.

2. *Substrate Composition*

On September 2, 1948, the California Department of Fish and Game conducted a stream survey on the mainstem Garcia River from Zeni Ranch to the mainstem falls formerly located just below Larmour Creek. The surveyor observed a "good combination of excellent spawning riffles and deep pools, and stretches of rough, boulder- and rubble-strewn water.

3. *Width/depth ratio*

On September 2, 1948, the California Department of Fish and Game conducted a stream survey on the mainstem Garcia River from Zeni Ranch to the mainstem falls formerly located just below Larmour Creek. The surveyor estimated the stream to be about 25 feet wide. He did not note the average depth. A review of the 1952 aerial photograph showed a fair amount of sediment in the mainstem Garcia River channel from the eastern planning unit boundary to Stansbury Creek. A good base flow in the mainstem Garcia River channel was noted in the 1952 photos from Stansbury Creek to the western planning unit boundary.

4. *Confinement*

Confinement was measured using both the 1952 and 1988 aerial photographs. The degree of confinement does not appear to have changed during this time period. The mainstem Garcia River channel from the eastern planning unit boundary to Stansbury Creek is measured as moderately confined. From Stansbury Creek down to the western planning unit boundary, the mainstem Garcia River is measured as well confined.

5. *Bankfull discharge*-- See flows, above

<u>Aquatic Habitat</u>

1. *Habitat Types and Distribution*

See Substrate Composition above.

2. *Instream Cover*

See Substrate Composition above.

3. *Water Temperature*

In 1995, the Friends of the Garcia collected summer temperature data on the mainstem Garcia at a location near its confluence with Blue Waterhole Creek. The data was collected from

July 2, 1995 through October 6, 1995 using a Hobo Temp. The maximum day time temperature was approximately 83F (28C) and the maximum night time temperature was approximately 70F (21C). Thus the diurnal range was approximately 13F (7C). The average summer temperature (July through September) was approximately 68F (20C). The maximum weekly average temperature ranged from 70F (21C) in early July to 74F (23C) in mid July to 63F (17.1C) in late September to 59F (14C) in early October. The summer temperature exceeded the coho salmon's preferred range 95% of the time.

4. *Barriers*

There used to be a bedrock falls on the Garcia River mainstem in Planning Watershed 113.70012. The Department of Fish and Game blew up the falls to open up the upper watershed to the anadromous fishery in the 1960s.

5. *Population Composition and Distribution*

Live population survey results:

On September 2, 1948, the California Department of Fish and Game conducted a stream survey on the mainstem Garcia River from Zeni Ranch to the mainstem falls formerly located just below Larmour Creek. The surveyor observed abundant schools of steelhead and coho salmon 2 to 3.5 inches long.

There is no known redd or carcass survey results for the Garcia River mainstem in this planning watershed.

6. *Food Supply*

There is no known data regarding food supply on the mainstem Garcia River in this planning watershed.

7. *Water Quality*

There is no known water quality data on the mainstem Garcia River in this planning unit.

Existing Data for
Planning Watershed 113.70013
Blue Waterhole Creek Sub-basin

General Setting

Location

Planning Watershed 113.70013 contains the Blue Waterhole Creek sub-basin. It is found on the Zeni Ridge and Eureka Hill U.S. Geological Survey 7.5 minute topographical maps. It is further described by Township 13 North and Range 15 West, Sections 25-28 and 33-35 and T 12 N, R 15 W, Sections 2-4 and 10-11. See accompanying Planning Watershed base map.

Soils

The soils contained in Planning Watershed 113.70013 include:

- Squawrock-Witherell complex, 15-50% slopes
- Squawrock-Garcia-Witherell complex, 15-50% and 50-75% slopes
- Yellowhound-Kibesillah-Ornbaun complex, 30-50% slopes
- Garcia-Snook-Gube complex, 30-50% and 50-75% slopes
- Ornbaun-Zeni complex, 50-75% slopes
- Woodin-Yellowhound complex, 30-50% slopes
- Casabonne-Wholy complex, 30-50% slopes
- Pardaloe-Woodin complex, 30-50% slopes
- Yorkville-Yorktree-Squawrock complex, 30-50% slopes

Personnel at the Natural Resource Conservation Service reviewed the soil complexes and organized them into vegetative types. A description of the vegetation types follows.

Predominant Vegetation

The soils on the southwest side of Blue Waterhole Creek predominantly support redwood forest with the exception of the ridgetop soils which support chaparral. The soils on the northeast of Blue Waterhole Creek predominantly support mixed evergreen forest and oak woodland/grassland with the exception of the ridgetop soils which support chaparral.

Land Use

Major Land Owners

According to the County Tax Assessor's rolls, Planning Watershed 113.70013 is owned by 4 major landowners: Coastal Forestlands, Ltd.; Louisiana-Pacific Corporation; the Bewleys, and the Hanes. Coastal Forestlands, Ltd. and Louisiana-Pacific Corporation are an industrial timber owners. The other two properties are private ranches.

Historic Land Use

The 1952 aerial photographs indicate that by 1952, the stream-side roads in Blue Waterhole Creek had been built and logging had begun in and along the stream corridor all the way from Mountain View Road to within 0.25 miles of the mouth of Blue Waterhole Creek. Logging and road-building had also been initiated in the tributaries to Blue Waterhole Creek with landings erected at stream forks. A 1959 Hollow Tree Lumber ownership map indicates that Hollow Tree Lumber then owned property on the west side of Blue Waterhole Creek as well as timber rights on the east side. Presumably, in 1952, it is their activity which is in evidence.

The County actively encouraged and permitted land conversion in the 1950s and 1960s. Records indicate that by 1960, permits had been issued to convert to grazing land a total of approximately 3,159 acres, approximately 2,451 acres of it timber land.

In 1966, the California Department of Fish and Game published its "Stream Damage Surveys - 1966" in which it rated the tributaries of the Garcia River as severely damaged, moderately damaged, lightly damaged or undamaged. Blue Waterhole Creek and all of its tributaries were rated as severely damaged.

Hydrology

Drainage Area

1. *Acres*

Planning Watershed 113.70013 contains 4,929 acres. Runoff through this sub-basin which includes a portion of the Garcia River mainstem is 25,924 acres.

2. *Flows*

There are no flow measurements available for Planning Watershed 113.70013. However, at the April 28, 1997 Watershed Advisory Group meeting it was noted that Blue Waterhole has particularly good summer flows. Also, if the discharge with a 2-year recurrence interval, as measured at the USGS gaging station at Connor Hole is 14,000 cfs, and the total drainage area of Planning Unit 113.70013 is 41.3% of the area above Connor Hole, and area is roughly proportional to flow, then the discharge with a 2-year recurrence interval in Planning Watershed 113.70013 can be approximated as 5,781 cfs. By a similar calculation, the bankfull flows for Blue Waterhole Creek along can be estimated at 1,059 cfs.

The U.S. Geological Survey recommends, in Water-Resources Investigations 77-21, using the following equation to estimate flow with a 2-year recurrence interval: $Q_u=Q_g(A_u/A_g)^b$ where Q_g is the discharge at a nearby gaging station, A_u is the drainage area in square miles of the ungaged basin, A_g is the drainage area in square miles of the gaged basin, and b is a coefficient equal to 0.9 for the North Coast Region. The equation results in an estimate for the discharge with a 2-year recurrence interval of 1,417 cfs when Q_g is equal to 14,000 cfs, A_u is equal to 7.70 square miles, and A_g is equal to 98.10 square miles.

3. *Diversions*

There are no known water diversions in this Planning Unit.

Precipitation

According to the Fire Resource Assessment Program of the California Department of Forestry and Fire Protection, the average annual rainfall in Planning Watershed 113.70013 is 65 inches.

Geology

Geologic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program. However, it's program included mapping in only a portion of this planning unit. Coastal Forestlands, Ltd., the industrial timber owner in this planning unit, may have geologic information relevant to this unit contained in the watershed assessment portion of its Sustained Yield Plan. As of this writing, however, neither the Watershed Assessment nor the Sustained Yield Plan has been released for public review.

According to the Division of Mines and Geology mapping, the western portion of the Blue Waterhole Creek sub-basin is characterized by a northwest-southeast trending fault which separates a block of Franciscan Melange from a block of Coastal belt Franciscan material. The western branch of the upper fork of Blue Waterhole Creek generally flows in this fault.

Mountain View Road, on the northwestern ridge also follows a lithologic contact between the Franciscan Melange and Coastal belt material.

Geomorphic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program. However, it's program included mapping in only a portion of this planning unit.

According to the Division of Mines and Geology mapping, four earthflows and one rotational slide originate on the northern ridge along the western and southern edge of Mountain View Road. There features, when active, impact the western branch of the upper fork of Blue Waterhole Creek. Another earthflow, associated with a spring, originates on the southern ridge of the western branch of the upper fork of Blue Waterhole Creek.

Three earthflows and two rotational slides are noted on the mid reach of the mainstem Blue Waterhole Creek. One of the rotational slides is quite large and is associated with debris sliding at its upper edge. Two debris torrents are also noted along the mainstem.

Three earthflows, one associated with several springs, are noted on the first major west-side tributary to Blue Waterhole Creek. One debris torrent is also noted.

The sub-basin, in general, has scattered active slide areas, debris slide slopes, and disrupted ground.

The Division of Mines and Geology has also participated in preharvest inspections on Timber Harvest Plans conducted in this Planning Watershed. Excerpts from their preharvest inspection reports are included here.

1. *THP 1-89-257*

The plan was located at T13N, R15W, Sections 33-34 and T12N, R15W, Sections 3-4. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- Davenport (1984) mapped several debris slides, debris flows, and disrupted ground. The mapped slides are consistent with field observations.
- Almost all of the recent landsliding and gully erosion is from poor road and skid trail construction.

2. *THP 1-89-258*

The plan was located at T13N, R15W, Sections 33-34. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- No major deep seated landslides mapped by Davenport or observed on aerial photographs within the THP area.
- Almost al of the small landslides within the THP area associated with poor skid trail and road construction.
- Roads and skid trails have been constructed in the bottom of streams and draws.
- The main haul road was built within a channel of the west branch of the Blue Waterhole Creek.
- In places, there is still fill perched 10-15 feet above the current channel on both sides of the creek.
- There is a large gully where runoff was directed over the edge of road fill.
- Reconstruction of a switchback that is gullied has slumped. There is a 5 foot wide, 3 foot deep gully on the face of the slope between the road switchback.
- A gully has formed for more than 100 feet due to flow from a spring which is running down the road surface.
- Water from a crossing has flowed across the edge of the existing road and eroded a 6 foot wide, 4 foot deep gully in the road fill.
- A diverted Class III stream at a skid trail crossing has caused a 15 foot wide, 8-10 foot deep gully for 500-700 feet.
- Road construction across 65% slopes and at the steep (80%) head of a Class II stream.

3. *THP 1-91-451*

The plan was located at T12N, R15W, Sections 2, 3, and 11. The Division of Mines and Geology and Regional Water Board inspectors noted the following features during the preharvest inspection:

<u>Mines and Geology</u>

- There are several unstable areas within the plan area.
- There are rotational landslides and debris slides associated with roads, skid trails, and landings, particularly in areas with pre-existing dormant landslide features.
- There is an inner gorge along Blue Waterhole Creek and along the Class II stream with active debris sliding.
- A dormant rotational landslide covering half of the 690 acre plan was identified by Davenport (1984) and confirmed in more recent aerial photographs.
- There is severe gully erosion along some of the skid trails. A majority are stable with little evidence of gully erosion.

- A Class I Watercourse and Lake Protection Zone (WLPZ) skid trail has a 5-6 foot wide, 6-10 foot deep gully.
- There is a Class III instream skid trail.
- There is a slide above and below the road. The slide below the road is associated with sidecast material placed on slopes greater than 70% within a larger slide feature.

<u>Regional Water Board</u>

- There is a gullied skid trail within a Class I WLPZ. The gully is 12-15 feet deep. A failing, undersized road crossing caused the gully noted.
- The Class II cobble/boulder substrate has noticeable fines where gravels have been disturbed. The cobbles are not highly embedded.
- There are Class I and II WLPZ skid trails and landings in the THP area.

4. *THP 1-93-219*

The plan was located at T12N, R15W, Sections 2-4, 11, and 34. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- There are several unstable areas within the plan area.
- There are translational landslides, debris slides, and gully erosion associated with roads, skid trails and landings, particularly in areas with pre-existing dormant landslide features.
- There is an inner gorge along portions of Blue Waterhole Creek and along some Class II and III streams.
- Davenport (1984) identified debris slide slopes over portions of the plan area with slopes greater than 50%.
- Road cutslopes fail as viscous mudflow slumps.
- There is a road fill failure at the intersection of 2 roads and a landing. The fill slumped 10-15 feet across. Spring flow at the base of the slump formed a viscous debris flow.
- Another road failure at the cutbank slumped as a viscous debris flow.
- A debris slide below a road was caused by sidecast on 70% slopes. The debris slide was within a larger slide extending upslope of the road. The active slide portion of the slide was about 130 feet wide. The cutslope also failed and was about 70 feet high.
- An instream landing in a Class III stream has been downcut at least 6 feet by the channel which has re-established itself across one end of the landing.
- A diversion of a Class III stream caused a mudflow which deposited a viscous mudflow lobe about 5 feet wide on the surface of an instream Class II landing.

5. *THP 1-95-526*

This plan is on the same ground as THP 1-91-451. The Regional Water Board inspector noted the following features during the preharvest inspection:

- A fail crossing diverted a Class II stream down the road, across and WLPZ landing and down an old truck road. The diversion caused a substantial gully of up to 15 fete deep with direct access to Blue Waterhole Creek.
- Many lengths of inside ditch were noted as eroding.
- An existing shotgun crossing onto erodible fill was noted.
- The road surface exhibited rill erosion.
- A Class III stream was diverted down a skid trail and into a Class II stream.

Channel Morphology

Slope

According to measurements collected from the Zeni Ridge U.S. Geological Survey 7.5 minute topographic map and those generated by GIS from the Eureka Hill quad, the slope of Blue Waterhole Creek's lower channel is less than 1% as is the first west-side Class I tributary. The GIS slope calculations indicate that the Blue Waterhole Creek mainstem up past its confluence with the first Class I tributary takes a short, steep jump of greater than 20% and then continues up at a slope ranging from 1-3% until its confluence with the next major tributary. The next major tributary is marked by another short, steep jump ranging from 7-10% slope up past which the Blue Waterhole Creek mainstem continues at a slope ranging from 1-3%. It then jumps to slopes ranging from 3-5% just before the upper Blue Waterhole Creek fork. At the upper Blue Waterhole Creek fork there is yet a third short, steep jump ranging from 10-15% slope. The upper east-side upper fork continues up at a slope ranging from 3-5% with its upper reaches ranging from 15-20%. The upper west-side fork continues up at a slope ranging from 3-5% then flattens and steepens again to slopes greater than 20% in its upper reaches. The first major west-side tributary continues from its confluence with the Blue Waterhole Creek mainstem (at the second short, steep jump) at a slope ranging from 1-3%. It then steepens in a series of steps ranging from 5% to greater than 20% in slope.

Substrate Composition

On August 22, 1967, the California Department of Fish and Game conducted a stream survey of Blue Waterhole Creek. The surveyor walked from the mouth to the headwaters. He concluded that the substrate was predominantly gravel and rubble in the lower and mid reaches. It was largely bedrock and boulders in the upper reaches.

On August 15, 1993, the North Coast Regional Water Quality Control Board and the California Department of Forestry and Fire Protection published a report entitled "Testing Indices of Cold Water Fish Habitat." The study included the measurement of habitat variable in 60 streams within the North Coast Planning Basin of California. Sampling was limited to the Franciscan geologic formation. Blue Waterhole Creek was studied as one of the 60 streams.

Measurements on Blue Waterhole Creek included Riffle Armour Stability Index (RASI), the geometric mean particle size (D_{50}), and V*, among others.

RASI is a measure of the cumulative percent of the riffle particles (measured using a modified Wolman pebble count) that are less than or equal to the size of the largest annually mobile particles on the riffle. According to Knopp, the report's primary author, RASI numbers greater than 80 are believed to indicate unnaturally high sediment loads. The RASI for the reach studied in Blue Waterhole Creek was 79.0.

The D_{50} was determined using a modified Wolman Pebble Count within the bankfull channel. The count used 200 points per riffle and included 3 riffles per reach. The values were then averaged. The average D_{50} for the reach studied in Bluewater Hole Creek was 55.3 mm (very coarse gravel).

V* represents the proportion of fine sediment that occupy the scoured residual volume of a pool. The primary selection criteria for V* pools was a maximum depth of at least 4 times the riffle crest depth (at low flows). A minimum of 4 transects per pool were measured. Six pools per 1000 meter reach were sampled. The V* for the reach studied in Bluewater Hole Creek was 0.40 (40% of the pools filled by fine sediment).

Coastal Forestlands, Ltd. reported in its *Watershed and Aquatic Habitat Assessment* (1997) that at a sampling location on the Garcia River mainstem at the mouth of Blue Waterhole Creek:

- The D16 was approximately 5 mm in diameter
- The D50 was approximately 45 mm in diameter
- The D84 was approximately 245 mm in diameter
- 9.5% of the fines were finer than 2 mm.

Width/depth Ratio

On August 22, 1967, the California Department of Fish and Game conducted a stream survey of Blue Waterhole Creek. The surveyor walked from the mouth to the headwaters. He estimated the stream depth to range between 1 inch and 3 feet with an average of about 3 inches. He estimated that stream width to range from 1 foot to 8 feet with an average of about 5 feet.

On November 24, 1995, the Mendocino County Resource Conservation District established cross-sections at several locations on Blue Waterhole Creek to monitor the effect of restoration work conducted by New Growth Forestry. Site A is a location where a Humboldt crossing from an old logging road over the Blue Waterhole Creek mainstem had previously been removed but left road fill which continued to erode into the creek. Fill was excavated, banks were recontoured and log structures were placed at this site. The cross-section taken after work completion indicates a width of 54 feet, a cross-sectional area of 454 square feet, and a mean depth of 8. The width to depth ratio, then, is 7.

Site G is a location where a large log jam/debris barrier formed during the winter of 1994/95. The barrier was removed, the banks recontoured and armoured, and sediment recruitment structures installed. The cross-section taken after work completion indicates a width of 69 feet, a cross-sectional area of 512 square feet, and a mean depth of 7 feet. The width to depth ratio, then, is 10.

Site H is a location where a Humboldt crossing from an old logging road over a tributary was had previously been removed but left road fill which continued to erode into the creek. Fill was excavated and bank revetment and sediment recruitment structures were installed. The cross-section taken after work completion indicates a width 40 feet, a cross-sectional area of 84 square feet, and a mean depth of 2 feet. The width to depth ratio, then, is 20.

A cross-section was established on a tributary just downstream of Site F. Site F was the location of a small log jam/barrier which formed during the winter of 1994/95 and was then removed. The cross-section taken downstream indicates a width of 48 feet, a cross-sectional area of 408 square feet, and a mean depth of 9 feet. The width to depth ratio, then, is 5.

A cross-section was established about 250 feet downstream of the Casper Creek tributary between Sites E and F. The cross-section indicates a width of 50 feet, a cross-sectional area of 254 square feet, and a mean depth of 5 feet. The width to depth ratio, then, is 10.

These calculations assume that "right bank" and "left bank" as indicated on the cross-sections refer to widths at bankfull stage.

Coastal Forestlands, Ltd. sampled one location on the mainstem Garcia River at the mouth of Blue Waterhole Creek as part of its *Watershed and Aquatic Habitat Assessment* (1997). The measured bankfull width was 78 feet while the measured bankfull depth was 6.5 feet. The calculated width/depth ratio is12.

<u>Confinement</u>

Confinement has not been measured for this planning unit. However, on August 22, 1967 the California Department of Fish and Game conducted a stream survey of Blue Waterhole

Creek. The surveyor noted that "the stream heads in a steep V-shaped canyon at a very steep gradient. (The) stream then levels to a more gradual slope." In addition, as noted on the 1952 aerial photographs, there were significant stream-side road building and logging activities in Blue Waterhole Creek. As such, one might presume that the headwaters are confined and the mid and lower reaches are moderately to poorly confined.

Coastal Forestlands, Ltd. reported in its *Watershed and Aquatic Habitat Assessment* (1997) a confinement measurement in the mainstem Garcia River at the mouth of Blue Waterhole Creek of 1.0. This is characterized as confined.

Bankfull Discharge

See Flow, above.

On August 22, 1967, the California Department of Fish and Game conducted a stream survey of Blue Waterhole Creek. The surveyor noted that Blue Waterhole Creek is a major contributor of water to the Garcia River during critical water periods. The flow in August was estimated at 2.5 cfs at the mouth of the basin and 2.0 cfs 6 miles up from the mouth. The surveyor also noted that the debris on the slopes and the height of the bank indicated to him that the winter stream flow was 7 to 8 times that of summer flows.

At the April 28, 1997 Watershed Advisory Group meeting, it was noted that Blue Waterhole has particularly good summer flows.

Aquatic Habitat

Habitat Types and Distribution

On August 22, 1967, the California Department of Fish and Game conducted a stream survey of Blue Waterhole Creek. The surveyor walked from the mouth to the headwaters. He concluded that 60% of the stream was suitable for spawning and the remaining 40% of the stream was comprised of pools. Only in the headwater section (upper 2 miles) did the surveyor note a lack of spawning habitat. The pools, he concluded, were well developed. The average pool was 6 feet by 4 feet and 2 feet deep. They ranged in size from 20 feet by 12 feet and 4 feet deep to 2 feet by 3 feet and 1 foot deep.

On August 15, 1993, the North Coast Regional Water Quality Control Board and the California Department of Forestry and Fire Protection published a report entitled "Testing Indices of Cold Water Fish Habitat." The study included the measurement of habitat variable in 60 streams within the North Coast Planning Basin of California. Sampling was limited to the

Franciscan geologic formation. Bluewater Hole Creek was studied as one of the 60 streams. Measurements collected included the number of pools per 1000 meter reach and the maximum pool depth. Twenty-nine pools per 1000 meter reach were counted in Blue Waterhole Creek. This compares well with data for streams that were identified in this study as index streams, even though Blue Waterhole Creek was identified as highly disturbed. However, the watershed size was apparently a confounding factor in evaluating the pool data. The maximum pool depth was measured as 1.5 meters. This, too, compares well with data from index streams. In general, pool-related measurements were not found to be capable of discerning levels of watershed disturbance.

In the April 17, 1997 Limiting Factors meeting it was noted that Blue Waterhole Creek has a lot of pool relative to other tributaries in the basin.

Coastal Forestlands, Ltd. reportd in its *Watershed and Aquatic Habitat Assessment* (1997) that based on sampling at a location in the mainstem Garcia River at the mouth of Blue Waterhole Creek:

- Approximately 62% of the Class I streams in Planning Watershed 113.70013 have slopes less than 3%. Low gradient stream reaches are attractive to coho salmon.
- Approximately 15% of the bankfull channel was covered by canopy, approximately 2% of it attributable to coniferous species.
- Approximately 4 pieces of large woody debris were found per bankfull width.
- Approximately 49 cubic feet of large woody debris were found.
- Residual pool depth was approximately 4.4 feet.
- Residual pool volume was approximately 3000 cubic feet

<u>Instream Cover</u>

On August 22, 1967, the California Department of Fish and Game conducted a stream survey of Blue Waterhole Creek. The surveyor walked from the mouth to the headwaters. He notes abundant instream shelter, primarily made up of logs and boulders. He noted that there was very little stream-side vegetation.

During Knopp's study, measurements collected included the volume of wood in the channel and the amount of cover provided by wood. In Blue Waterhole Creek, 351 cubic meters of wood per 1000 meter reach were measured. This compares well to data for streams identified in this study as previously-managed index streams, even though Blue Waterhole Creek was identified as a highly disturbed watershed. Wood related cover within the study reach was measured at 398 square meters. In general, the wood-related measurements were not found to be stream parameters capable of discerning levels of watershed disturbance.

In the April 17, 1997 Limiting Factors meeting it was noted that Blue Waterhole Creek has a lot of boulder cover.

Water Temperature

On August 22, 1967, the California Department of Fish and Game conducted a stream survey of Blue Waterhole Creek. The surveyor walked from the mouth to the headwaters. The mid-day August water temperature was 67F (19C) at the mouth and 65F (18C) at the headwaters.

Beginning in 1993, the Friends of the Garcia has collected summer water temperatures in Blue Waterhole Creek. In 1994, they expanded their sampling network in Blue Waterhole Creek from 1 station to 3.

FrOG Station #1 is located near the upper Blue Waterhole Creek fork. 1994 data was collected from June 4, 1994 through September 26, 1994. It indicates a maximum day time temperature of approximately 78F (26C) and a maximum night time temperature of approximately 65F (18C). Thus the diurnal range is approximately 16F (9C). The average summer temperature was approximately 64F (18C). The maximum weekly average temperatures range from 63F (17C) in June to 68F (20C) in July and to 55F (13C) in late September. The summer temperatures exceed the upper limit of the coho salmon's preferred range 85% of the time.

The 1995 data was collected from July 2, 1995 through October 6, 1995. It indicates a maximum day time temperature of approximately 78F (26C) and a maximum night time temperature of approximately 62F (17C). Thus, the diurnal range is approximately 16F (9C). The average summer temperature was approximately 67F (19C). The maximum weekly average temperatures range from 65F (18C) in mid September to 67F (19C) in late September and to 68F (20C) in mid October. The summer temperatures exceed the upper limit of the coho salmon's preferred range 90% of the time.

FrOG Station #2 is located near the second Blue Waterhole Creek fork. 1994 data was collected from June 4, 1994 through September 26, 1994. It indicates a maximum day time temperature of approximately 67F (19C) and a maximum night time temperature of approximately 64F (18C). Thus the diurnal range is approximately 3F (1C), considerably less than at Station #1. The average summer temperature was approximately 63F (17C). The maximum weekly average temperatures ranged from 61F (16C) in June, to 66F (19C) in July, and to 55F (13C) in late September. The summer temperatures exceeded the upper limit of the coho salmon's preferred range 90% of the time.

The 1995 data was collected from July 8, 1995 through October 6, 1995. It indicates a maximum day time temperature of approximately 76F (24C) and a maximum night time temperature of approximately 66F (19C). Thus, the diurnal range is approximately 10F (5C), still less than at Station #1. The average summer temperature (from July through September) was approximately 67F (19C). The maximum weekly average temperatures ranged from 66F (19C) in early July, to 69F (21C) in mid July, to 63F (17C) in late August, and to 57F (14C) in early October. The summer temperatures exceeded the upper limit of the coho salmon's preferred range 96% of the time.

FrOG Station #3 is located near the mouth of Blue Waterhole Creek. 1994 data was collected from July 5, 1994 through October 27, 1994. It indicates a maximum day time temperature of approximately 75F (24C) and a maximum night time temperature of 65F (18C). Thus the diurnal range is 10F (6C). The average summer temperature (from July through September) was approximately 65F (18C). The maximum weekly average temperatures ranged from 69F (21C) in July, to 61F (16C) in September, and to 52F (11C) in October. Summer temperatures exceeded the coho salmon's preferred ranged 64% of the time.

1995 data was collected from this location from July 2, 1995 through October 6, 1995. The station was formerly known as Station #3 but in 1995 was renamed Station #4. The maximum day time temperature was approximately 76F (24C) and the maximum night time temperature was approximately 67F (19C). Thus the diurnal range was 9F (5C). The average summer temperature (July through September) was approximately 66F (19C). The maximum weekly average temperature ranged from 66F (19C) in early July, to 70F (21C) in mid July, to 63F (17C) in mid September, and to 56F (14C) in early October. The summer temperatures exceed the coho salmon's preferred range 92% of the time.

In 1995, FrOG added a new station on the mainstem of Blue Waterhole Creek between the mouth and the first major stream fork. This station was named Station #3 and the former Station #3 was renamed Station #4. Data was collected from July 8, 1995 through October 6, 1995. The maximum day time temperature was approximately 83F (28C). The maximum night time temperature was 70F (21C). Thus, the diurnal range was 13F (7C). The average summer temperature (July through September) was approximately 69F (21C). The maximum weekly average temperature ranged from 66F (19C) in early July, to 70F (21C) in mid July, to 63F (17C) in mid September, and to 56F (14C) in early October. The summer temperature exceeded the upper limit of the coho salmon's preferred range 92% of the time.

Water temperature was also collected by a consultant to Coastal Forestlands, Ltd. at a location on Blue Waterhole Creek (exact location unknown). Using a Hobo Temp, the consultant measured temperatures from June 1, 1995 through November 4, 1995. The maximum day time temperature was approximately 78F (25C) and the maximum night time temperature was approximately 65F (18C). Thus the diurnal range was approximately 13F (7C). The average summer temperature (June through September) was approximately 65F (18C).

At the April 17, 1997 Limiting Factors meeting and the April 28, 1997 Watershed Advisory Group meeting it was noted that the canopy cover in Blue Waterhole Creek is generally quite poor. It was also noted that volunteer tree planting efforts have resulted in riparian plantings down much of the upper east-side fork as well as up and downstream on the west-side fork and mainstem at that junction. The stretch along the mainstem Blue Waterhole Creek between the second and upper forks was noted as having relatively food canopy closure as a result of the plantings.

Barriers

In the April 17, 1997 Limiting Factors meeting it was noted that fish passage is blocked immediately up stream of the second major fork on Blue Waterhole Creek. In the April 28, 1997 Watershed Advisory Group meeting it was noted that fish passage is blocked in the upper end of the upper east-side fork. Cascades were noted in the first major west-side fork, as well as a landing site which may impede fish passage. A rock barrier was also noted in that tributary system. A rock barrier was also noted on the upper west-side tributary.

Population Composition and Distribution

1. *Live Population Survey Results*

On August 22, 1967, the California Department of Fish and Game conducted a stream survey of Blue Waterhole Creek. The surveyor walked from the mouth to the headwaters. He observed many Western suckers from the mouth up about 0.5 miles. And, he also observed many steelhead which he concluded were very successful in the Blue Waterhole Creek sub-basin. He estimated the steelhead density at about 100 fish per 100 feet and their size as ranging from 1 to 10 inches. The surveyor also observed frogs, water snakes, and a few California newts.

In the March 31, 1997 Watershed Advisory Group meeting it was noted that during the last tree planting on Blue Waterhole Creek, the planting crews saw many steelhead, including large, adult fish.

2. *Redd Survey Results*

There is no known redd data for Blue Waterhole Creek.

3. *Carcass Survey Results*

There is no known carcass data for Blue Waterhole Creek

Food Supply

On August 22, 1967, the California Department of Fish and Game conducted a stream survey of Blue Waterhole Creek. The surveyor walked from the mouth to the headwaters. He estimated the food supply at about 25 organisms per square foot of rock area. He observed mayfly and stonefly nymph.

Water Quality

No known water quality data in Blue Waterhole Creek.

Existing Data for
Planning Watershed 113.70014
Inman Creek

General Setting

Location

Planning Watershed 113.70014 contains the Inman Creek sub-basin. It is found on the Zeni Ridge and McGuire Ridge U.S. Geological Survey 7.5 minute topographic maps. It is further described by Township 12 North and Range 14 West, Sections 7-10 and 15-18 and T 12 N, R 15 W, Sections 12-14.

Soils

The soils contained in Planning Watershed 113.70014 include:

- Ornbaun-Zeni complex, 9-30%, 30-50%, and 50-75% slopes
- Garcia-Snook-Gube complex, 50-75% slopes
- Woodin-Yellowhound complex, 30-50% and 50-75% slopes
- Squawrock-Garcia-Witherell complex, 30-50% and 50-75% slopes
- Yellowhound-Kibesillah-Ornbaun complex, 9-30%, 30-50%, and 50-75% slopes
- Yorkville-Yorktree-Squawrock complex, 15-30% and 30-50% slopes
- Pardaloe-Woodin complex, 30-50% slopes
- Yellowhound-Kibesillah complex, 50-75% slopes
- Casabonne-Wohly complex, 9-30% and 30-50% slopes

Personnel from the Natural Resource Conservation Service reviewed the soil complexes and organized them into vegetative types. The vegetative types are described below.

Predominant Vegetation

The soils identified in Planning Watershed 113.70014 primarily support redwood forests with sporadic oak woodland/grasslands and a small strip of chaparral in the northeastern corner of the sub-basin.

Land Use

Major Land Owners

According to the County Tax Assessor's rolls, there are three major landowners in the Inman Creek sub-basin. Coastal Forestlands, Ltd. and Louisiana-Pacific Corporation are both industrial timber owners while the Alden's own a private ranch. CFL owns 83% of the sub-basin, Alden 15% and L-P 2%.

Historic Land Use

The aerial photographs indicate that the lower portion of Inman Creek up to about the confluence with the Pepperwood Creek sub-basin was untouched as of 1952. The upper portion of Inman Creek and its tributaries had already been logged, however, by this date. Roads, landings and logging activities in and around the stream corridor are visible on the 1952 aerial photographs. A road across open grassland on the ridge separating the Inman Creek and Whitlow Creek sub-basins is also evident. A Hollow Tree Lumber ownership map indicates their ownership of this property as of 1959. Presumably the activity evident in the 1952 aerial photograph is theirs.

The County actively encouraged and permitted land conversion in the 1950s and 1960s. Records indicate that through 1965, no permits were issued in the Inman Creek basin.

In 1966, the California Department of Fish and Game published its "Stream Damage Surveys - 1966" in which it rated the tributaries of the Garcia River as severely damaged, moderately damaged, lightly damaged or undamaged. Inman Creek was rated as moderately damaged in its lower and upper reaches and severely damaged in its mid reach. The North Fork of Inman, including Pepperwood Creek, was rated as severely damaged.

Hydrology

Drainage Area

1. *Acres*

Planning Watershed 113.70014 contains 5,481 acres. Runoff originates only in this unit.

2. *Flows*

There are no flow measurements available for Planning Watershed 113.70014. However, if the discharge with a 2-year recurrence interval, as measured at the USGS gaging station at Connor Hole, is 14,000 cfs, and the total drainage area of Planning Unit 113.70014 is 8.7% of the area above Connor Hole, and area is roughly proportional to flow, then the discharge with a 2-year recurrence interval in Planning Watershed 113.70014 can be approximated as 1,222 cfs.

3. *Diversions*

There are no known diversions in Planning Watershed 113.70014.

<u>Precipitation</u>

According to the Fire Resource Assessment Program of the California Department of Forestry and Fire Protection, the average annual rainfall in Planning Watershed 113.70014 is 75 inches throughout most of the basin and 65 inches in the lower end of the basin.

<u>Geology</u>

<u>Geologic Features</u>

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program. However, it's program did not include mapping in this planning watershed.

<u>Geomorphic Features</u>

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program. However, it's program did not include mapping in this planning watershed. Nonetheless, the Division of Mines and Geology an Regional Water Board have participated in preharvest inspections in this Planning Watershed. Their observations are noted below.

1. *THP 1-89-289*

This plan was located at T12N, R15W, Section 24 and T12N, R14N, Sections 7 and 18. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- The slopes above Inman Creek form an inner gorge with debris sliding accelerated by road construction along the stream channel.
- There are erosional gullies traveling down the existing road for up to 500 feet. They are caused by diversions of streams, a lack of water breaks and poor road locations.
- A significant amount of erosion was noted near Carolyns Creek where the road constructed through friable mudstone.
- Earthflows were noted in the blue-grey, expansive clay.

- The outside of the road fill at Map Point F failed and pushed the stream channel to the opposite side. A skidtrail perpendicular to the road probably contributed to the failure.
- The outside edge of the road and cutbank at Map Point G failed due to a concentration of drainage along a skidtrail above the road. The erosion affected about 50 feet of road.
- The entire area around Map Point H is part of an earthflow slump. Blue-gray expansive clay is exposed on the grassy slopes.
- At Map Point I and Crossing 23, about 100 feet of the road has eroded into the creek.
- At Map Point J, the road is gullied for 200 feet and the road is washed out for about 40 feet.
- At Map Point K, half the roadbed failed into a Class II stream from improper drainage along the road.
- At Map Points L and M, the outside edge of the roadbeds have washed out from the concentration of water down the roads.
- At Map Point N, half the roadbed has slumped at a spring along the road for a distance of 60 feet. Crossing 41 has been blocked and diverted down the road.
- At Map Point O, the road crosses through a pre-existing rotational slump.
- At Map Point P, the area appears to be affected by a much larger slide complex. The road has dropped 3 feet for a distance of about 60 feet.
- At Map Point Q, about 60 feet of the road edge has failed by the undercutting of the stream.
- At Map Point R, the outside edge of the road has slumped for 40 to 50 feet, exposing blue-gray clay. The rotational slump toes into Inman Creek.

2. *THP 1-89-312*

This plan was located at T12N, R14W, Sections 8 and 9. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- Near and instream roads, landings, and skidtrail systems have left the channel aggraded in the plan area with a much higher base level because of log and debris jams downstream. Erosional gullies down skidtrails are up to 10 feet deep and 8 feet wide by the diversions of what might have been Class II streams. (Area G).
- The remaining road system is in relatively good condition although sidecast is perched along steep slopes in several locations. Most of the watercourse crossings have failed depositing large amounts of material and woody debris into the stream system.
- In Area S7, there are existing skidtrails and benches within a rotational slide with slopes averaging 30-35%. Some of the second growth trees are jackstrawed illustrating some recent movement.
- In Area S8, a rotational slump was identified which has been active since the last period of logging. The existing skidtrails are cracked and have 1-2 foot deep gullies eroded down the center of the trails.
- In Area A, the stream channel is severely aggraded to the point that the base level is well above what the natural level would be and the gradient is flat.

- In Area C, a debris slide occurring in a deeply weathered and friable sandstone, siltstone and blue clay material removed the road for a distance of 130 feet.
- Active springs have saturated the slope just below where the road would be and along the bench of debris deposited at the base of the slope. This slide occurs at the beginning of the road system that accesses the plan.
- The cutbank in Area D is failing within deeply weathered sandstone material. The slopes below the road are covered with perched sidecast material and averages 70-75%. The bank is unstable and will continue to fail.
- Area H is within a dormant earthflow slid which is characterized by non-timbered hummocky grass covered slopes. Gully erosion has occurred down the road in this location. The earthflow has probably been active prior to the first logging in this area.

3. *THP 1-90-076*

This plan was located at T12N, R15W, Section 14. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- Along several stretches of the Garcia River, adjacent slopes from a steep inner gorge containing several slope failures. The existing road was constructed across the inner gorge in some areas and have been affected by bank and fill failures as a result of inner gorge processes and diversion of natural drainages. Inner gorge slope failures resulting from stream activity will undoubtedly continue.
- Map Point S2 is a translational/rotational slide area consisting of several relatively small eroded slump blocks contained on slopes of 45-60% below an existing skid trail and 20-30% above. Channel are broad and up to 2-3 feet deep.
- Map Point S6 is a relatively small failure above the existing road which has the appearance of an earthflow. Several other small slump/earthflow features were observed on adjacent, hummocky slopes.
- Area A is a small translational/rotational failure onto the existing road.

4. *THP 1-90-089*

This plan was located at T12N, R15W, Sections 13-15 and 22-23. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- Map Point S2 is a debris slide/fill failure below the existing road on 50-70% slopes consisting of two or three adjacent small failures. Approximately 10 square feet of the outer edge of the roadbed has been lost. The failure appears to have been caused by concentration of water flowing onto and across the roadbed from an existing skid trail upslope on the opposite side of the road.

- Map Point S2 is a debris slide failure for 150-175 feet along the inner gorge of Saddle Ridge Creek. The failure may extend to the creek which is approximately 100-150 feet below. Vertical offset in the road surface is up to 6 feet.
- Map Point S3 includes several hundred feet of the existing road which have been affected by slumping along the inner gorge of the Garcia River. This is a translational/rotational failure consisting of several relatively small rotational slump blocks in and below the existing road. The failure extends for 50-70 feet above the road and 100+ feet below.
- Map Point S4 is an inner gorge failure along the Garcia River which extends for 50-60 feet above the road and 70-80 feet below. The slide area consisted of small eroded slump blocks with maximum length of about 30 feet and width of 15-20 feet.
- Map Point S5 is a debris slide failure on 70-75% slopes extending for 60-80 feet below the existing road and 30-40 feet above. This slide area consisted of two distinct failures which have eliminated roughly 60-80 feet of an existing spur road below the haul road.
- Area A is a small translational/rotational failure which is part of a much larger hummocky, slide areas consisting of similar slump blocks. Overall, the slide mass is approximately 40-100 feet wide and 150-200 feet long on slopes varying form 10-30%.
- Area C is an area of inner gorge debris slide failures along the Garcia River. A 40-50 foot long by 4-5 foot wide section of the outer bank has been eroded resulting in part from concentration of water on the existing road and at a point on the slopes above.
- Area E is an outer bank fill failure in the existing road within 75-100 feet of a Class II watercourse. The opening is approximately 6 feet wide and 7-8 feet deep.
- Area F is an area of outer bank erosion on the existing road. The eroded area is approximately 40-50 feet from the creek and extends fro 3-4 feet into the road prism, for about 6-8 feet along the road and 12-15 feet downslope form the road edge.
- Area F1 is an existing landing site with an incised channel perpendicular to the road alignment, draining into the Class II watercourse. The channel varies in width up to 5-6 feet and in depth up to 4-5 feet.
- Number 4 is a crossing of a Class III watercourse on the existing road. A small spring a the crossing is causing flow onto and along the inside edge of the road for approximately 70-80 feet at which point flow crosses the road onto the adjacent slope.

5. *THP 1-90-589*

This plan was located at T12N, R14W, Sections 15-16, and 21-22. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- The eastern portion of the plan along Palmer Creek are a series of inner gorge slopes and debris slide slopes with several debris slides and a debris flow torrent which is associated with past tractor logging. The lack of cross drainage, stacking of several skidtrails above the truck road along slopes over 65%, and the sidecast perched below the trails and road have all contributed to the failures. Several sections of the truck road and skidtrails are severely gullied by the diversion of Class III watercourses or water accumulation down the road or trail in locations for hundreds of feet.

- Area D appears to be a debris slide above the lower road which deposited a plug of debris on the lower road and the slope below. Later gully erosion has affected the road and the debris on the road.
- Area F show gully erosion for at least 400 feet.
- At Area H1, a debris flow torrent was identified where a gully along the road dumped off into perched sidecast which failed. The slide is about 60 feet wide.
- There is a landing located on a dormant rotational landslide in Area I which has had renewed movement. The lower portion of the slide below the landing has experienced active debris sliding along the inner gorge of Palmer Creek.
- A Class III watercourse was diverted in Area J.
- Sidecast from a truck road in Area L failed as a debris slide into Palmer Creek. The slope remains bare and unstable. A section of the road is about 75 wide and has lost about 75% of the roadbed. Slopes between the road and the creek are 110%.
- In Area P, Palmer Creek and an adjoining Class III watercourse were diverted down the old haul road which resulting in the removal of half of the roadbed for about 80 feet.

6. *THP 1-91-007*

This plan was located at T12N, R14W, Sections 4-5, and 7-9. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- The grassy slopes in the plan are underlain by shallow, rocky soils with relatively low cohesion.
- The plan area includes many examples of poor logging practices dating back to the original harvesting 25-30 years ago. Instream roads, landings, and skidtrail systems are still evident along Inman Creek leaving the channel severely aggraded with an altered base level behind debris jams. Erosional gullies along skidtrails and roads from stream diversions and lack of cross drainage are noted.
- Areas I, J and K included a road which is within a dormant predominantly rotational feature. Area I has an active spring which surfaced at he road and saturated the fill causing slumping. Area J is a similar slump along the road with a spring. Area K is a 300 foot gully in the bed of the road.
- Map Point S1 includes a 15 foot gully down a skidtrail within a slump.
- Map Point S2 is a dormant rotational feature within a much large dormant slide complex.
- Map Point S3 is a fill slump where the tow of al old road fill is within the Class II watercourse channel. Gully erosion is also present along the old road in this location.
- Along sections of the permanent Inman Creek haul road, the inside ditch relief culverts are separated by about 2000 feet. The outside berm on the crowned road was breached by

surface runoff accumulating on the outside edge of the road which drained onto one of many sidecast failure below the road.

6. *THP 1-91-192*

This plan was located at T12N, R14W, Sections 16 and 21. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- Both the northern corner of the plan above the Class I watercourse and the southern portion of the plan have areas of debris slide slopes. Severe gully erosion was noted in several areas, too. All of the Class III watercourse channels observed were used as skidtrails. Several log jams from landing construction in the Class I watercourse remain changing the base levels 10 to 15 feet behind the jam. Vertical eroding banks remain and contribute fine grain sediment to the watercourse in peak flows during winter storms.
- Map Point 13 appears to be a debris slide from the sidecast of a skidtrail which diverted a Class III watercourse. The material was deposited along the Class I watercourse channel where an old landing was constructed in the channel.
- Map Point 15 appears to be a rotational slump which toes into the truck road and below on the flood plain of the watercourse.
- Map Point C is an area of gully erosion caused from skidding down Class III watercourses. The gully running down the hill is 2-8 feet wide and about 3 feet deep exposing dark brown friable siltstone bedrock.
- The stream channels will continue to experience flushes of sediment into the watercourse from the sediment stores left with the instream logging.
- There is a substantial lack of shade producing trees and vegetation along the watercourse from the instream activities which produced broad flat landing areas. The stream channel has downcut 4-8 feet through the debris in some locations.

7. *THP 1-91-244*

This plan was located at T12N, R14W, Sections 9-11 and 14-15. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- The Registered Professional Forester has noted several slides which are debris slides and rotational slumps and debris slides lopes which are susceptble to fill and sidecast failures below the road. The non-stocked grasslands are generally the boundary of earthflows which are hummocky grass covered slopes exhibiting continued soil creep. These soils are susceptible to gully erosion along compacted surfaces such as roads and skidtrails.
- At Map Point A the ditch off of the county road has eroded a gully across the loging road: 5 feet wide and 10-15 feet deep.
- At Map Point B, the upper road concentrated water onto the fill which failed.

- At Map Point E, there is a cutbank failure of 200 feet. The cutbank exposes highly fractured gray meta-sedimentary rocks. The bank is 40 feet high and the sidecast below the road has slumped along slopes which average 75% below. The bank is unstable and will continue to fail.
- At Map Point AA, there are two fill failres which remvoed the roadbed for a distance of 180 feet. The failure is gully erosion from a concentration of water for several hundred feet along Fish Rock County Road. The slide began at the truck road as a debris slide and continued down a newly formed Class III watercourse channel as debris flow torrent.
- At Map Point BB, the fill failed on the outside edge of the road for a distance of 175 feet. there is a spring which caused the instability at the road. A rotational slide which extends upslope of the road was observed.

8. *THP 1-95-081*

This plan was located at T12N, R14W, Sections 7-8, 17, and 21. The Division of Mines and Geology and Regional Water Board inspectors noted the following features during the preharvest inspection:

- The main road from the Mendocino County Fish Rock Road leading into the harvesting units (not controlled by the landowner) was reopened during the last entries 4-5 years ago and was not adequately cross drained. One section of the road has an inside ditch running 660 feet without any relief. Several culverts were not adequately down spouted along the perched sidecast which left more gullying.
- Map Point D includes a sidecast failure along the old skidtrail.
- Map Point F is a Class III watercourse diversion along an old skidtrails and over the cutslope of an existing road. The diverted flow has eroded a large gully that has washed out a portion of the road estimated to be about 50 feet long, 10 feet wide and 5 feet deep.
- Map Point G is a debris slide/fill failure along the truck road which removed 50 feet of the road and toes into Inman Creek.

9. *THP 1-96-193*

This plan was located at T12N, R14W, Sections 16-17 and 20-21. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- Large, dormant rotational landslide features and associated disrupted ground were mapped during the field review. These features form broad concave basins with numerous active springs.
- Skidtrails on slope up to 80% and gradients up to 45% were noted.
- The section of Inman Creek between crossing 9 and 19 was lined with boulders and was oversteepened. There was evidence of an old truck road and crossings along the channel and

there was a noticeable lack of overstory vegetation. However, there was good channel complexity with pools and overhanging banks made of large woody debris and rocks.

The Regional Water Board inspector noted the following features during the preharvest inspection:

- At crossing 19, there were numerous fish, probably young of the year steelhead.
- At crossing 17, there were vertical banks at the Class II crossing. Seepage from an upslope cutbank was flowing down into the watercourse causing the fill to slump into a position to enter the watercourse.

Channel Morphology

Slope

According to the measurements collected from the Zeni Ridge and McGuire Ridge U.S. Geological Survey 7.5 minute topographic maps, the channel slope ranges from <1 to 3% from its mouth to its upper fork. The southern branch of the upper fork ranges in slope from 4-5% in its lower reach to 8-10% in its mid reach to greater than 20% in its upper reach. The northern branch of the upper fork ranges in slope from 2-3% in its lower reach to 10-15% in its mid reach to greater than 20% in its upper reach. A tributary to the northern branch ranges in slope from 6-7%. The North Fork Inman Creek ranges in slope from 2-3% in its lower reach and 8-10% up past its confluence with Pepperwood Creek. Pepperwood Creek ranges in slope from 2-3% for most of its length with its upper reach ranging from 7-8% slope.

Substrate Composition

In 1994, a consultant to Coastal Forestlands, Ltd. measured the particle size distribution of substrate at two stations on Inman Creek. Four McNeil cores were collected from each of the two stations, both located at pool/riffle crests at the mouth of Inman Creek. The consultant found that the substrate at Station 1 was composed of 16.6% fines <0.85 mm (very fine sand). Fines at Station 2 averaged 15.2%. The average percentage of fines from the two stations was 15.8%. She also found that 38.5% of the substrate material at Station 1 was less than or equal 2 mm (sand) and 75.9% was less than or equal to 8 mm (medium gravel). At Station 2, she found that 34.4% of the substrate material was less than or equal to 2 mm (sand) and 67.5% was less than or equal to 8 mm (medium gravel). The average percentage of sand from the two stations was 36.5% and the average percentage of medium gravel was 71.7%. The geometric mean particle size at Station 1 ranged from 4.2 to 6.4 mm with an average of 5.3 mm (fine gravel). The geometric mean particle size at Station 2 ranged from 4.7 to 10.4 mm with an average of 6.7 mm (fine gravel). The average geometric mean particle size from the two stations was 6.0 mm (fine gravel).

In 1995, a consultant to Coastal Forestlands, Ltd. again measured the particle size distribution at the mouth of Inman Creek. Data is reported as part of Timber Harvest Plan 1-96-337 MEN. However, the THP does not indicate whether the graphically presented data represents the results from Station 1, Station 2, or an average of the 2. The graph indicates that the substrate was composed of 12.8% fines <0.85 mm (very fine sand). It also indicates that 27.2% of the substrate material was composed of particles less than or equal to 2 mm (sand) and 46.3% of the substrate material was composed of particles less than or equal to 8 mm (medium gravel). Though the geometric mean particle size was not indicated as part of the reported data, the percent fines appear to have dropped dramatically as compared to the 1994 data.

The section in Timber Harvest Plan 1-96-337 MEN entitled Watercourse Condition reports the following observations:

< Some aggradation of substrate was observed, but not at excessive levels.
< Embeddedness of substrate was checked at various sites during the surveys and ranged from 40 to 80 percent.
< No signs of scouring were observed other than at erosional sites shown on the geological hazard map.
< No sign of excessive pool filling was noted.

At the April 17, 1997 Limiting Factors meeting it was noted that instream structures installed in 1995 were buried by sediment during the storms of 1995-96.

Coastal Forestlands, Ltd. reported in its *Watershed and Aquatic Habitat Assessment* (1997): 1) a D16 ranging from approximately 5-8 mm in diameter, 2) a D50 ranging from approximately 30-35 mm in diameter, and 3) a D84 ranging from approximately 70-100 mm in diameter. Particles less than 2 mm ranged from approximately 6-13%.

Width/depth Ratio

Coastal Forestlands, Ltd. reports in its *Watershed and Aquatic Habitat Assessment* (1997) bankfull widths and depths at three stations surveyed in Inman Creek. The bankfull width at each of the three stations was 39 feet whereas the bankfull depths were 3.1, 3.2 and 5.1 feet, respectively. The calculated width/depth ratio ranges from 12.6 to 7.6.

Confinement

At the April 17, 1997 Limiting Factors meeting it was estimated that Inman Creek is moderately confined. Coastal Forestlands, Ltd. reports in *its Watershed and Aquatic Habitat Assessment* (1997) that the confinement measurements collected in Inman Creek range from 1.0

to 3.5. Confinement measurements between 2 and 4 are characterized as moderately confined. Confinement measurements less than 2 are characterized as confined.

Bankfull Discharge

At the April 17, 1997 Limiting Factors meeting, it was estimated that the summer flows in Inman Creek are approximately 1.5 cfs, on average and the winter flows are anywhere from 26-32 cfs. See Flows, above.

Aquatic Habitat

Habitat Types and Distribution

In a grant proposal for restoration work to be conducted in 1990 on Inman Creek, New Growth Forestry reported the following observations:

< The north branch of the northern-most tributary contains excellent salmonid habitat: almost continuous full canopy, pools and riffles, gentle gradient, and clean gravels, suitable for both coho and steelhead. The south branch of the northern tributary contains suitable habitat but has a steeper gradient. The southern-most tributary contains suitable habitat and gentle gradients but has less canopy.

In a final report of its 1995 restoration work in Inman and Signal Creeks, the Mendocino Watershed Service, Inc. states that Inman Creek is lacking in large woody debris structures that allow young-of-year steelhead to reach proper size before outmigration.

In Timber Harvest Plan 1-96-337 MEN, the following observations are reported:

< Embeddedness of substrate was checked at various sites during the surveys and ranged between 40 and 870 percent. The presence of button-up fry indicate that steelhead are successfully finding and utilizing available spawning sites.

< Numerous pools exist along the Class I stream. Woody debris was also the formative cause of several pools throughout the surveyed area. no sign of excessive pool filling was noted.

< Several Level I and II habitats were observed during the survey, the diversity of habitat types in conjunction with the salmonids observed, the amount and types of large and small woody debris, the number of pools (average depth approximately 2 feet) and the cover associated with them provide ample variety of shelter and feeding habitats.

< The diversity among habitat types and their respective properties indicate the abundance of suitable habitat both instream and along the riparian corridor indicate that past logging practices within the watershed have had no permanent detrimental effects upon North Fork Inman Creek.

At the April 17, 1997 Limiting Factors meeting it was noted that the spawning habitat in Inman Creek is okay.

Coastal Forestlands, Ltd. sampled three stations in Inman Creek as part of its *Watershed and Aquatic Habitat Assessment* (1997). They reported that:

- Approximately 90% of the Class I streams in Planning Watershed 113.70014 have a channel slope less than 3%. Low gradient streams are most suitable for coho salmon.
- The number of pieces of large woody debris (predominantly 0.5-1 foot in diameter) ranged from approximately 0.5 to 2.2 pieces per channel bankfull width.
- The volume of large woody debris ranged from approximately 28 to 59 cubic feet.
- The residual pool depths ranged from approximately 2.1 to 2.8 feet.
- The residual pool volume ranged from approximately 600 to 1600 cubic feet.

<u>Instream Cover</u>

At the April 17, 1997 Limiting Factors meeting, it was noted that with the exception of the upper reaches of Inman where there were log jams, most of Inman Creek has little large woody debris. Most of the cover in the stream is composed of cobble and boulder.

In Timber Harvest Plan 1-96-337 MEN, the following observation was reported:

< Several Level I and II habitats were observed during the survey, the diversity of habitat types in conjunction with the salmonids observed, the amount and types of large and small woody debris, the number of pools (average depth approximately 2 feet) and the cover associated with them provide ample variety of shelter and feeding habitats.

Coastal Forestlands, Ltd. reported in its *Watershed and Aquatic Habitat Assessment* (1997) a canopy closure at three locations on Inman Creek of approximately 24% (4% coniferous), 30% (5% coniferous), and 39% (8% coniferous).

<u>Water Temperature</u>

In 1994 and 1995, a consultant to Coastal Forestlands, Ltd. collected summer water temperatures at the mouth of Inman Creek. In 1994, the maximum day time temperatures reached approximately 76F (24C) and the maximum night time temperatures reached approximately 66F (19C). Thus, the diurnal range was approximately 10F (5C). The average summer temperature (July through September) was approximately 67F (19C). In 1995, the maximum day time temperatures reached approximately 69F (20.5C) and the maximum night time temperatures reached approximately 67F (19.3C). Thus, the diurnal range was approximately 2F (1.5C). The average summer temperature (June through September) was approximately 63F (17.5C).

Barriers

In a grant proposal for restoration work to be conducted in 1990 on Inman Creek, New Growth Forestry reported the following observations:

< There are 16 major logjam barriers and 5 additional logjams which critically impede access. A number of these logjams have triggered stream diversions which are eroding streambanks and causing significant sedimentation.

< The majority of proposed work is located in the 2 unnamed tributaries... Modification of log barriers near the mouths of these streams will restore salmonid fish access into approximately 4.5 miles of suitable spawning and nursery habitat.

The accompanying map indicates barriers at the mouth of Pepperwood Creek and on the North Fork Inman just up from its confluence with Pepperwood Creek. It also indicates barriers at the forks of the upper most tributaries on the mainstem of Inman Creek.

Population Composition and Distribution

1. *Live Population Survey Results*

On August 20, 1987, the California Department of Fish and Game conducted a population survey and found 87 steelhead per 30 meters on Inman Creek. Steelhead density was calculated at 4,698 steelhead per mile of stream. Sculpin and lamprey were also noted.

On August 25, 1994, a consultant to Coastal Forestlands, Ltd. conducted a population survey on Inman Creek in a study reach of 90.8 square meters and under 10% canopy closure. She found 0.28 steelhead trout per square meter, 0.13 3-spined stickleback per square meter, 0.01 lamprey per square meter, 0.02 Pacific giant salamander per square meter, and 0.08 yellow-legged frogs per square meter. No coho were seen.

On August 10, 1995, Louisiana-Pacific Corporation conducted a population survey at the mouth of Inman and found less than 10 young-of-year and 1+ steelhead. L-P repeated the survey on August 15, 1996 and found greater than 40 young-of-year, 1+ and 2+ steelhead. The surveyor also noted Pacific giant salamanders, stickleback, sculpin and yellow-legged frogs.

During the winter of 1995-96, Salmon Trollers Association conducted a survey of redds in Inman Creek. As part of their survey they noted no live fish. During the winter of 1996-97, they noted 1 coho.

2. *Redd Survey Results*

During the winter of 1995-96, Salmon Trollers Association conducted a survey of redds on Inman Creek. They surveyed from the mouth up 1.5 miles and found 2.0 redds per mile. During the 1996-97 survey they surveyed from the mouth up 2.0 miles and found 2.5 redds per mile.

3. *Carcass Survey Results*

During the winter of 1995-96, Salmon Trollers Association conducted a survey of redds on Inman Creek. As part of their survey they noted no carcasses. During the winter of 1996-97, they also found no carcasses.

<u>Food Supply</u>

In Timber Harvest Plan 1-96-337 MEN, a consultant to Coastal Forestlands, Ltd. reports the following observations:

- Abundant amount of large and small woody debris were observed throughout the length of Class I and Class II streams surveyed. Fish observed during the survey fled to such cover when disturbed. Macroinvertebrates were also observed utilizing the debris.

<u>Water Quality</u>

There is no known water quality data on Inman Creek.

Existing Data for
Planning Watershed 113.70020
Signal Creek Sub-basin

General Setting

Location

Planning Watershed 113.70020 contains the Signal Creek sub-basin. It is bordered on the south by Signal Ridge which separates the Garcia River basin from the Gualala River basin. The Signal Ridge Road (as depicted on the USGS map) cuts across this ridge top, originating at its intersection with Iverson Road and continuing east along the southern edge of the watershed where it exists in Ornbaun Valley. Planning Watershed 113.70020 is contained on the Zeni Ridge and McGuire Ridge U.S. Geological Survey 7.5 minute topographic map. The unit is further described by Township 12 North and Range 14 West, Sections 18-21 and 28-30. The western portion of the sub-basin is described by T 12 N, R 15 W, Sections 23-26 and 33-34.

Soils

The soils contained in Planning Watershed 113.70020 include:

- Woodin-Yellowhound complex, 30-50% and 50-75% slopes
- Yellowhound-Kibesillah complex, 9-30%, 30-50%, and 50-75%
- Ornbaun-Zeni complex, 30-50% slopes
- Yellowhound-Kibesillah-Ornbaun complex, 9-30% and 30-50% slopes
- Dehaven-Hotel complex, 50-75% slopes

Personnel at the Natural Resource Conservation Service reviewed the soil complexes and organized them into vegetative types. The vegetative types are summarized below.

Predominant Vegetation

The soils found in Planning Watershed 113.70020 are capable of supporting a redwood forest.

Land Use

Major Land Owners

According to the County Tax Assessor's rolls, the Signal Creek sub-basin is owned by 2 major industrial landowners. Coastal Forestlands, Ltd. owns 98% of the sub-basin and Louisiana-Pacific Corporation owns the remaining 2%.

Historic Land Use

The aerial photographs indicate that while there was no discernible activity near the mouth of Signal Creek by 1952, there was logging activity in the upper reaches of Signal Creek, including road building along the mainstem of Signal Creek. The 1988 photos indicate that most of the sub-basin was logged during the ensuing years, with activity in the first southern tributary of Signal Creek, most discernible. A 1959 map of Hollow Tree Lumber's ownership in the basin indicates that they owned most of the basin by that year. Presumably the logging activities seen in the 1952 aerial photographs are theirs.

In 1966, the California Department of Fish and Game published its "Stream Damage Surveys - 1966" in which it rated the tributaries of the Garcia River as severely damaged, moderately damaged, lightly damaged or undamaged. The upper reaches of Signal Creek were rated as severely damaged. The mid-reach was rated as moderately damaged. And, the lower reach was rated as lightly damaged.

At the April 17, 1997 Limiting Factors meeting it was noted that in 1992? there was a fire in the Signal Creek sub-basin. Results from Salmon Troller Association's spawning surveys indicate that the fire had little to no impact on the sediment delivery to the stream. Spawning habitat, though limited, appears to have suffered no significant changes. Similarly, there have been no significant changes in the number of redds observed since the fire.

Louisiana-Pacific Corporation in its Sustained Yield Plan estimates that its road density in the Signal Creek basin is about 2.0 miles of road per square mile of property. They report that there are no stream crossings associated with their roads nor are any of the roads within 100 feet of a stream.

Hydrology

Drainage Area

1. *Acres*

Planning Watershed 113.70020 contains 3,954 acres. Runoff through this unit originates in this unit alone. Thus, the total drainage area is 3,954 acres.

2. *Flows*

There are no flow measurements available for Planning Watershed 113.70020. However, if the discharge with a 2-year recurrence interval as measured at the USGS gaging station at Connor Hole is 14,000 cfs, and the total drainage area of Planning Watershed 113.70020 is 6.3% of the area above Connor Hole, and area is roughly proportional to flow, then the discharge with a 2-year recurrence interval in Planning Watershed 113.70020 is roughly 882 cfs.

3. *Diversions*

There are no known water diversions in Planning Watershed 113.70020.

Precipitation

According to Louisiana-Pacific Corporation's Sustained Yield Plan (1997), the mean annual precipitation in the Signal Creek sub-basin is 67 inches per year. According to the Fires Resource Assessment Program of the California Department of Forestry and Fire Protection, the average annual rainfall in the Signal Creek sub-basin is 65 inches with the exception of the most eastern ridge where the average annual rainfall is 75 inches.

Geology

Geologic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program. However, it's program did not include mapping in this planning watershed.

According to Louisiana-Pacific Corporation's *Sustained Yield Plan for Coastal Mendocino County* (1997), the strata of the Coastal Belt Franciscan are homoclinally folded, striking to the northwest and dipping moderately to steeply to the northeast except where they are disrupted near fault zones. Signal Creek flows in a predominantly northwest direction.

Geomorphic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program. However, it's program did not include mapping in this planning watershed.

According to L-P's Erosion Hazard Rating map contained in its *Sustained Yield Plan for Coastal Mendocino County* (1997), the Signal Creek sub-basin is predominantly rated with a "high" EHR. Areas of "extreme" EHR exist along the south western portion of the Signal Creek Ridge, as well as along the ridge separating Planning Watershed 113.70021 and 113.70020. There are also patches rated with a "moderate" EHR. For example, the southeastern edge of the Signal Ridge, as well as the southern ridge along the lower portion of the Signal Creek mainstem, are rated with a "moderate" EHR.

According to L-P's Shallow Landslide Potential map contained in its *Sustained Yield Plan for Coastal Mendocino County* (1997), much of the Signal Creek basin is identified as having a zero to low potential instability. Areas along the inner gorges, particularly in the basin defined by the first southern tributary to Signal Creek, indicate a chronic potential instability. Stretches along the mainstem Signal Creek, at its mouth and approximately 1 mile from the mouth are identified as having a chronic potential instability. This later site is also associated with a spring, according to the notations on the Zeni Ridge U.S. Geological Survey 7.5 minute topographic map.

In summary, L-P reports in its *Sustained Yield Plan for Coastal Mendocino County* (1996) that the shallow landsliding instability is high, the road instability is moderately high, and the hillslope instability relative hazard is high. L-P also estimates the total erosion rate in Signal Creek as 12.3 cubic yards/acre/entry. They estimate the sediment yield as 2.5 cubic yards/ acre/entry. The methods by which these cumulative ratings and figures were developed are unknown.

At the April 17, 1997 Limiting Factors meeting it was noted that the soils in this basin appear to be relatively stable, even with the number of roads that criss-cross the stream.

The Division of Mines and Geology participated in preharvest inspections in Planning Watershed 113.70020. Below are excerpts of the inspections reports written.

1. *THP 1-91-012*

This plan was located at T12N, R14W, Sections 18-19 and T12N, R15W, Sections 22-26. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- Erosion has been severe where waterbars discharge on sidecast that is perched on steep slopes below roads. Both gullies and debris flows have removed large volumes of sediment in these areas.
- The dominant unstable areas are shallow debris sliding which are associated with poor road drainage and with inner gorges along stream channels.
- Along roads such as the permanent haul road along Signal Creek, no appropriate locations to discharge water below the road were observed because of the excessive steepness of the slopes and the volume of perched sidecast.
- In Area D, the outside edge of the landing has experienced gully erosion from concentrated runoff that has been diverted over fill. Vertical edges to the gullies are continuing to expose erosive fill material.
- In Area F, the roadbed has been affected for 30 lineal feet by gullying and debris sliding of sidecast and fill. The fill was undercut by the concentration of runoff along the road which caused the debris slide.
- In Area P, there is sidecast perched along the road and several areas where waterbars have caused erosion and deposition of material into the stream.
- In Area BB, an inner gorge debris slide was noted. The bedrock exposed in this location is the highly fractured and sheared siltstone and mudtsone which is friable.
- The most visible impacts which continue to supply the watershed with fine-grained sediment include roads and landings constructed during the 1950s and 1960s. The location of the road system within the inner gorge of the Class I stream and landings within watercourses continue to impact the watershed today.

Channel Morphology

Slope

According to the measurements collected from the Zeni Ridge U.S. Geological Survey 7.5 minute topographic map, the channel slope in Signal Creek is 3-4% for the first 3 miles. It ranges from 5-6% for the next mile or so and then steepens to 10-15% in its upper reach.

According to Louisiana-Pacific's Channel Network map, the mainstem of Signal Creek is a response reach ranging in slope from 0-3%. The upper tributaries of Signal Creek are transport reaches ranging in slope from 3-20%, as are the main forks in the sub-basin defined by the first southern tributary to Signal Creek. The first order streams are predominantly source reaches with slopes exceeding 20%.

Substrate Composition

On August 19, 1987, the Department of Fish and Game conducted a stream survey. The survey reach was 98 meters long with an area of 1,011 square meters. The surveyor estimated that the substrate within the survey reach was composed of 1% sand, 13% gravel, 42% rubble, 40% boulder, and 2% bedrock.

On November 6, 1995, the Department of Fish and Game repeated the stream survey in Signal Creek. The reach was 108 meters long with an area of 1,467 square meters. In this reach (with a slope of ranging from 3-4%), the Department of Fish and Game estimated the substrate to be 5% silt, 3% sand, 25% gravel, 55% rubble, 10% boulder, and 2% bedrock.

At the April 17, 1997 Limiting Factors meeting it was noted that Signal Creek has lots of large cobble and boulder.

Coastal Forestlands, Ltd. reported in its *Watershed and Aquatic Habitat Assessment* (1997):

- D16s of approximately 5-8 mm in diameter
- D50s of approximately 35-40 mm in diameter
- D84s of approximately 130-170 mm in diameter
- 9-13% fines less than 2 mm

Width/depth Ratio

Coastal Forestlands, Ltd. sampled three stations in Signal Creek as part of its *Watershed and Aquatic Habitat Assessment* (1997). They report bankfull widths at these locations to be 39, 26, and 35 feet. They report bankfull depths at these locations to be 3.7, 2.6, and 3.3 feet, respectively. The calculated width/depth ratios for Signal Creek, then, are 7.0, 13.5, and 10.9, respectively.

Confinement

According to Louisiana-Pacific's Channel Sensitivity map contained in its Sustained Yield Plan (1997), the channels making up the Signal Creek basin are confined. At the April 28, 1997 Watershed Advisory Group meeting it was also noted that the channel appeared to be confined.

Coastal Forestlands, Ltd. reports in its *Watershed and Aquatic Habitat Assessment* (1997) confinement measurements of 1.2, 3.2, 4.1. Confinement measurements greater than 4 are characterized as unconfined. Confinement measurements between 2 and 4 are characterized as moderately confined. And, confinement measurements less than 2 are characterized as confined. According to CFL's data, all three conditions exist in Signal Creek.

According to a review of aerial photographs since 1952, the channel used to be moderately confined with a potential to meander, perhaps due to channel aggradation.

<u>Bankfull discharge</u>

See Flows, above.

Aquatic Habitat

<u>Habitat Types and Distribution</u>

On August 19, 1987, the Department of Fish and Game conducted a stream survey. The reach was 98 meters long with an area of 1,011 square meters. The habitat within the study reach was estimated to be 30% pools, 60% riffles, and 20% runs.

On November 6, 1995, the Department of Fish and Game repeated the stream survey. The reach was 108 meters long with an area of 1,467 square meters. The habitat within the study reach was estimated to be 70% pools, 15% riffles and 15% runs.

At the April 17, 1997 Limiting Factors meeting it was noted that Signal Creek has little spawning habitat.

Coastal Forestland, Ltd. reported in its *Watershed and Aquatic Habitat Assessment* (1997) that:

- Approximately 70% of the Class I streams in Planning Watershed 113.70020 have channel gradients less than 3%. Low gradient stream reaches are attractive to coho salmon.
- The pieces of large woody debris per bankfull width are approximately 5.1, 1.3, and 1.9 respectively.
- The volume of large woody debris per bankfull width is approximately 68, 65, and 64 cubic feet, respectively.
- The residual pool depths were approximately 1.4, 2.9, and 1.3 respectively.
- The residual pool volumes were approximately 100, 600, and 250 cubic feet, respectively.

Instream Cover

During the Department of Fish and Game's August 19, 1987 stream survey ,the surveyor concluded that instream objects made up the largest proportion of quality cover (rated as 90). Cover due to turbulence rated as 70, undercut banks rated as 2 and overhanging vegetation rated as 5.

During his November 6, 1995 stream survey, the surveyor concluded that instream objects made up the largest proportion of quality cover (rated as 60). Cover due to undercut banks rated at 30, turbulence rated as 15, and, overhanging vegetation rated as 10.

At the April 17, 1997 Limiting Factors meeting it was noted that there is a fair amount of boulder and sedge cover in the stream. At the April 28, 1997 Watershed Advisory Group meeting it was noted that there is not very much large woody debris in the basin to provide cover and help sort sediment particles.

Coastal Forestlands, Ltd. reported in its *Watershed and Aquatic Habitat Assessment* (1997) that the canopy closure at three locations on Signal Creek was approximately 38% (18% coniferous), 49% (7% coniferous) and 76% (6% coniferous).

The Mendocino Watershed Service installed numerous woody debris structures in the Signal Creek basin. They survived the 1995 winter storms fairly well.

Water Temperature

During his August 1987 stream survey, the surveyor measured the water temperature as 63F. During his November 1995 survey, he measured the water temperature at 54F.

At the April 17, 1997 Limiting Factors meeting it was noted that the temperatures generally appear to be good in Signal Creek.

Barriers

At the April 17, 1997 Limiting Factors meeting it was noted that fish passage on Signal Creek may extend less than 1 mile up from the mouth. At the April 28, 1997 Watershed Advisory Group meeting it was noted that there is a steep bedrock falls near the confluence with the Garcia River. It was also noted that there is a big jam in Signal Creek which could provide woody debris to build more functional habitat structures. The exact location of this jam was not identified.

Population Composition and Distribution

1. *Live Population Survey Results*

On August 19, 1987, the Department of Fish and Game conducted as stream survey. The stream reach was 98 meters long with an area of 1,011 square meters. A total of 96 young-of-year trout were counted as well as 3 1-year old steelhead. The steelhead density was calculated as 1.30 fish per square meter. The steelhead biomass was calculated at 109.09 kilograms per hectare.

During his November 6, 1995 stream survey, the surveyor counted a total of 168 young-of-year trout were counted as were 8 1-year old steelhead. Crayfish, salamanders, and frogs were also noted. The steelhead density was calculated as 1.73 fish per square meter. The steelhead biomass was calculated as 69.44 kilograms per hectare.

During the winter of 1995-96, Salmon Trollers Association conducted a spawning survey in Signal Creek. During the period from December 17, 1995 to February 8, 1996, the surveyors calculated a population density of 0.9 live fish per mile in 3.5 miles of survey up from the mouth of the stream. Of these, 2 of the fish were identified as coho.

During the winter of 1996-97, Salmon Trollers Association repeated the spawning survey in Signal Creek. Four fish were seen in the period of December to January, 2 adults and 2 grilse. These were identified as coho. Two adult fish were seen in the period from February to April. These were identified as steelhead. The densities were calculated as 1.1 and 0.6 fish per mile, respectively.

At the April 17, 1997 Limiting Factors meeting it was noted that a consultant to Coastal Forestlands, Ltd. saw juvenile coho in Signal Creek in 1992. It was also noted that Signal Creek may be suffering from a broken coho cycle.

2. *Spawning Survey Results*

During the 1995-96 spawning survey, Salmon Trollers Association calculated a density of 8.6 redds per mile.

During 1996-97 spawning survey, they counted one redd in the period from December 1996 to January 1997 and eleven redds in the period from February to April, 1997. Redd densities were calculated at 0.3 and 3.1 redds per mile, respectively.

At the April 17, 1997 Limiting Factors meeting it was noted that there are generally lots of redds in Signal Creek and they are always located in the same area.

3. *Carcass Survey Results*

During both the 1995-96 and 1996-97 spawning surveys, Salmon Trollers Association noted no carcasses.

Food Supply-- There is no known data regarding food supply in Signal Creek.

Water Quality-- There is no known water quality data in Signal Creek.

Department of Fish and Game Stream Surveys
<u>Signal Creek</u>

	1987	**1995**
Temperature (degrees F)	63 ^{o} F	54 ^{o} F
Flow (cfs)	1.46 cfs	0.75 cfs
Substrate (percent)	0% clay 0% silt 1% sand 13% gravel 42% rubble 40% boulder	0% clay 5% silt 3% sand 25% gravel 55% rubble 10% boulder
Canopy (percent)	35%	18%
Fish Habitat (percent)	30% in pools 60% in riffles 10% in runs	70% in pools 15% in riffles 15% in runs
Instream Cover (rating)	70 turbulence 90 object 2 undercut banks 5 overhanging vegetation	15 turbulence 60 objects 30 undercut banks 10 overhanging vegetation
Spawning Habitat (percent)	0%	3%
Steelhead densities (fish/m^2)	1.3 fish/m^2	1.73 fish/m^2
Steelhead biomass (kg/hectare)	109.09 kg/hectare	69.44 kg/hectare
Coho densities (fish/m^2)	0	0
Coho biomass (kg/hectare)	0	0

Existing Data for
Planning Watershed 113.70021
<u>Graphite Creek Sub-basin</u>

General Setting

Location

Planning Watershed 113.70021 contains a mid-section of the Garcia River mainstem from Blue Waterhole Creek to Signal Creek. It also includes Casper Creek, Graphite Creek and two unnamed, east side tributaries. Planning Watershed 113.70021 is found on the Eureka Hill and Zeni Ridge U.S. Geological Survey 7.5 minute topographical maps. It if further described by Township 12 North and Range 15 West, Sections 9-11, 14-17, and 21-23. See accompanying Planning Watershed base map.

Soils

The soils contained in Planning Watershed 113.70021 include:

- Squawrock-Witherell complex, 15-50%
- Gube-Garcia-Snook complex, 30-50%
- Woodin-Yellowhound complex, 30-50% and 50-75% slopes
- Yorkville-Yorktree-Squawrock complex, 30-50% slopes
- Yorkville-Squawrock-Witherell complex, 15-30% slopes
- Yorkville-Kibesillah-Ornbaun complex, 9-30%, 30-50%, and 50-75% slopes
- Ornbaun-Zeni complex, 9-30% slopes
- Dehaven-Hotel complex, 50-75% slopes

Personnel at the Natural Resources Conservation Service reviewed the soil complexes and organized them into vegetative types. The vegetative types are summarized below.

Predominant Vegetation

The soils contained in Planning Watershed 113.70021 predominantly support redwood forest with the exceptions of a large patch of oak woodland/grassland on the ridge north of Casper Creek and a small patch of chaparral at the just north of the headwaters of Graphite Creek.

Stream Class

Louisiana-Pacific Corporation in its Sustained Yield Plan (1996) reports a total of 7.4 miles of Class I stream and 4.9 miles of Class II stream in Planning Watershed 113.70021. They estimate that 2.7 miles of stream in this unit provide potential coho habitat due to their low gradient (<3%).

Land Use

Major Land Owners

According to the County Tax Assessor's rolls, there are two major land owners in this Planning Watershed. Louisiana-Pacific Corporation and Coastal Forestlands, Ltd. are both industrial timber owners. Louisiana-Pacific Corporation in its Sustained Yield Plan reports that its holdings in this planning unit include 1,050 acres or 30.7% of the unit.

Historic Land Use

The aerial photographs show no discernible activity in this planning watershed as of 1952. The activity up through 1988 is only faintly observable in the 1988 aerial photographs, with the exception of some activity on the northeast slope of Casper Creek and significant road building along the mainstem corridor and across the lower reaches of both Graphite and Casper Creek.

In 1966, the California Department of Fish and Game published its "Stream Damage Surveys - 1966" in which it rated the tributaries of the Garcia River as severely damaged, moderately damaged, lightly damaged, or undamaged. Casper Creek and Graphite Creek were identified as severely damaged. The mainstem Garcia River was identified as lightly damaged, through this planning unit.

Louisiana-Pacific Corporation in its Sustained Yield Plan estimates that the density of roads on its property in this planning watershed is 0.8 miles of road per square mile of property. They also report that there are 15 stream crossings on L-P roads in this unit. They calculate a stream crossing density of 9.2 crossings per square mile. They also report that there are 0.7 miles of roads within 100 feet of a stream. They calculate a density of 0.4 miles of roads within 100 feet of a stream per square mile of property.

Hydrology

Drainage Area

1. *Acres*

Planning Watershed 113.7021 contains 3,425 acres. Runoff through this unit originates from the 5 planning units upstream of it as well as from its own borders. The total drainage area for this unit is 34,784 acres.

2. *Flows*

There are no flow measurements available for Planning Watershed 113.70021. However, if the discharge with a 2-year recurrence interval, as measured at the USGS gaging station at Connor Hole is 14,000 cfs, and the total drainage area of Planning Watershed 113.70021 is 61.8% of the area above Connor Hole, and area is roughly proportional to flow, then the discharge with a 2-year recurrence interval in Planning Watershed 113.70021 is roughly 8,648 cfs.

Louisiana-Pacific Corporation in its Sustained Yield Plan (1996) reports a mean annual runoff volume from Planning Watershed 1130.70021 of 45.0 inches.

3. *Diversions*

There are no known water diversions in Planning Unit 113.70021. However, the 1988 aerial photographs indicate the presence of enough small orchards and fields that summer irrigation may have affected flow conditions up through that time.

Precipitation

According to Louisiana-Pacific Corporation's Sustained Yield Plan, the mean annual precipitation in Planning Watershed 113.70021 is 64 inches per year. According to the Fire Resource Assessment Program of California Department of Forestry and Fire Protection, the average annual precipitation is 65 inches.

Geology

Geologic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program. However, it's program included mapping in only a portion of this planning watershed.

According to the Division of Mines and Geology map, Planning Watershed 113.70021 is primarily set in the Coastal Belt Franciscan with a block of Franciscan Melange on the northeastern edge of the unit. Coastal Belt Franciscan is well consolidated, hard sandstone interbedded with small amounts of siltstone, mudstone and conglomerate. It is pervasively sheared; is often times highly weathered; and tends to easily disaggregate, resulting in numerous debris slides along creeks and roads within debris slide amphitheaters/slopes. Franciscan Melange is pervasively sheared sandstone, mudstone, and minor amounts of conglomerate resulting form 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. It includes exotic outcrops of limestone, chert, serpentine, and greenstone. A northwest-southeast trending lineament is noted between the two geologic formations, but its exact origin is unknown. Casper Creek flows along this margin.

Alluvial terrace deposits are noted at the mouth of Casper Creek and along the mainstem. Holocene river channel deposits are also noted along the mainstem. (Division of Mines and Geology, Watershed Mapping Program 1984, Point Arena N.E. Quadrangle).

According to Louisiana-Pacific Corporation's *Sustained Yield Plan for Coastal Mendocino County* (1997), the strata of the Coastal Belt Franciscan are homoclinally folded, striking to the northwest and dipping moderately to steeply to the northeast except where they are disrupted near fault zones. The Garcia River cuts into the Zeni Ridge (formed by the isolated block of Franciscan melange) and forms a gorge upon its entry into Planning Unit 113.70021. For the southwest-trending remainder of its course before the stream reaches the San Andreas fault zone, low-gradient the Garcia River flows within the relatively narrow valley with steep walls and Holocene alluvium deposited on its bottom.

Geomorphic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program. However, it's program included mapping in only a portion of this planning watershed.

According to the Division of Mines and Geology map, there is a translational/rotational slide in Casper Creek, as well as two earthflows and two debris flows. Several springs, active slides, and areas of disrupted ground are also noted. Much of the southwest slope-- in Coastal belt Franciscan-- is defined as a debris slide slope. That in the Franciscan Melange is not.

There is no deep-seated mass movement noted in Graphite Creek. However, several debris flows, debris slides, active slides, and areas of disrupted ground are noted. Much of the sub-basin is also defined as a debris slide slope.

A translational/rotational slide is noted on the mainstem Garcia River just below Graphite Creek. A few small debris slides are also noted.

According to L-P's *Sustained Yield Plan for Coastal Mendocino County* (1997), the southwest trending portion of the Garcia River mainstem is profusely marked by large and small debris slides occurring both in the immediate vicinity of the active channel, and on adjacent, very steep hillsides. Along the active channel, areas of instability actually form zones of instability hundreds of feet long, and include long failures along steep gulches in bends of the Garcia River.

According to L-P's Shallow Landslide Potential map contained in its *Sustained Yield Plan for Coastal Mendocino County* (1997), the inner gorges of Graphite Creek have areas of chronic potential instability, as do the inner gorges on the southwest slope of Casper Creek. Areas if chronic potential instability are also noted on the mainstem between Casper and Graphite Creeks as well as in the inner gorges of the east side tributaries.

According to L-P's Erosion Hazard Rating map contained in its *Sustained Yield Plan for Coastal Mendocino County* (1997), Casper Creek has a "moderate" EHR on its northeastern slope and a "high" EHR on its southwestern slope. Graphite Creek is predominantly rated with a "high" EHR with the exception of sections in its mid and lower reaches which are rated with an "extreme" EHR. The mainstem Garcia River, too, is predominantly rated with a "high" EHR, with the exception of that region immediately below Graphite Creek which is rated with an "extreme" EHR. The headwaters of one of the southeastern unnamed tributaries is rated with an "extreme" EHR. All else on the southeastern side is otherwise rated with a "high" EHR.

Casper Creek

Channel Morphology

1. *Slope*

The GIS calculates the channel slope in Casper Creek to range from 1-3% in its lower reach, 5-7% in its mid-reach, and 7 to greater than 20% in its upper reaches. Casper's confluence with the mainstem Garcia River results in a short, steep slope of 10-15%.

L-P has published, as part of its Sustained Yield Plan, a Channel Network map (1997). The Channel Network map identifies the mainstems of Casper Creek, Graphite Creek, and 2 east side tributaries as a transport reaches (3-20% slope) and their tributaries as source reaches (>20%).

2. *Substrate Composition*

L-P has published, as part of its Sustained Yield Plan (1997), a Channel Substrate Predicted Particle Size map. The map indicates that the particle sizes predicted in the Casper Creek channel are 128-256 mm (large cobble) from the lower reach and greater than 256 mm (boulder) elsewhere in the sub-basin. Though these predictions are based on slope and discharge, the precise method by which these figures were derived is unknown.

3. *Width/Depth Ratio*-- There are no known cross-sections or other data from which to calculate the width to depth ratios in this planning watershed.

4. *Confinement*

L-P has published, as part of its Sustained Yield Plan, a channel sensitivity map (1997). Channel sensitivity is defined by slope and confinement. Though the method by which confinement was determined is unknown, Casper Creek is identified as confined.

5. *Bankfull Discharge*-- The bankfull discharge of Casper Creek is currently unknown.

<u>Aquatic Habitat</u>

1. *Habitat Types and Distribution*

In 1995 and 1996, Louisiana-Pacific Corporation conducted a population distribution survey in Casper Creek. The habitat sequence noted in the study reach in 1995 was: pool, riffle, pool, riffle. In 1996, the sequence was: pool, pool, pool, riffle.

2. *Instream Cover* -- There is no known data regarding instream cover in Casper Creek.

3. *Water Temperatures*

In 1995 and 1996, Louisiana-Pacific Corporation conducted a population distribution survey in Casper Creek. The temperature on August 10, 1995 was 15C (59F). The temperature on August 15, 1996 was 15.5C (60F).

4. *Barriers*-- There is no known data regarding barriers in Casper Creek.

5. *Population Composition and Distribution*

In 1995 and 1996, Louisiana-Pacific Corporation conducted a population distribution survey in Casper Creek. In neither year did they find any fish. However, they noted the presence of Pacific giant salamanders and yellow-legged frogs.

6. *Food Supply*-- There is no known data regarding food supply in Casper Creek.

7. *Water Quality*-- There is no known water quality data in Casper Creek.

Graphite Creek

Channel Morphology

1. *Slope*

The GIS calculates the channel slope in Graphite Creek to range from 3-5% in its lower reach with a short, steep section ranging from 10-15%. It calculates a range of 7-10% in the mid-reach with a short, more shallow section ranging from 5-7%. It calculates a range of 15-20% in the upper reach with a short, more shallow section ranging from 10-15%. Graphite's confluence with the mainstem Garcia River results in a short, steep slope of 10-15%.

A review of the 1988 aerial photographs indicates a rather large drop-off at the mouth of Graphite Creek which may pose as a migration barrier to salmonids.

L-P has published, as part of its Sustained Yield Plan, a Channel Network map (1997). The Channel Network map identifies the mainstems of Casper Creek, Graphite Creek, and 2 east side tributaries as a transport reaches (3-20% slope) and their tributaries as source reaches (>20%).

2. *Substrate Composition*

L-P has published, as part of its Sustained Yield Plan, a Channel Substrate Predicted Particle Size map. The map indicates that the particle sizes predicted in Graphite Creek channel are greater than 256 mm (boulders) except for a very short segment at the mouth which is predicted to contain particles ranging from 128 to 256 mm (cobble). Though the predictions are based on slope and discharge, the precise method by which these figures were derived is unknown.

At the April 17, 1997 Limiting Factors meeting it was suggested that Graphite Creek probably has a fair amount of fines.

3. *Width/Depth Ratio--* There are no cross-sections or other data by which the width to depth ratio can be calculated.

4. *Confinement*

L-P has published, as part of its Sustained Yield Plan, a channel sensitivity map. Channel sensitivity is defined by slope and confinement. Though the method by which confinement was determined is unknown, Graphite Creek was identified as confined.

5. *Bankfull Discharge--* The bankfull discharge of Graphite Creek is currently unknown.

<u>Aquatic Habitat</u>

1. *Habitat Types and Distribution--* There is no known data regarding habitat types and distribution in Graphite Creek.

2. *Instream Cover*

There is no known data regarding instream cover. However, at the April 17, 1997 Limiting Factors meeting it was suggested that Graphite Creek probably has a fair amount of large woody debris.

3. *Water Temperature--* The summer temperatures in Graphite Creek are currently unknown.

4. *Barriers*

A review of the 1988 aerial photographs indicates a rather large drop off at the mouth of Graphite Creek which may pose as a barrier to migrating salmonids. At the April 28, 1997 Watershed Advisory Group meeting it was noted that a bedrock barrier exists on Graphite Creek at a location approximately where the road crosses the stream. (*Double check this).*

5. *Population Composition and Distribution*

Live Population Survey Results

From December 1996 to January 1997, the Salmon Trollers Association conducted a spawning survey of Graphite Creek up 1 mile from the mouth of the stream. They found no live fish. From February 1997 to April 1997, they repeated the survey, but only covered a 0.3 mile reach. Again, they found no live fish. Nonetheless, at the April 17, 1997 Limiting Factors meeting it was suggested that Graphite Creek could be a good coho spawning stream.

Spawning Survey Results

From December 1996 to January 1997, the Salmon Trollers Association conducted a spawning survey of Graphite Creek up 1 mile from the mouth of the stream. They found no redds. From February 1997 to April 1997, they repeated the survey, but only covered a 0.3 mile reach. Again, they found no redds.

Carcass Survey Results

From December 1996 to January 1997, the Salmon Trollers Association conducted a spawning survey of Graphite Creek up 1 mile from the mouth of the stream. They found no carcasses. From February 1997 to April 1997, they repeated the survey, but only covered a 0.3 mile reach. Again, they found no carcasses.

6. *Food Supply*-- There is no data regarding food supply in Graphite Creek.

7. *Water Quality*-- There is no water quality data in Graphite Creek.

Garcia River from Blue Waterhole Creek to Signal Creek

Channel Morphology

1. *Slope*

The GIS calculates the channel slope in the mainstem Garcia River to range from less than 1% where it enters the unit, to 3-5% just before its confluence with Casper Creek, to 10-15% at its confluence with Casper Creek, to 1-3% past its confluence with Graphite Creek, to 3-5% as it exists the unit just before its confluence with Signal Creek.

L-P has published, as part of its Sustained Yield Plan, a Channel Network map (1997). The Channel Network generally identifies the mainstem Garcia River as a response reach (<3%), with exception of a short segment beginning at Casper Creek and ending before Graphite Creek which it describes as a transport reach (3-20%). The very small tributaries to the mainstem Garcia River are all identified as sources reaches.

2. *Substrate Composition*

In 1995, a consultant to Coastal Forestlands, Ltd. collected substrate particle size distribution data from a location near the Mill D bridge on the mainstem Garcia River immediately downstream from Blue Waterhole Creek. She found that the substrate in the study reach was composed of 18.2% fines <0.85 (sand), 37% particles less than or equal to 2 mm (very fine gravel) and 61.9% particles less than or equal to 8 mm (medium gravel). The geometric mean particle size was not reported.

In 1997, as part of its Sustained Yield Plan, L-P published a Channel Substrate Predicted Particle Size map. The map indicates that the particle sizes predicted in the mainstem Garcia River channel are 8-16 mm (medium gravel) where it enters the planning unit, 16-32 mm (coarse gravel) up to its confluence with the first east side tributary, and 32-64 mm (very coarse gravel) through its length until it exists the unit. Though the predictions are based on slope and discharge, the precise method by which these figures were derived is unknown.

Coastal Forestlands, Ltd. reported in its *Watershed and Aquatic Habitat Assessment* (1997):

- A D16 of approximately 5 mm in diameter
- A D50 of approximately 35 mm in diameter
- A D84 of approximately 155 mm in diameter
- 7% fines less than 2 mm

3. *Width/Depth Ratio*

At the April 28, 1997 Watershed Advisory Group meeting it was noted that the channel in this stretch of the mainstem Garcia River is quite wide.

Coastal Forestlands, Ltd. sampled one station on the mainstem Garcia River in Planning Watershed 113.70021 as part of its *Watershed and Aquatic Habitat Assessment* (1997). CFL reported a bankfull width of 93 feet and a bankfull depth of 7.2 feet. The calculated width/depth ratio is 12.9.

4. *Confinement*

Using the 1952 and 1988 aerial photographs, the mainstem Garcia River was measured as confined through this planning watershed. L-P's Channel Sensitivity map also identifies this stream segment as confined. CFL reports a confinement measurement of 1.1 which is characterized as confined.

5. *Bankfull Discharge*-- See Flow, above.

Aquatic Habitat

1. *Habitat Types and Distribution*

Coastal Forestlands, Ltd. sampled one station on the Garcia River mainstem in this Planning Watershed as part of its *Watershed and Aquatic Habitat Assessment* (1997). They report that:

- Approximately 82% of the Class I streams in Planning Watershed 113.70021 have slopes less than 3%. Low gradient stream reaches are attractive to coho salmon.
- Canopy closure was approximately 22% with 3% attributable to coniferous species.
- The pieces of large woody debris (predominantly 0.5-1 foot in diameter) per bankfull width were approximately 0.4.
- The volume of large woody debris pre bankfull width was approximately 72 cubic feet.
- The residual pool depth was approximatley 3.7 feet
- The residual pool volume was 5,527 cubic feet

2. *Instream Cover*-- There is no known instream cover data for this stretch of the mainstem Garcia River.

3. *Water Temperature*

There is no known water temperature data for this stretch of the mainstem Garcia River. However, at the April 28, 1997 Watershed Advisory Group meeting it was noted that temperatures in this stretch of the mainstem Garcia River are fairly warm. It was mentioned, for example, that there is a lot of algae growing in this region of the river.

4. *Barriers*-- There is no known information regarding barriers on this stretch of the mainstem Garcia River.

5. *Population Composition and Distribution*

Live Population Survey Results

On August 19, 1987, the California Department of Fish and Game conducted a population survey using an electroshocking device. The survey resulted in 27 steelhead per 200 feet of surveyed stream. The density was calculated as 602 steelhead per mile of stream.

In the April 28, 1997 Watershed Advisory Group meeting it was noted that young-of-year steelhead have been observed in this stretch of the mainstem Garcia River.

Redd Survey Results

In the April 28, 1997 Watershed Advisory Group meeting, it was noted that a substantial number of redds have been seen on this stretch of the mainstem Garcia River. Lamprey redds have also been seen.

Carcass Survey Results-- There is no known carcass survey data on this stretch of the mainstem Garcia River.

6. *Food Supply*-- There is no known data regarding food supply on this stretch of the mainstem Garcia River.

7. *Water Quality*-- There is no known water quality data on this stretch of the mainstem Garcia River.

Existing Data for
Planning Watershed 113.70022
Beebe Creek Sub-basin

General Setting

Location

Planning Watershed 113.70022 contains the a middle section of the Garcia River mainstem-- that section which flows in a predominantly southwest-northeast trending valley. The unit also includes two small north-side tributaries (e.g., Beebe Creek) and 3 small south-side tributaries. Planning Watershed 113.70022 is contained on the Eureka Hill and Gualala U.S. Geological Survey 7.5 minute topographical maps. It is further defined by Township 12 North and Range 15 West, Sections 20-22, 27-29, 33-34. See the accompanying Planning Watershed base map.

Soils

The soils contained in Planning Watershed 113.70022 include:

- Yellowhound-Kibesillah-Ornbaun complex, 9-30% and 30-50% slopes
- Ornbaun-Zeni complex, 9-30% slopes
- Woodin-Yellowhound complex, 30-50% and 50-75% slopes
- Yellowhound-Kibesillah complex, 50-75% slopes
- Dehaven-Hotel complex, 50-75% slopes

Personnel from the Natural Resources Conservation Service reviewed the soil complexes and organized them into vegetative types. The vegetative types are summarized below.

Predominant Vegetation

The soils contained in Planning Watershed 113.70022 support redwood forest.

Stream Class

Louisiana-Pacific Corporation in its Sustained Yield Plan (1997) reports a total of 6.1 miles of Class I streams and 5.1 miles of Class II streams within the planning unit. They estimate that 3.0 miles of stream provide potential coho habitat due to low gradients (<3%).

Land Use

Major Land Owners

According to the County Tax Assessor's rolls, Planning Watershed 113.70022 is owned by two major landowners: Louisiana-Pacific Corporation and Coastal Forestlands, Ltd., both of them industrial timber owners. Louisiana-Pacific Corporation in its Sustained Yield Plan reports that its holdings include 243 acres in Planning Watershed 113.70022 or 9.3% of the watershed. The County Tax Assessor, via the California Department of Forestry and Fire Protection's Geographic Information System, reports their ownership as 14% of the watershed. The Air Force owns property at the top of the ridge upon which it has operated a Radar Station since the 1950s. Coastal Forestlands, Ltd. owns the largest share of property within this sub-basin.

Historic Land Use

The 1952 aerial photographs of this Planning Watershed indicate that little noticeable landuse activity had occurred prior to 1952. The 1988 aerial photographs show the tracks of timber activities and road building in the unit in the intervening years. The 1988 photos show more revegetation than in some other sub-basins. However, there are several patches of open ground indicated, probably landslide-related.

In 1966, the California Department of Fish and Game published its "Stream Damage Surveys - 1966" in which it rated the tributaries of the Garcia River as severely damaged, moderately damaged, lightly damaged or undamaged. Beebe Creek was rated as severely damage as were northwest and southwest draining tributaries to the mainstem Garcia. The Garcia River, in this unit, was rated as lightly damaged.

Louisiana-Pacific Corporation in its Sustained Yield Plan (1996) reports a road density in Planning Watershed 113.70022 of 1.78 miles of road per square mile of property. In its 1997 update, L-P reports a total of 0.8 miles of roads in Planning Watershed 113.70022 which are within 100 feet of a stream. They calculate the density as 0.2 miles of road within 100 feet of a stream per square mile of property. See the road density figures presented on the Planning Watershed base map.

Hydrology

Drainage Area

1. *Acres*

Planning Unit 113.70022 contains 2,625 acres. Runoff through this unit originates in all the upstream units, as well as in Unit 11.70022 itself. The total drainage area through Planning Unit 113.70022, therefore, is 41,409 acres.

2. *Flows*

There are no known flow measurements available for Planning Unit 113.70022. However, if the discharge with a 2-year recurrence interval as measured at the USGS gaging station at Connor Hole is 14,000 cfs, and the total drainage area of Planning Unit 113.70022 is 66.0% of the area above Connor Hole, and area is roughly proportional to flow, then the discharge with a 2-year recurrence interval in Planning Unit 113.70022 is roughly 9,233 cfs.

Louisiana-Pacific Corporation in its Sustained Yield Plan (1996) reports a mean annual runoff volume from Planning Unit 113.70022 of 37.87 inches.

3. *Diversions*-- There are no know water diversions in Planning Watershed 113.70022.

Precipitation

The mean annual precipitation in Planning Watershed 113.70022 is reported by the Fire Resource Assessment Program of the California Department of Forestry and Fire Protection as 60 inches.

Geology

Geologic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program. However, it's program included mapping in only a portion of this planning watershed.

According to the Division of Mines and Geology's mapping, Planning Unit 113.70022, specifically Beebe Creek and its neighboring northwestern tributary, are found in Coastal Belt Franciscan. Coastal Belt Franciscan is a well consolidated, hard sandstone which is interbedded with small amounts of siltstone, mudstone, and conglomerate. It is pervasively sheared and often times highly weathered. And, it tends to easily disaggregated, resulting in numerous debris slides along creeks and roads within debris slide amphitheaters/slopes. The upper ridge of this unit includes an outcrop of presumed Ohlson Ranch Formation from the Pliocene. It is a semi-consolidated marine nearshore deposit of slit, sand, and gravel lying unconformably over Franciscan rocks. The Division of Mines and Geology further notes a lineament which runs northwest-southeast through the Point Arena Air Force Station property. It is a linear feature of unknown origin.

According to Louisiana-Pacific Corporation's *Sustained Yield Plan for Coastal Mendocino County* (1997), the strata of the Coastal Belt Franciscan are homoclinally folded, striking to the northwest and dipping moderately to steeply to the northeast except where they are disrupted near fault zones. The Garcia River cuts into the Zeni Ridge (formed by the isolated block of Franciscan melange) and forms a gorge upon its entry into Planning Unit 113.70021. For the southwest-trending remainder of its course before the stream reaches the San Andreas fault zone, the low-gradient Garcia River flows within the relatively narrow valley with steep walls and Holocene alluvium deposited on its bottom.

The Division of Mines and Geology and Regional Water Board have participated in preharvest inspections in this Planning Watershed. Below are excerpts from their reports.

1. *THP 1-94-059*

This plan was located at T12N, R15W, Sections 20-21 and 28-29. The Division of Mines and Geology and Regional Water Board inspectors noted the following features during the preharvest inspection:

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

- The geologic map illustrates debris slide slopes over most of the plan, several dormant debris slides, disrupted ground, debris flow torrent tracks and small slides. These features are consistent with the observations made on the ground. Many of the slopes exposing shallow rocky surface soils include 50% and steeper exhibit active soil/rock creep. First order stream channels are often scoured either from past debris flows or instream tractor operations which took place throughout the plan. Most of the instability mapped along the stream channels can be attributed to instream landing and road construction which has caused severe sedimentation and inner gorge debris sliding.
- Sediment has risen in the channel over 8 feet just below Crossing #1.
- An old crossing of a Class III watercourse failed at Crossing #10, removing about 25 feet of road.

- At Map Point E, a debris slide covers about 100 feet of old road through deeply weathered and sheared mudstone and siltstone.
- At Map Points N and O there are old instream landings along a narrow and steep Class II watercourse channel. The channels have tens of feet of stored sediment and logs forcing the stream underground for about 100 feet. The stored sediment extends for several hundred feet and is too voluminous to remove without extreme cost and environmental damage.

Regional Water Board

- Crossing #4 was washed out by the Class II stream.
- Crossing #10 was washed out by the Class III stream.
- There is a large, old instream Class II landing with sediment/large woody debris jam.
- There is a road-related slide into Fall Creek (Beebe Creek)-- a Class II stream.
- Road reconstruction across the debris slide toes into a Class II stream.

Geomorphic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program. However, it's program included mapping in only a portion of this planning unit. Coastal Forestlands, Ltd., one of the industrial timber owner in this planning unit, may have geomorphic information relevant to this unit contained in the watershed assessment portion of its Sustained Yield Plan. As of this writing, however, neither the Watershed Assessment nor the Sustained Yield Plan has been released for public review. Louisiana-Pacific Corporation, the other industrial timber owner in the unit, has published as part of its Sustained Yield Plan, an erosion hazard rating map and shallow landslide potential map (1997).

According to the Division of Mines and Geology map, there are scattered debris slides, debris slide slopes, and disrupted ground throughout the unit. A few debris flow/torrent tracks were identified in the upper portion of the unnamed tributary northeast of Beebe Creek. Several small active slides are identified in the headwaters of Beebe. There is no deep-seated mass movement noted in the planning unit, though little of the Garcia River mainstem in the unit is mapped.

According to L-P's Sustained Yield Plan (1997), the southwest trending portion of the Garcia River mainstem is profusely marked by large and small debris slides occurring both in the immediate vicinity of the active channel, and on adjacent, very steep hillsides. Along the active channel, areas of instability actually form zones of instability hundreds of feet long, and include long failures along steep gulches in bends of the Garcia River.

According to L-P's Shallow Landslide Potential map contained in its Sustained Yield Plan (1997), the inner gorges of Beebe Creek have areas of chronic potential instability, as do the inner gorges of its neighboring tributary to the northeast. Areas of chronic potential instability are also noted on the mainstem where the Garcia River enters the unit and at other distinct locations on the northern and southern slopes.

According to L-P's Erosion Hazard Rating map contained in its Sustained Yield Plan (1997), the unit is predominantly rated as having a "high" erosion hazard rating, with the exception of the northeastern ridge which is rated with an "extreme" EHR. A section on the western ridge is rated with a moderate EHR.

Beebe Creek

Channel Morphology

1. *Slope*

According to measurements collected from the Eureka Hill U.S. Geological Survey 7.5 minute topographic map, the channel slope in Beebe Creek is approximately 13% in its lower and mid reaches and exceeds 20% in its upper reach. Louisiana-Pacific Corporation reports the slope as ranging from 7-12% in two stretches of the channel and >12% throughout the rest of its reach, including in the headwaters. L-P identifies the lower to mid reach of the stream as a transport reach and the upper portion, including its tributaries, as source reaches.

2. *Substrate Composition*

On December 21, 1989, the Department of Fish and Game conducted a stream survey on Beebe Creek. The surveyor noted that instream cover consisted of rock less than 1 foot in diameter and that the gravel and rocks were loose.

L-P has published, as part of its 1997 Sustained Yield Plan, a Channel Substrate Predicted Particle Size map. The map indicates that the predicted particle sizes in the Beebe Creek channel are greater than 256 mm (boulder) throughout the sub-basin. Though the predictions are based on slope and discharge, the precise method by which these figures were derived is unknown.

At the April 28, 1997 Watershed Advisory Group meeting, it was noted that there is a bedrock barrier near the Garcia Haul Road crossing with lots of sediment above it.

3. *Width/Depth Ratio*-- There are no known cross-sections for Beebe Creek.

4. *Confinement*

L-P has published, as part of its Sustained Yield Plan, a channel sensitivity map. Channel sensitivity is defined by slope and confinement. Though the method by which confinement was determined is unknown, Beebe Creek is identified as confined.

5. *Bankfull Discharge*

There is no known bankfull discharge measurement in Beebe Creek. However, on December 21, 1989, the Department of Fish and Game conducted a stream survey of Beebe Creek. The surveyor estimated that the flow over a pool-forming log was approximately 0.2 cfs.

Aquatic Habitat

1. *Habitat Types and Distribution*

On December 21, 1989, the California Department of Fish and Game conducted a stream survey of Beebe Creek using a Smith-Root Type VII backpack electrofisher unit. The survey covered approximately 100 feet of stream above the Garcia Haul Road crossing. The surveyor reported a 54 foot riffle above the road preceded by a 1 foot high rocky falls. Above the falls he noted a 25 foot riffle with a width ranging from 65 to 120 inches and depths ranging from 0 to 7 inches. Above the riffle he noted a 15 foot pool with widths ranging from 50 to 130 feet and depths ranging from 2 to 16 inches. The pool was formed by a fallen log of approximately 24 inches in diameter.

2. *Instream Cover*

During the December 1989 survey, the California Department of Fish and Game surveyor made note of instream cover characteristics. He reported instream cover consisting of full and partial logs and rocks, less than 1 foot in diameter. He also note an absence of cover related to stream side vegetation.

3. *Water Temperature*-- There is no known temperature data on Beebe Creek.

4. *Barriers*

At the April 28, 1997 Watershed Advisory Group meeting, it was noted that there is a bedrock barrier near the Garcia Haul Road crossing.

5. *Population Composition and Distribution*

a. Live Population Survey Results

On December 21, 1989, the Department of Fish and Game conducted a stream survey of Beebe Creek using a Smith-Root Type VII backpack electrofisher unit. The surveyor recovered 18 steelhead trout, 1 Pacific giant salamander and Dicamptodon ensatus larvae. The steelhead density is calculated as 1901 steelhead per linear mile of stream.

b. Spawning Survey Results-- There is no known redd data on Beebe Creek.

c. Carcass Survey Results-- There is no known carcass data on Beebe Creek.

6. *Food Supply*

On December 21, 1989, the Department of Fish and Game conducted a stream survey. The surveyor reported 1-3 mayflies per rock.

7. *Water Quality*-- There is no known water quality data on Beebe Creek.

Mainstem Garcia River from Signal Creek to an Unnamed Tributary

Channel Morphology

1. *Slope*

According to the GIS calculations, the mainstem Garcia River channel has a slope which is <1% as it enters the planning unit. At its confluence with Beebe Creek, the mainstem channel slope steepens slightly to range from between 1-3%. Louisiana-Pacific Corporation reports the mainstem channel slope throughout the unit as ranging from 0-3%. It also reports the mainstem as a response reach (SYP, 1997).

2. *Substrate Composition*

L-P has published, as part of its 1997 Sustained Yield Plan, a Channel Substrate Predicted Particle Size map. The map indicates that the particle sizes predicted in the mainstem Garcia River as it enters the planning unit are 64-128 mm (small cobble). At its confluence with Beebe Creek, the particle sizes predicted in the mainstem Garcia River are 32-64 mm (very coarse gravel). Though the predictions are based on slope and discharge.

Coastal Forestlands, Ltd. collected substrate data from one sampling location in this Planning Watershed as part of its *Watershed and Aquatic Habitat Assessment* (1997). CFL reports:

- A D16 of approximately 5 mm in diameter
- A D50 of approximately 25 mm in diameter
- A D84 of approximately 75 mm in diameter
- Approximately 12% fines less than 2 mm

3. *Width/Depth Ratio*

Coastal Forestlands, Ltd. measured bankfull width and depth at a location on the mainstem Garcia River within Planning Watershed 113.70022 as part of its *Watershed and Aquatic Habitat Assessment* (1997). The bankfull width was measured at 122 feet and the depth at 6.1 feet. The calculated width/depth ratio is 20.

4. *Confinement*

Using the 1952 and 1988 aerial photographs, the mainstem Garcia River was measured as confined from where it enters the planning watershed to moderately confined as it leaves the planning watershed. Louisiana-Pacific Corporation identifies the mainstem as confined for most of its length except at the meanders where the channel is reported as moderately confined. Coastal Forestlands, Ltd. reports a confinement of 1.6 in its *Watershed and Aquatic Habitat Assessment* (1997). A confinement measurement of 1.6 is characterized as confined.

5. *Bankfull Discharge*-- The bankfull discharge on the mainstem in this planning watershed is currently unknown.

<u>Aquatic Habitat</u>

1. *Habitat Types and Distribution*

There is no known data regarding habitat types and distribution on this stretch of the mainstem Garcia River. However, at the April 28, 1997 Watershed Advisory Group meeting it was noted that the mainstem is warm and wide along this stretch. The pools are not deep enough for rearing salmonids.

Coastal Forestlands, Ltd. collected a variety of information related to habitat quality as part of its *Watershed and Aquatic Habitat Assessment* (1997). For example,

- 100% of the Class I streams in Planning Watershed 113.70022 have slopes less than 3%. Low gradient stream reaches are attractive to coho salmon.
- Approximately 15% of the bankfull channel is covered by canopy. Approximately 2% of it is attributable to coniferous species.
- Approximately 0.7 pieces of large woody debris (predominantly 0.5-1 foot in diameter) were found per bankfull width.
- Approximately 100 cubic feet of large woody debris were found in the stream reach sampled (<80 cubic feet per bankfull channel).
- The residual pool depth was measured at approximately 5. 3 feet.
- The residual pool volume was measured at approximately 10,510 cubic feet.

2. *Instream Cover*

There is no known data regarding instream cover on this stretch of the mainstem Garcia River. However, at the April 18, 1997 Watershed Advisory Group meeting it was noted that the mainstem is warm and wide.

3. *Water Temperature*

The Friends of the Garcia collected water temperature data from a location near the Hot Springs Camp. The 1994 data was collected from August 24 through October 23, 1994. It indicated a maximum day time temperature of approximately 7-F (21C) and a maximum night time temperature of approximately 62F (16.5C). Thus the diurnal range was approximately 8F (4.5C). The maximum weekly average temperatures ranged from 64F (18C0 in early September to 63F (17C) in late September and well below 63F (17C) thereafter. The late summer temperatures exceeded the upper limit of the preferred coho range approximately 90% of the time.

At the April 28, 1997 Watershed Advisory Group meeting it was noted that the mainstem is warm and wide along this stretch.

4. *Barriers*

There are no known barriers on this stretch of the mainstem Garcia River.

5. *Population Composition and Distribution*

There is no known data regarding population composition and distribution on this stretch of the mainstem Garcia River. However, at the April 28, 1997 Watershed Advisory Group meeting it was noted that there is a lot of lamprey and salmonid spawning in this stretch-- but, no rearing due to the lack of pools and elevated temperatures.

6. *Food Supply*

There is no known data regarding food supply.

7. *Water Quality*

There is no known water quality data on this stretch of the Garcia River mainstem.

Existing Data for
Planning Watershed 113.70023
South Fork Garcia Sub-basin

General Setting

Location

Planning Watershed 113.70012 contains the South Fork Garcia River sub-basin, a stretch of the mainstem Garcia River and unnamed tributaries to the Garcia River located northwest and north east of the South Fork Garcia River. The planning watershed is found on the Gualala U.S. Geological Survey 7.5 minute topographic map. It is further identified by Township 12 North and Range 15 West, Sections 29-34 and T 11 N, R 15 W, Sections 3-4. The mainstem Garcia River enters the San Andreas fault zone at its confluence with the South Fork Garcia River thereby altering its directions from a predominantly southwest direction to a predominantly northwest direction. The South Fork Garcia River flows in the San Andreas fault zone in a predominantly northwest direction. This sub-basin includes several northeast-southwest trending tributaries, including Fleming Creek.

Soils

The soils contained in Planning Watershed 113.70023 include:

- Dehaven-Hotel complex, 50-75% slopes
- Irmulco-Tramway complex, 9-30% and 30-50% slopes
- Yellowhound-Kibesillah-Ornbaun complex, 9-30% and 30-50% slopes
- Bigriver loamy sand, 0-5% slopes
- Ornbaun-Zeni complex, 9-30%, 30-50% and 50-75% slopes
- Yellowhound-Kibesillah complex, 50-75% slopes
- Threechop-Ornbaun complex, 9-30% slopes
- Carlain loam, 2-9% slopes
- Iversen loam, 2-15% slopes
- Fishrock-Iverson complex, 2-15% and 15-30% slopes
- Havensneck sandy loam, 2-15% and 15-30% slopes
- Seaside-Rock outcrop complex, 5-30% slopes
- Dehaven-Hotel-Irmulco complex, 30-50% slopes

Personnel at the Natural Resources Conservation Service reviewed the soil complexes and organized them into vegetative types. A summary of the vegetative types in Planning Watershed 113.70023 is given below.

Predominant Vegetation

The soils identified in Planning Watershed 113.70023 predominantly support redwood forest. Small sections along the mainstem Garcia River have been converted to cropland and some of the northeastern facing slope along the mainstem is classified as supporting “other.” Along the western ridge, a small patch of soils supporting northern seashore vegetation and coastal cypress/pine is also noted.

Land Use

Major Land Owners

According to the County Tax Assessor’s rolls, Planning Watershed 113.70023 is predominantly owned by Louisiana-Pacific Corporation, an industrial timber owner, who owns 91% of the sub-basin.

Historic Land Use

The 1952 aerial photographs indicate no widespread land use activity in Planning Watershed 113.70023 at that time with the exception of a large ranch and orchard on the Signal Ridge Road looking down into the South Fork basin. The 1988 photos show clearcut areas, other broad areas of open land, and multiple roads and skid trails.

In 1966, the California Department of Fish and Game published its "Stream Damage Surveys - 1966" in which it rated the tributaries of the Garcia River as severely damaged, moderately damaged, lightly damaged or undamaged. The lower South Fork Garcia was rated as lightly damaged, the mid reach as moderately damaged, and the upper reach as severely damaged. Fleming Creek was rated as severely damaged. And, the "Little South Fork" was rated as severely damaged. The mainstem was rated as severely damaged in its southwest trending leg and moderately damaged in its northwest trending one.

Louisiana-Pacific Corporation in its Sustained Yield Plan reports a road density of 2.2 miles of road per square mile of property in Planning Unit 113.70023. They report the total number of stream crossings at 94 and the crossing density at 11.7 crossings per square mile. They report a total of 6.5 miles of roads within 100 feet of a stream and a density of 0.8 miles of roads within 100 feet of streams per square mile.

Hydrology

Drainage Area

1. *Acres*

Planning Watershed 113.70023 contains 5,595 acres. Runoff through this unit originates in all the units upstream of it, as well as within Planning Unit 113.70023 itself. As such, the total drainage area of Planning Unit 113.70023 is 47,004 acres.

2 *Flows*

There are no known discharge measurements for Planning Watershed 113.70023. However, if the discharge with a 2-year recurrence interval as measured at the USGS gaging station at Connor Hole is 14,000 cfs, and the total drainage area of Planning Unit 113.70023 is 74.9% of the area above the Connor Hole, and area is roughly proportional to flow, then the discharge through Planning Watershed 113.70023 is 10,481 cfs. Using a similar calculation, the bankfull flow estimated for the South Fork Garcia River is 622 cfs.

Louisiana-Pacific Corporation in its Sustained Yield Plan (1996) reports a mean annual runoff volume from Planning Unit 113.70023 of 27.80 inches.

3 *Diversions*

There are no known water diversions in Planning Watershed 113.70023.

Precipitation

Louisiana-Pacific Corporation in its Sustained Yield Plan (1997) reports the mean annual precipitation in Planning Unit 113.70023 as 53 inches. According to the Fire Resource Assessment Program of the California Department of Forestry and Fire Protection, the average annual rainfall in Planning Watershed 113.70023 is 55 inches with an annual average rainfall of 45 inches along the southwestern ridge.

Geology

Geologic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program, including the South Fork Garcia River sub-basin. Louisiana-Pacific Corporation, the major industrial timber owner in this unit, has released its Sustained Yield Plan and includes a general description of the geology in the Garcia Watershed and Wildlife Assessment Area.

According to the Division of Mines and Geology map, Planning Unit 113.70023 is predominantly Coastal Belt Franciscan material. Coastal Belt Franciscan is a well consolidated, hard sandstone which is interbedded with small amounts of siltstone, mudstone, and conglomerate. It is pervasively sheared and often times highly weathered. And, it tends to easily disaggregated, resulting in numerous debris slides along creeks and roads within debris slide amphitheaters/slopes.

The unit has several alluvial terrace deposits of the Quaternary era composed of poorly consolidated flat-lying deposits of silt, sand, and gravel elevated above the present stream channel. Such deposits are mainly seen at the confluence of the South Fork Garcia River with the mainstem and on the ridge separating the South Fork Garcia River basin and the North Fork Gualala basin. There also are deposits of alluvium of the Holocene era composed of unconsolidated silt, sand, and gravel deposited by the stream above the active channel. These deposits are most notable in the lower South Fork Garcia and along the mainstem Garcia River, particularly downstream of the South Fork Garcia. These deposits are characteristically vegetated. Then, there are stream/river channel deposits also of the Holocene era composed of silt, sand and gravel within the active stream channel. These deposits are most notable right before meanders in the mainstem Garcia.

A dramatic geologic feature associated with Planning Unit 113.70023 is the San Andreas fault. The fault is a right lateral strike-slip fault and includes a series of faults southwest of the San Andreas which run in parallel up to the ridge and Iverson Road. A San Andreas Fault gouge material is associated with the fault. It is a highly sheared, chaotic and unconsolidated mixture of various pre-Quaternary rock types. The outcrops resemble colluvium.

Louisiana-Pacific Corporation in its Sustained Yield Plan (1997) discusses the geology oft he Garcia River basin. Related to this unit, they report that "rocks of the Coastal Belt are highly sheared, and comprise structurally deformed massive, hard greywacke sandstone and shale interbedded with small amounts of limestone and pebble conglomerate. Strata are homoclinally folded, strike to the northwest, and dip moderately to steeply to the northeast except where they are disrupted near fault zones. The Garcia River cuts into the Zeni Ridge and forms a gorge upon its entry into Planning Unit 113.70021. For the southwest-trending remainder of its course before the stream reaches the San Andreas fault zone, the low gradient Garcia River flows within a relatively narrow valley with steep walls and Holocene alluvium deposits on its bottom. This several mile long channel reach is profusely marked by large and small debris slides occurring both in the immediate vicinity of the active channel, and on adjacent, very steep hillsides. Along the active channel, areas of instability actually form zones of instability hundreds of feet long, and include long failures along steep gulches in bends of the Garcia River. In the North Fork Garcia River, Rolling Brook and South Fork Garcia River planning watersheds, all southwest-flowing Garcia River tributaries, including North Fork Garcia River, deeply dissect the greywacke bedrock. They are very densely marked with small and medium size debris slides occurring in the vicinity of their V-shaped channels, and within the gorge steep sidewalls.

There the Garcia River flows within the wide valley of the San Andreas fault zone, the geomorphic setting changes. Between the two different geologic terrains on each side is a fault zone with a highly sheared Quaternary mixture of pre-Quaternary rocks. These rocks, called fault gouge, are unconsolidated and highly erosive. Flowing northward within this tectonically active zone, the Garcia Rive sinuously meanders through the thick Holocene alluvium and occasional Holocene-Pleistocene river terraces. As a result, a high natural level of channel erosion is expected."

Geomorphic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program, including the South Fork Garcia River sub-basin. Louisiana-Pacific Corporation, the major industrial timber owner in the unit, has published as part of its Sustained Yield Plan, an erosion hazard rating map and shallow landslide potential map (1997).

According to the Division of Mines and Geology map, there are many large translational/rotational slides in Planning Unit 113.70023 particularly along the southwest slope of the South Fork Garcia River and the mainstem Garcia. Two slides on the mainstem Garcia, just below the Ten Mile Cutoff Road before it intersects with Iverson Road, are particularly massive. Another such slide is seen on the east slope of the South Fork Garcia River at that location where the stream changes its course from a southwest to northwest direction. They have also mapped an earthflow on the south side of the upper reach of the South Fork Garcia.

The Division of Mines and Geology has mapped numerous debris slide through the planning unit. They are scattered throughout the upper Fleming Creek sub-basin and along the South Fork Garcia with a cluster in the upper reach of the South Fork. They are also scattered along the southwest trending section of the mainstem Garcia and clustered in the unnamed tributary to the mainstem which is located northeast of the South Fork Garcia.

The Division of Mines and Geology has mapped various debris flow/torrent tracks. For example, there are a few noted on the southwest trending section of the mainstem Garcia. Similarly, there are a few noted on the upper reach of the South Fork Garcia. Finally, there are a few noted on Fleming Creek, a couple of them specifically associated with visible debris slides. Much of the sub-basin is identified as debris slide slope.

And, the Division of Mines and Geology has mapped many small, active slides. There is, for example, a concentration of them identified on the southwest trending section of the mainstem Garcia. Similarly, there is a concentration of them identified along the upper reach of the South Fork Garcia. Finally, they are noted as scattered in Fleming Creek and along the lower and mid reaches of the South Fork Garcia River.

According to Louisiana-Pacific Corporation's Erosion hazard Rating map, most of Planning Unit 113.70023 is rated with a "high" EHR. The southwest ridge following along the South Fork and mainstem Garcia are rated with a "moderate" EHR as are the ridges separating the upper reach of the South Fork Garcia River from the unnamed tributaries to the mainstem located northeast of the South Fork. Patches of ground on the northwest slope of the upper reach of the South Fork are rated with an "extreme" EHR as are patches near the southwest ridge above Voorhees Grove.

According to L-P's Shallow Landslide Potential map, most of Planning Unit 113.70023 has no potential instability due to shallow landslides. Only small stretches along the mainstem and in inner gorges on the eastern side of the unit have chronic potential instability due to landsliding. It is unclear whether or not the model used to develop this information accounted for the massive deep-seated landsliding associated with the activity in the San Andreas Fault.

South Fork Garcia River

Channel Morphology

1. *Slope*

The GIS has calculated the channel slope of the South Fork Garcia River to range from 1-3% in the lower and mid reaches. The upper reaches are marked by a 10-15% slope at that location where the South Fork changes course from a southwest to northwest trending direction. It then flattens back out to a 1-3% slope and ranges from 5-20% until the headwaters where the slope exceeds 20%.

Louisiana-Pacific Corporation in its Sustained Yield Plan (1997) reports the lower and mid reaches of the South Fork as sloping from 0-3%. The upper reach of the South Fork is reported to slope from 0 to greater than 12% throughout its length. L-P does not report an abrupt slope change at that location where the South Fork changes course.

According to L-P's Channel Network map, the lower and mid reaches of the South Fork are a response reach, the upper reach is a transport reach and the associated first order streams are source reaches, along with the upper headwaters.

At the April 28, 1997 Watershed Advisory Group meeting it was noted that the lower reach of the South Fork has a low gradient which is insufficient for scouring. It was further noted, however, that because of the stream's low gradient, the South Fork may be the best potential coho stream in the Garcia River basin.

2. *Substrate Composition*

The Department of Fish and Game conducted stream surveys in the South Fork Garcia River in 1987, 1988, 1989, 1991, and 1992. The surveys were conducted at locations between 836 and 1004 feet from the mouth. The survey reaches were 98-106 meters long. During this time, the Department of Fish and Game observed significant changes in the substrate composition. For example, in 1987 the substrate was estimated as 1% sand, 74% gravel, and 25% rubble. In 1988, the silt and sand fraction increased slightly, the gravel fraction decreased dramatically, and the rubble fraction increased dramatically. In 1989, the clay, silt and sand fraction increased, the gravel fraction decreased dramatically and the rubble fraction decreased dramatically. In 1991, the clay, silt and sand fraction decreased, the gravel fraction increased moderately, and the rubble fraction stayed the same. Finally, in 1992, the clay, silt and sand fraction stayed the same, the gravel fraction decreased dramatically, and the rubble fraction once again increased. The results are included in the attached table.

According to Louisiana-Pacific Corporation's Channel Substrate Predicted Particle Size map, the particles in the upper reach of the South Fork should be greater than 256 mm (boulder) where as the particles in the mid reach should range from 64 mm to greater than 256 mm (cobble to boulder). The lower reach of the South Fork (such as where the Department of Fish and Game's data was collected) should range from 8 mm to greater than 256 mm (medium gravel to boulder). The method by which these predictions were made is unknown.

Louisiana-Pacific Corporation in its Sustained Yield Plan (1996) reported several substrate statistics resulting from its 1995 stream survey. For example, mean embeddedness in the South Fork Garcia was calculated as 14.5%. Mean subsurface fines were rated as a 1 (<20%).

At the April 28, 1997 Watershed Advisory Group meeting it was noted that there is lots of sediment stored in the South Fork Garcia River channel. In fact, the South Fork flow underground at several locations near its confluence with the Garcia River. The lack of particle size data was also mentioned.

3. *Width/Depth Ratio*

The Department of Fish and Game reported the mean width of its sample areas on the South Fork Garcia from 1987 through 1992 as 2.9, 3.1, 2.6, 2.6 and 2.6 meters, respectively. These measurements may correspond to the width of the active channel.

Louisiana-Pacific Corporation in its Sustained Yield Plan (1996) reports the mean bankfull width of the South Fork Garcia as 47.8 feet (approximately 14.5 meters).

The only known depth measurement in the South Fork Garcia is that collected by the Salmon Trollers Association during its 1989-90 spawning survey. They calculated a mean pool depth of 72.2 cm.

4. *Confinement*

According to Louisiana-Pacific Corporation's Channel Sensitivity map, the lower reach of the South Fork is moderately confined and the mid and upper reaches confined.

5. *Bankfull Discharge*

The bankfull discharge in the South Fork Garcia River is estimated as 622 cfs. However, as part of its stream survey, the Department of Fish and Game estimated the flow each time the surveyor was in the field. On August 17, 1987 the flow was 0.64 cfs. On October 13, 1988 the flow was 0.36 cfs. On October 19, 1989 the flow was 0.51 cfs. On October 8, 1991, the flow was 0.27 cfs. And, on October 6, 1992, the flow was 0.48 cfs. In the month of October, the flow in the South Fork Garcia ranged from 0.27-0.51 cfs from 1988 to 1992 with a mean of 0.41 cfs.

At the April 28, 1997 Watershed Advisory Group meeting it was noted that redds may fail with winter storms because of the size of flows through the South Fork basin.

Aquatic Habitat

1. *Habitat Types and Distribution*

The Department of Fish and Game conducted stream surveys on the South Fork Garcia River from 1987-1989 and 1991-1992. The survey reaches were 98-106 meters long 836-1004 square meters in area. The habitat of the survey reaches in 1987 and 1988 were estimated as 40% pools, 50% riffles and 10% runs. In 1989 the percentage of pools dropped to 25% and the percentage of riffles increased to 25%. In 1992, the percentage of pools dropped again to 20% and the percentage of riffles increased to 80%. The percentage of runs dropped in 1992 to 0. The results are included in the attached table and figure.

Louisiana-Pacific Corporation in its Sustained Yield Plan (1996) reported several habitat statistics for the South Fork Garcia resulting from its 1995 stream survey. For example, in a survey reach of 1,468 feet, L-P identified 21 distinct habitat units, including 9 pools. Pools made up 42.9% of the habitat units identified, but 22.4% of the total survey area. There were no pools with depths greater than 3 feet. The total spawning area was measured at 328 square feet or 0.5% of the overall study area.

2. *Instream Cover*

The Department of Fish and Game conducted stream surveys on the South Fork Garcia River from 1987-1989 and 1991-1992. The survey reaches were 98-106 meters long and 836-1004 square meters in area. In 1987, turbulence provided the highest rated cover with a rating of 30 and instream objects provided the second highest rated cover with a rating of 25. The mean cover rating was 6.25. In 1988, instream objects provided the highest rated cover with a rating of 80 while turbulence provided the second highest rated cover with a rating of 15. The mean cover rating was 23.8. In 1989, the cover was more diverse including turbulence, instream objects, undercut banks and overhanging vegetation. The mean cover rating was 25.3. By 1992, the most diverse and best rated cover of all survey years was noted: turbulence (60), instream objects (60), undercut banks (15) and overhanging vegetation (5). The mean cover rating was 35.

Louisiana-Pacific Corporation in its Sustained Yield Plan (1996) reported instream cover statistics resulting from its 1995 stream survey. For example, it calculated a mean shelter rating for the South Fork Garcia of 68.9. L-P also reported 20.4 key large woody debris pieces per 1,000 feet of stream.

3. *Water Temperature*

During the 1989-90 winter spawning survey: water temperature of about 7.5 degrees C

The Friends of the Garcia collected summer water temperature data using a Hobo Temp at the mouth of the South Fork Garcia River in 1995 and 1996. In 1994 and 1995, Louisiana-Pacific Corporation also collected water temperature data using StowAways at the mouth of the South Fork Garcia River.

L-P's 1994 temperature data was collected from June through September. It indicates that the maximum day time temperature was approximately 59F (15C). The maximum night time temperatures were not depicted. The mean summer temperature was approximately 56F (13C).

L-P's 1995 temperature data was collected from July through September. It indicates that he maximum day time temperature was approximately 63F (17C) and the maximum night time temperature was approximately 58F (14C). Thus the diurnal range was approximately 5F (3C). The mean summer temperature was approximately 59F (15C).

FrOG's 1995 temperature data was collected from mid July through early October. It indicates that the maximum day time temperature was approximately 62F (17C) and the maximum night time temperature was approximately 58F (14C). Thus the diurnal range was approximately 4F (3C). The average summer temperature was approximately 59F (15C). The maximum weekly average temperature ranged from approximately 57F (14C) to 59F (15C). The summer temperatures exceeded the upper limit of the coho salmon's preferred temperature range approximately 30% of the time.

At the April 28, 1997 Watershed Advisory Group meeting it was noted that the temperatures are generally good in the South Fork sub-basin because of the complex riparian vegetation.

4. *Barriers*

At the April 28, 1997 Watershed Advisory Group meeting it was noted that the South Fork Garcia River flows underground in some reaches. If winter rains do not come until very late in the season, then coho arriving in December may not be able to migrate up the South Fork Garcia for spawning. Steelhead are frequently seen pooled up on the mainstem trying to get in the South Fork and unable to because of sediment barriers.

5. *Population Composition and Distribution*

Live Population Survey Results:

The Department of Fish and Game conducted stream surveys on the South Fork Garcia River from 1987-1989 and 1991-1992. The survey reaches were 98-106 meters long and 836-1004 square meters in area. Steelhead densities ranged from 0.51 to 1.05 fish per square meter. The mean steelhead density over the 5 survey period was 0.73 fish per square meter. Steelhead biomass ranged from 16.37 to 28.74 kilograms per hectare. The mean steelhead density over the 5 year survey period was 23.26 kilograms per hectare. Coho were found in 1987 and 1988. The results are included in the attached table and figure.

On May 16, 1988 and again on May 24, 1988, the Department of Fish and Game planted Noyo River coho salmon which were raised at the Warm Springs Hatchery. On May 16 they planted 30,000 fish and on May 24 they planted 24,000 fish.

Members of Salmon Trollers Association conducted spawning surveys on the South Fork Garcia during the winters of 1989-90, 1990-91, and 1996-97. In 1989-90 they found 0.6 adult fish per mile. In 1990-91 they did not find any live fish. In 1996-97 they found 2 coho in the period of December to January (0.3 fish per mile) and 6 steelhead in the period of February to April (0.5 fish per mile).

During the years of 1994-1996, Louisiana-Pacific Corporation collected fish distribution data at three locations on the South Fork Garcia. The first station is located at the mouth of the South Fork, the second just before the northeast bend in the stream, and the third just after the northeast bend in the stream. At the first station, in 1994, L-P found 10-40 young-of-year and 1+ steelhead and less than ten 1+ coho. In 1995, it found 10-40 young-of-year and 1+ steelhead. And, in 1996, it found greater than 40 young-of year, 1+ and 2+ steelhead, as well as less than 10 young-of-year coho. At the second station, in 1994, L-P found greater than 40 young-of-year and 1+ steelhead. In 1995 and 1996, it found 10-40 young-of-year and 1+ steelhead. At the upper station, in 1994 and 1996, L-P found 10-40 young-of-year and 1+ steelhead. In 1995, it found less than ten 1+ and 2+ steelhead. L-P also saw sculpin, frogs, Pacific giant salamanders, yellow-legged frogs, and crayfish.

At the April 17, 1997 Limiting Factors meeting it was noted that the South Fork appears to support large populations of juvenile steelhead. At the April 28, 1997 Watershed Advisory Group meeting it was noted that according to the "old timers" the South Fork and the little South Fork used to be big coho producers.

Redd Survey Results:

Members of Salmon Trollers Association conducted spawning surveys on the South Fork Garcia during the winters of 1989-90, 1990-91, and 1996-97. In 1989-90 they found 9.8 redds per mile. In 1990-91 they found 0.3 redds per mile. From December 1996 through January 1997 they found 1.5 redds per mile and from February through April, 1997 they found 12 redds per mile. The redds found in December are assumed to be those of coho.

Carcass Survey Results:

Members of Salmon Trollers Association conducted spawning surveys on the South Fork Garcia during the winters of 1989-90, 1990-91, and 1996-97. In 1989-90 they found 2 steelhead carcasses. In 1990-91 and 1996-97 they did not find any carcasses.

6. *Food Supply*-- There is no known data regarding food supply in the South Fork Garcia.

7. *Water Quality*-- There is no known water quality data in the South Fork Garcia.

Fleming Creek

Channel Morphology

1. *Slope*

According to measurements taken from the Gualala U.S. Geological 7.5 minute topographic map, the slope in Fleming Creek is about 6% up to the first fork. The left fork exceeds 20% and the right fork is at about 14%. Louisiana-Pacific Corporation in its Sustained Yield Plan (1997) reports that Fleming Creek slopes at <3% at its mouth, steepens from 3-12% up to the first fork and exceeds 12% in the left fork. The first order tributaries are identified as source reaches, the forks and mainstem of Fleming are identified as transport reaches and the mouth is identified as a storage reach.

2. *Substrate Composition*

In 1987-1989 and 1991-1992, the Department of Fish and Game conducted stream surveys in Fleming Creek. The study reaches were 98 meters and ranged in area from 617 to 743 square meters. The surveyor estimated that the substrate in 1988 was 1% silt, 2% sand, 95% gravel and 2% rubble. In 1989 the sand component was estimated to have increased by 8%, the gravel to have decreased by 45% and the rubble to have increased by 38%. In 1990, a clay component was introduced, the sand component was estimated to have decreased by 9%, the gravel to have increased by 14% and the rubble to have decreased by 10%. In 1991, the clay component was absent, the gravel increased by 32%, the rubble decreased by 25% and a small boulder component was present.

According to Louisiana-Pacific Corporation's Channel Substrate Predicted Particle Size map, the particles in Fleming Creek should be greater than 256 mm (small boulder). The particles at the mouth of Fleming should ranged between 128-256 mm (large cobble). The method by which these predications were made is unknown.

The Department of Fish and Game may have collected McNeil samples at the mouth of Fleming Creek in the late 1980s. To date, the data has not been located.

At the April 17, 1997 Limiting Factors meeting it was noted that Fleming Creek is inundated with instream-stored sediment. It was also noted that there is no exposed bedrock in Fleming Creek.

3. *Width/Depth Ratio*

In 1987-1989 and 1991-1992, the Department of Fish and Game conducted stream surveys in Fleming Creek. The mean widths of the study areas ranged from 1.9 to 2.3 meters with an average of 2.1 meters. These figures may correspond to the width of the active channel.

4. *Confinement*

At the April 17, 1997 Limiting Factors meeting is was noted that Fleming Creek is well confined in its upper reaches. Louisiana-Pacific Corporation in its Sustained Yield Plan (1997) reports that Fleming Creek is confined throughout its length.

5. *Bankfull Discharge*

The bankfull discharge of Fleming Creek is currently unknown. However, the Department of Fish and Game, during its stream surveys, measured water flows in August 1987 at 0.53 cfs. They measured flows in October 1989, 1990 and 1992 ranging from 0.07 to 0.31 cfs with a mean October flow of 0.22 cfs. Fish and Game measured the flow in November 1991 at 0.16 cfs.

<u>Aquatic Habitat</u>

1. *Habitat Types and Distribution*

In 1987-1989 and 1991-1992, the Department of Fish and Game conducted stream surveys in Fleming Creek. The study reaches were 98 meters and ranged in area from 617 to 743 square meters. The surveyor estimated that 50% of the habitat, in 1987, was in pools, 30% in riffles and 20% in runs. The percentage of pools and riffles reversed in 1988. The percentage of pools further decreased in 1989. They increased slightly in 1990 and increased significantly in 1991.

2. *Instream Cover*

In 1987-1989 and 1991-1992, the Department of Fish and Game conducted stream surveys in Fleming Creek. The study reaches were 98 meters and ranged in area from 617 to 743 square meters. The surveyor rated instream cover. In general, he noted an increase in cover provided by instream objects and undercut banks. Cover provided by turbulence and overhanging vegetation has fluctuated over time.

3. *Water Temperature*

There is no known temperature data in Fleming Creek. However, at the April 17, 1997 Limiting Factors meeting it was noted that Fleming Creek as a dark, dense canopy cover-- much of it conifer-- which is likely promoting good stream temperatures.

4. *Barriers*

At the April 17, 1997 Limiting Factors meeting it was noted that there is a culvert on Fleming Creek which blocks fish passage.

5. *Population Composition and Distribution*

Live Population Survey Results:

In 1987-1989 and 1991-1992, the Department of Fish and Game conducted stream surveys in Fleming Creek. The study reaches were 98 meters and ranged in area from 617 to 743 square meters. Steelhead densities ranged form 0.10 to 1.54 fish per square meter. The mean steelhead density over a 5 year period is 0.55 fish per square meter. The steelhead biomass ranged from 5.68 to 37.11 kilograms per hectare. The mean steelhead biomass over a 5 year period is 19.91 kilograms per hectare. Coho were seen in 1988 with a density of 0.50 fish per square meter and a biomass of 19.65 kilograms per hectare.

Louisiana-Pacific Corporation collected fish distribution data on Fleming Creek in 1994 through 1996. In all years, fish were counted as sampling stations at the mouth of Fleming Creek. In 1996, data was also collected from a sampling station less than 0.5 miles up Fleming Creek. At the first station, in 1994, L-P found greater than 40 young-of-year, 1+ and 2+ steelhead. In 1995, it found 10-40 young-of-year, 1+ and 2+ steelhead. In 1996, L-P found 10-40 young-of-year and 1+ steelhead at the first station and less than 10 young-of-year and yearling fish at the upper station. In no year did L-P report seeing any coho in Fleming Creek.

There are no known redd or carcass survey results for Fleming Creek.

6. *Food Supply*-- There is in no known data regarding food supply on Fleming Creek.

7. *Water Quality*-- There is no known water quality data on Fleming Creek.

Mainstem Garcia River

Channel Morphology

1. *Slope*

The GIS calculates the stream channel slope in the mainstem Garcia as less than 1%. Louisiana-Pacific Corporation in its Sustained Yield Plan (1997) reports the channel slope as 0-3%. L-P identifies the mainstem as a response reach.

2. *Substrate Composition*

According to Louisiana-Pacific Corporation's Channel Substrate Predicted Particle Size map, the particles in the sinuous portions of the mainstem should range from 32-64 mm (very coarse gravel). The particles on the southwest trending leg of the Garcia in the section that runs fairly straight should range from 16-32 mm (coarse gravel). The particles in and around Voorhees Grove should range from 4-8 mm (fine gravel). And, the particles as the river runs through its last meander before leaving the planning unit should range from 2-32 mm (very fine to coarse gravel). The method by which these predictions were made is unknown.

At the April 17, 1997 Limiting Factors meeting its was noted that there is a lot of sediment in this stretch of the river, often forming a braided channel.

3. *Width/Depth Ratio*

There are no known cross-sections or other data from which to calculate the width to depth ratio. However, at the April 17, 1997 Limiting Factors meeting its was noted that the mainstem here has a wide channel.

4. *Confinement*

Confinement was measured on both the 1952 and 1988 aerial photographs. On the 1952 aerial photos, the stream was measured as moderately confined except for a straight-flowing section on the southwest trending leg of the mainstem. This segment was measured as confined. In the 1988, the whole mainstem channel within this planning unit was measured as moderately confined.

Louisiana-Pacific Corporation in its Sustained Yield Plan reports that the mainstem Garcia River as it runs through Planning Unit 113.70023 is moderately confined except for two segments on the southwest-trending leg of the mainstem. As the river bends sharply to the northwest and then straightens in a southwest-trending direction, L-P reports that the channel is confined. It is again confined in that reach which is predominantly straight, flowing in a southwest-trending direction.

5. Bankfull Discharge

See Flow, above.

The Department of Fish and Game conducted a stream survey between August 15 and September 8, 1967. The surveyor reported that the flow was about 20 cfs at a location 1.5 miles upstream from the mouth of the South Fork Garcia. The surveyor also predicted that the river increases to approximately 10 times its summer width and 5 times its summer depth during winter flows.

<u>Aquatic Habitat</u>

1. *Habitat Types and Distribution*

From August 15 to September 8, 1967, the Department of Fish and Game conducted a stream survey. The surveyor concluded that most of the pool habitat in the mainstem Garcia was formed from boulders or logs. It was noted at the April 17, 1997 Limiting Factors meeting that there are nice bedrock pools in this stretch of the mainstem.

2. *Instream Cover*

At the April 17, 1997 Limiting Factors meeting it was noted that the channel in this stretch of the mainstem is fairly simple with little woody debris, boulders or other instream objects providing roughness and cover.

3. *Water Temperature*

The Friends of the Garcia have collected water temperature using Hobo Temps on the mainstem Garcia River above the South Fork. The 1995 data was collected from mid July to late September. It indicates a maximum day time temperature of approximately 75F (24C) and a maximum night time temperature of 68F (20C). Thus the diurnal range is approximately 7F (4C). The maximum weekly average temperatures range from 70F (21C) in late July to 64F (17.5C) in late September. The summer temperatures exceeded the upper limit of the preferred coho range 100% of the time.

In July 1995, a consultant to Coastal Forestlands, Ltd. installed a Hobo Temp on the mainstem Garcia River just upstream of its confluence with the South Fork. While the data itself was not provided, the data sheet indicates that the water temperature on that day was 62F (17C).

4. *Barriers*-- There are no known barriers on this stretch of the mainstem.

5. *Population Composition and Distribution*

From August 15 through September 8, 1967, the Department of Fish and Game conducted as stream survey of the mainstem of the Garcia River from the South Fork to the headwaters. The surveyor concluded that the mainstem above the South Fork was not very suitable fro spawning because of the high winter flows.

At the April 17, 1997 Limiting Factors meeting it was noted that there is spawning activity in the mainstem downstream of the mouth of the South Fork. At the April 28, 1997 Watershed Advisory Group meeting it was noted that there are frequently steelhead which pool up on the mainstem at the mouth of the South Fork unable to get in due to sediment barriers.

6. *Food Supply*-- There is no known data regarding food supply in this stretch of the mainstem.

7. *Water Quality*-- There is no known water quality data in this stretch of the mainstem.

Department of Fish and Game Stream Survey Results
South Fork Garcia River

	1987	**1988**	**1989**	**1991**	**1992**
Temperature (degrees F)	62 F	54 F	51 F	59 F	54 F
Flow (cfs)	0.64 cfs	0.36 cfs	0.51 cfs	0.27 cfs	0.48 cfs
Substrate (percent)	0% clay 0% silt 1% sand 74% gravel 25% rubble 0 % boulder	0% clay 1% silt 3% sand 26% gravel 70% rubble 0% boulder	10% clay 0% silt 5% sand 50% gravel 30% rubble 5% boulder	0% clay 0% silt 2% sand 67% gravel 30% rubble 1% boulder	0% clay 0% silt 2% sand 30% gravel 68% rubble 0% boulder
Canopy (percent)	75%	95%	65%	90%	90%
Fish Habitat (percent)	40% pools 50% riffle 10% run	40% pools 50% riffle 10% run	25% pools 65% riffle 10% run	25% pools 65% riffle 10% run	20% pools 80% riffle 0% run
Instream Cover (rating)	30 turbulence 25 objects 0 undercut 0 vegetation	15 turbulence 80 objects 0 undercut 0 vegetation	50 turbulence 30 objects 20 undercut 1 vegetation	5 turbulence 50 objects 1 undercut 1 vegetation	60 turbulence 60 objects 15 undercut 5 vegetation
Spawning Habitat (percent)	15%	20%		50%	80%
Steelhead densities (fish/m^2)	1.05 fish/m^2	0.51 fish/m^2	0.65 fish/m^2	0.85 fish/m^2	0.57 fish/m^2
Steelhead biomass (kg/hectare)	23.20 kg/hectare	16.37 kg/hectare	27.28 kg/hectare	28.74 kg/hectare	20.71 kg/hectare
Coho densities (fish/m^2)	0.12 fish/m^2	0.52 fish/m^2	0	0	0
Coho biomass (kg/hectare)	3.48 kg/hectare	19.88 kg/hectare	0	0	0

Department of Fish and Game Stream Survey Results

Fleming Creek

	1987	**1988**	**1989**	**1990**	**1991**
Temperature (degrees F)	60 degrees F	54 degrees F	51 degrees F	51 degrees F	54 degrees F
Flow (cfs)	0.53 cfs	0.29 cfs	0.31 cfs	0.16 cfs	0.07 cfs
Substrate (percent)		0% clay 1% silt 2% sand 95% gravel 2% rubble 0% boulder	0% clay 0% silt 10% sand 50% gravel 40% rubble 0% boulder	5% clay 0% silt 1% sand 64% gravel 30% rubble 0% boulder	0% clay 0% silt 2% sand 92% gravel 5% rubble 1% boulder
Canopy (percent)	85%	98%	75%	85%	98%
Fish Habitat (percent)	50% pools 30% riffle 20% run	30% pools 50% riffle 20% run	15% pools 75% riffle 10% run	20% pools 60% riffle 20% run	50% pools 40% riffle 10% run
Instream Cover (rating)	30 turbulence 30 objects 15 undercut 1 vegetation	15 turbulence 25 objects 10 undercut 2 vegetation	50 turbulence 35 objects 5 undercut 15 vegetation	30 turbulence 60 objects 20 undercut 10 vegetation	40 turbulence 60 objects 20 undercut 5 vegetation
Spawning Habitat (percent)	5%	15%	20%	10%	10%
Steelhead densities (fish/m^2)	1.54 fish/m^2	0.22 fish/m^2	0.57 fish/m^2	0.32 fish/m^2	0.10 fish/m^2
Steelhead biomass (kg/hectare)	37.11 kg/hectare	10.35 kg/hectare	24.62 kg/hectare	21.80 kg/hectare	5.68 kg/hectare
Coho densities (fish/m^2)	0	0.50 fish/m^2	0	0	0
Coho biomass (kg/hectare)	0	19.65 kg/hectare	0	0	0

Existing Data for
Planning Unit 113.70024
Rolling Brook Sub-basin

General Setting

Location

Planning Watershed 113.70024 is a unit of the mainstem Garcia River and includes the Mill Creek, Rolling Brook, Lee Creek and Hutton Gulch drainages. It is included on the Eureka Hill U.S. Geological Survey 7.5 minute topographic map. And, it is further described by Township 12 North and Range 15 West, Sections 7, 17-20, and 29-30 and T 12 N, R 16 W, Sections 9-15 and 22-26. The Garcia River mainstem flows in a predominantly southwest direction prior to its final turn towards the west before flowing to the ocean.

Soils

The soils contained in Planning Watershed 113.70024 include:

- Ornbaun-Zeni complex, 9-30% and 50-75% slopes
- Yellowhound-Kibesillah complex, 50-75% slopes
- Yellowhound-Kibesillah-Ornbaun complex, 9-30% and 30-50% slopes
- Irmulco-Tramway complex, 9-30%, 30-50%, and 50-75% slopes
- Dehaven-Hotel complex, 50-75% slopes
- Bigriver loamy sand, 0-5% slopes
- Vandamme-Caspar complex, 2-15% slopes
- Iversen loam, 2-15% slopes
- Woodin-Yellowhound complex, 30-50% and 50-75% slopes
- Pardaloe-Woodin complex, 3-50% slopes
- Tropaquepts, 0-15% slopes
- Fishrock-Iversen complex, 2-15% slopes
- Threechop-Ornbaun complex, 9-30% slopes
- Shinglemill-Gibney complex, 2-9% slopes
- Dehaven-Hotel-Irmulco complex, 30-50%
- Havensack-Seaside complex, 5-30% slopes

Personnel at the Natural Resources Conservation Service reviewed the soil complexes and organized them into vegetative types. A summary of the vegetative types found in Planning Watershed 113.70024 is given below.

Predominant Vegetation

The soils identified in Planning Watershed 113.70024 predominantly support redwood forests. Land along the mainstem Garcia River in this Planning Watershed have been converted for cropland or pasture and the vegetation supported by the soils on the northeastern facing slope of the Garcia River is classified by the Natural Resource Conservation Service as “other” with some coastal cypress/pine at the ridge top.

Land Use

Major Land Owners

According to the County Tax Assessor’s rolls, there are three major landowners in Planning Watershed 113.70024. They are all industrial timber companies: Louisiana-Pacific Corporation (55% of the sub-basin), Coastal Forestlands, Ltd. (7% of the sub-basin), and Georgia-Pacific Corporation (7% of the sub-basin). The rest is owned by small, individual landowners.

Historic Land Use

The aerial photographs indicate that by 1952 there had already been a significant amount of land clearing, particularly along the Ten Mile Cutoff Road on the southwest ridge and along the Garcia mainstem. These areas are dotted with ranches and orchards. The Eureka Hill Road is also a prominent feature on the 1952 photos. Logging in parcels along the road on both sides of the river are discernible from the photos, as well as on top of the hill surrounding the Air Force Station. According to a 1964 Hollow Tree Lumber Company ownership map, Holm Timber Industries owned the property on the mainstem whereas Hollow Tree Lumber Company owned the property surrounding the Air Force Station.

In 1966, the California Department of Fish and Game published its "Stream Damage Surveys - 1966" in which it rated the tributaries of the Garcia River as severely damaged, moderately damaged, lightly damaged or undamaged. Mill Creek was rated as moderately damaged in its lower and mid reaches and undamaged in its headwaters. Rolling Brook was rated as severely damaged in its lower to mid reaches and undamaged in its upper reach. Hutton Gulch was rated as moderately damaged in its lower and mid reaches and lightly damaged in its upper reach. And, the mainstem was rated as lightly damaged through most of its length, but moderately damaged downstream of the Eureka Hill Bridge.

The 1988 aerial photographs indicate that this unit was extensively logged prior to 1988. Nearly all of what is now Louisiana-Pacific Corporation's property was cut-over by this time.

Hydrology

Drainage Area

1. *Acres*

Planning Watershed 113.70024 contains 7,999 acres. Runoff through this unit originates from all of the upstream planning units as well as from 113.70024, itself. Thus, the drainage area of this unit is 55,003 acres.

2. *Flows*

There are no flow measurements available for Planning Watershed 113.70024. However, if the discharge with a 2-year recurrence interval, as measured at the USGS gaging station at Connor Hole is 14,000 cfs, and the drainage area of Planning Water 113.70024 is 87.6% of the basin above Connor Hole, and area is roughly proportional to flow, then the discharge with a 2-year recurrence interval in Planning Watershed 113.70024 is roughly 12,265 cfs. Using a similar calculation, the bankfull flow in Rolling Brook is estimated at 1,695 cfs.

3. *Diversions*

According to a table included in Gualala Aggregates Sand and Gravel Project Draft Environmental Impact Report (1994), the Point Arena Air Force Station has appropriative water rights at two locations in this planning unit. One is a maximum direct diversion of 0.025 cfs from an unnamed tributary to the Garcia River. The site is located in T 12 N, R 15 W, Section 17 which is in the vicinity of Rolling Brook. The second is a maximum direct diversion of 0.130 cfs from Rolling Brook itself. The total allowable maximum direct diversion, then, is 0.155 cfs.

Precipitation

Louisiana-Pacific Corporation in its Sustained Yield Plan (1997) reports that the mean annual precipitation in this planning watershed is 53 inches per year. According to the Fire Resource Assessment Program of the California Department of Forestry and Fire Protection, the average annual rainfall in Planning Watershed 113.70024 is generally 55 inches. The average annual rainfall on the ridge above Rolling Brook is reported at 65 inches whereas the average annual rainfall on coastal side of the basin is reported as 45 inches.

Geology

Geologic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program, including the South Fork Garcia River sub-basin. Louisiana-Pacific Corporation, the major industrial timber owner in this unit, has released its Sustained Yield Plan and includes a general description of the geology in the Garcia Watershed and Wildlife Assessment Area.

According to the Division of Mines and Geology map, this planning unit is primarily defined by the San Andreas fault which forms the valley in which the mainstem Garcia River flows. The northeast side of the valley is composed of the Coastal Belt Formation of the Tertiary-Cretaceous period. It is well consolidated, hard sandstone interbedded with small amount of siltstone, mudstone and conglomerate; 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 southwest side of the valley is predominantly composed of the German Rancho Formation of the Paleocene-Eocene period. Outcropping of Anchor Bay Member, Gualala Formation (Cretaceous) and Marine Terrace Deposits (Quaternary) are also depicted.

The German Rancho Formation is consolidated, moderately hard, coarse-grained sandstone interbedded with minor mudstone and less common conglomerate; overlain in many places by undifferentiated marine terrace sands; highly sheared and colluvial in appearance near the San Andreas fault system. The Anchor Bay Member, Gualala Formation is well consolidated, silicified mudstone interbedded with smaller amounts of sandstone near the coast. The Marine Terrace Deposits are poorly to moderately consolidated deposits of marine silts, sands and quartz-rich pea gravels forming extensive flat benches paralleling the coastline. It is probably much more extensive than is mapped and is in many places overlain by unconsolidated alluvial fan/colluvial deposits. The southwest side of the valley is also defined by faults running parallel to the San Andreas fault which make up the San Andreas Fault system.

The valley bottom is composed primarily of San Andreas Fault gouge of the Quaternary period. It is highly sheared, chaotic, and unconsolidated mixture of various pre-Quaternary rock types bounded by active or inactive strands of the San Andreas fault system. In association with this are alluvial deposits of the Quaternary and Holocene described as Alluvial Terrace Deposits, Alluvium, and Stream/River Channel Deposits. These are deposits of silt, sand, and gravel both within and above the currently active channel.

Louisiana-Pacific Corporation in its Sustained Yield Plan (1997) adds to this that "Flowing northward within this tectonically active zone, the Garcia River sinuously meanders through the thick Holocene alluvium and occasional Holocene-Pleistocene river terraces. As a result, a high natural level of channel erosion is expected."

Geomorphic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program, including the South Fork Garcia River sub-basin. Louisiana-Pacific Corporation, the major industrial timber owner in the unit, has published as part of its Sustained Yield Plan, an erosion hazard rating map and shallow landslide potential map (1997).

According to the Division of Mines and Geology map, there is a massive earthflow in the Mill Creek sub-basin which appears to defined by the shape and orientation of the sub-basin. Another, much smaller earthflow, is mapped on the southwest side of the Garcia River valley, a short distance downstream of Mill Creek.

The Division of Mines and Geology has also mapped 9 translational/rotational slides on the southwest and northeast side of the mainstem. These are in addition to the translocational/rotational slides depicted on the northwest side of Rolling Brook, the northwest side of Lee Creek, and the southeast side of Hutton Gulch.

There are debris slides mapped all throughout Mill Creek, Rolling Brook, and upper Hutton Gulch. Two debris torrent tracks are noted in upper Hutton Gulch, as well. Debris slide slopes are noted along most of the tributaries. Random patches of disturbed ground are also depicted.

According to Louisiana-Pacific Corporation's Shallow Landslide Potential map contained in its Sustained Yield Plan (1997), most of this planning unit, particularly on the southwest side of the Garcia River valley, has no potential instability. The northeast side of the valley is mapped as having low potential instability. A thin band of ground in the vicinity of the San Andreas fault, itself, is mapped as having moderate to chronic instability as are the first order streams, headwall swales and inner gorges of the tributaries. The Mill Creek sub-basin is sprinkled evenly with areas of chronic potential instability while Rolling Brook has few notable patches of chronic potential instability, in addition to the inner gorge areas. The upper portion of Hutton Gulch is mapped as having nearly continuous areas of chronic potential instability all along the stream courses.

According to Louisiana-Pacific Corporation's Erosion Hazard Rating map contained in its Sustained Yield Plan (1997), the southwest side of the Garcia River valley has a predominantly "moderate" EHR with areas rated with an "extreme" EHR in seven of the southwest side tributaries. The northeast side of the Garcia River Valley is predominantly rated with a "high"

EHR, except for the ridges which are rated as "moderate." The river valley bottom is rated with a "low" EHR.

Mill Creek

Channel Morphology

1. *Slope*

The GIS calculates the slope in the lower reach of Mill Creek as somewhere in the range of 1-3%. Just below the first fork, the slope steepens to 10-15%. The western most fork flattens for a short distance from 3-5% and then steepens in a series of cascades ranging from 7-10%, 10-15% and greater than 20%. The mainstem of Mill Creek continues from this first fork at a slope of 10-15%. At the second fork, the western most tributary forms a series of cascades ranging from 7-10%, 10-15% and greater than 20%. The eastern most tributary forms a steep incline which steps from 10-15% to 15-20% and greater than 20%.

According to Louisiana-Pacific Corporation's Channel Sensitivity map contained in its Sustained Yield Plan (1997), the slope of the lower reach of Mill Creek is somewhere in the range of 3-7%. The first western fork slopes at greater than 12% as do the second western fork and the second eastern fork. The mid reach of Mill Creek has a slope somewhere in the range of 7-12%.

According to Louisiana-Pacific Corporation's Channel Network map contained in its Sustained Yield Plan (1997), Mill Creek is predominantly a transport stream with the exception of the upper reaches of each of the forks and the other first order streams which are source reaches.

2. *Substrate Composition*

On August 16, 1967, the Department of Fish and Game conducted a stream survey of Mill Creek. The surveyor noted that the substrate in the lower reach was composed of gravel with some sand. Above the first tributary, he noted rubble, boulders and bedrock.

According to Louisiana-Pacific Corporation's Channel Substrate Predicted Particle Size map contained in its Sustained Yield Plan (1997), Mill Creek is predicted to contain particles throughout its reaches which are greater than 256 mm (small boulder), with two exception areas. The lower reach of Mill Creek is predicted to contain particles ranging from 32-256 mm (very coarse gravel to large cobble) and the first tributary is predicted to contain particles ranging from 64-128 mm (small cobble). While these predictions are based on slope and discharge, the exact method by which they were determined is unknown.

At the April 28, 1997 Watershed Advisory Group meeting, it was noted that Mill Creek flows subsurface during the summer. Though the delta at its mouth this year, however, is smaller than in past years.

3. *Width/Depth Ratio*

During its August 1967 stream survey, the Department of Fish and Game surveyor estimated the average width of lower Mill Creek as 3 feet, ranging from 2-8 feet. He estimated the average depth as 4 inches, ranging from 2-60 inches.

4. *Confinement*

As a result of his August 1967 stream survey, the Department of Fish and Game surveyor described the Mill Creek sub-basin as follows: "The canyon is bowl shaped with good humus soil until the first tributary. After that, the walls steepened to form a V-shaped canyon with rocky, thin soil."

According to Louisiana-Pacific Corporation's Channel Sensitivity map contained in its Sustained Yield Plan (1997), the Mill Creek channel is confined.

5. *Bankfull Discharge*

During his August 1967 stream survey, the Department of Fish and Game surveyor estimated the stream flow as 1.5 cfs, ranging from 1-2 cfs. He further noted that with a flow rate of 1.5 cfs, Mill Creek was contributing a better-than-average summer flow to the Garcia River system.

Aquatic Habitat

1. *Habitat Types and Distribution*

The Department of Fish and Game surveyor noted in his August 16, 1967 stream survey that Mill Creek served as an important spawning and nursery stream. He observed very good spawning gravels in the lower reach up to the first tributary. He estimated that 60% of the substrate was suitable for spawning. Above the first tributary, he noted that there was fairly good gravel for approximately 0.5 miles. But, migration was impeded beyond that by a large log jam. He noted very little gravel in the second and third tributaries. He also noted a fair number of pools (approximately 25% of the stream corridor). Pools, he estimated, were about 6 feet wide by 8 feet long by 1.5-2 feet deep.

On August 2, 1996, Louisiana-Pacific Corporation conducted a population distribution survey at a sampling station at the mouth of Mill Creek. The surveyor noted the following habitat sequence in the study reach: riffle, pool, riffle, pool, riffle, pool.

2. *Instream Cover*

On August 16, 1967, during his stream survey, a surveyor for the Department of Fish and Game observed available shelter from rocks and logs in pools. He did not observe much shelter from overhanging vegetation.

3. *Water Temperature*

The stream temperature on August 16, 1967 was 58F (14C).

The Friends of the Garcia River have been collecting stream temperatures at the mouth of Mill Creek since 1995. The 1995 data was collected from mid June through early September. It indicates that the maximum day time temperature was approximately 61F (16C) and the maximum night time temperature was approximately 57F (14C). Thus, the diurnal range was approximately 4F (2C). The weekly average temperature ranged from approximately 54F (12C) to 58F (14C). Summer temperatures exceeded the upper limit of the preferred range for coho salmon approximately 10% of the time.

4. *Barriers*

According to the Department of Fish and Game stream survey conducted on August 16, 1967, the gradient is a positive barrier in the second and third tributaries. The surveyor did not see any fish in these drainages. He also noted a natural log jam forming a 5 foot falls approximately 0.5 miles up the first tributary. He also saw no fish above this point.

5. *Population Composition and Distribution*

During his August 16, 1967 stream survey, the Department of Fish and Game surveyor saw abundant juvenile steelhead-resident trout. He estimated their density at about 75-100 fish per 100 feet. They ranged in size from 2-5 inches long. Though he saw no other resident fish, he did see frogs.

On August 2, 1996, Louisiana-Pacific Corporation conducted a population distribution survey at a surveying station at the mouth of Mill Creek. The surveyor reported between 10 and 40 young-of-year and yearling fish. These were caught by electroshocking for 3.7 minutes.

6. *Food Supply*

The Department of Fish and Game surveyor noted in his August 1967 stream survey that there were many caddis fly larvae on rocks and logs-- approximately 6 per fist-sized rock.

7. *Water Quality*

There is no known water quality data on Mill Creek.

Rolling Brook

Channel Morphology

1. *Slope*

The GIS calculates the slope of the lower reach of Rolling Brook as ranging somewhere between 3-5%. It then steepens in stretch of 7-10%, 10-15% and greater than 20%. The upper reaches are not measured because they are not classified as Class I or Class II streams.

According to Louisiana-Pacific Corporation's Channel Sensitivity map contained in its Sustained Yield Plan (1997), the lower reach of Rolling Brook slopes somewhere in the range of 3-7%. It then steepens to greater than 12% in the mid reach and flattens to 7-12% in the upper reach.

The Channel Network map (SYP 1997) identifies most of the mainstem of Rolling Brook as a transport stream with the exception of a portion in the mid reach which is identified as a source reach. Most of the first order streams are identified as source reaches as are some of the lower reaches of tributaries.

2. *Substrate Composition*

On August 10, 1967, the Department of Fish and Game conducted a stream survey of Rolling Brook. The surveyor noted that the substrate was composed primarily of rubble, gravel an sand in the lower 0.75 miles.

On August 18, 1987, the Department of Fish and Game conducted another stream survey on Rolling Brook, this one more quantitative in nature. The surveyor studied a stream reach which was 98 meters long with an area of 707 square meters. In it he estimated the substrate to be 1% silt, 1% sand, 85% gravel, 10% rubble and 3% boulder.

On June 17, 1995, Louisiana-Pacific Corporation conducted habitat typing on Rolling Brook. The surveyor studied a reach of 1,263 feet (approximately 383 meters) with an area of 30,066 square feet (approximately 2,758 square meters). S/he calculated a mean % embeddedness in pool tail-outs of 18.3% and a mean subsurface percent fines of 1.83%. *(This may be a mistake).*

According to Louisiana-Pacific Corporation's Channel Substrate Predicted Particle Size map contained in its Sustained Yield Plan (1997), the predicted particles in Rolling Brook are greater than 256 mm (small boulder) with one exception. The exception is at the mouth of Rolling Brook where particles ranging from 64-128 mm (small cobble) are predicted. While the predictions are based on slope and discharge, the exact method by which these figures are derived is unknown.

3. *Width/Depth Ratio*

In its 1967 stream survey, the Department of Fish and Game estimated the average stream width as 3 feet (0.9 meters), ranging from 2-8 feet (0.6-2.4 meters). The average stream depth was estimated as 6-10 inches (15.2-25.3 cm), ranging from 3-60 inches (7.6-151.5 cm). In 1987, the Department of Fish and Game calculated the mean width of its study reach as 2.2 meters. During its 1995 habitat typing survey, Louisiana-Pacific Corporation calculated the mean bankfull width in its study reach as 22.4 feet (6.8 meters)

4. *Confinement*

In its 1967 stream survey, the Department of Fish and Game described the Rolling Brook basin. The surveyor noted that the upper 2.75 miles of the canyon is V-shaped with thin rocky soil whereas the lower 0.75 miles is U-shaped with better humus soil.

According to Louisiana-Pacific Corporation's Channel Sensitivity map contained in its Sustained Yield Plan (1997), Rolling Brook is defined as confined.

5. *Bankfull Discharge*

The Department of Fish and Game surveyor, in his August 1967 stream survey, estimated the flow at the mouth of Rolling Brook as 1.5 cfs, ranging from 1-3.5 cfs. In his 1987 stream survey, another Department of Fish and Game surveyor measured the summer flow as 0.32 cfs. Based on the flow data collected at the USGS gaging station, the estimated bankfull flow for Rolling Brook is 378 cfs.

Aquatic Habitat

1. *Habitat Types and Distribution*

The Department of Fish and Game conducted a stream survey of Rolling Brook on August 10, 1967. In his survey, the surveyor noted that the lower 0.75 miles of Rolling Brook had good spawning gravels covering at least 50% of the channel. He also noted that the lower 0.75 miles of the stream had approximately 20% of its streambed in small pools. The size of the pools were estimated as 4 feet wide by 6-8 feet long by 2-2.5 feet deep (1.2 m X 1.8-2.4 m X 0.6-0.8 m).

In August of 1987, the Department of Fish and Game surveyor described his study reach as 15% pools, 65% riffles, and 20% runs.

The Louisiana-Pacific surveyor, in June 1995, described his/her study reach as containing 14.3% pools and 0.3% spawning gravels. The rest of the habitat within the study reach was not described.

At the April 28, 1997 Watershed Advisory Group meeting, it was noted that instream structures were installed in the lower 1 mile.

2. *Instream Cover*

In its 1967 stream survey, the Department of Fish and Game concluded that the shelter in the lower 0.75 miles of the stream was fair. The surveyor noted logs and boulders in the stream, undercut banks, and a little stream-side vegetation.

In its 1987 stream survey, the Department of Fish and Game rated the cover seen in its study reach. Turbulence was given a rating of 20, instream objects a rating of 70, undercut banks a rating of 5 and overhanging vegetation a rating of 1. The mean shelter rating, then, is 24.

Louisiana-Pacific Corporation in its 1995 habitat typing survey, calculated a mean shelter rating of 105. It described this as "good."

3. *Water Temperature*

On August 10, 1967, the Department of Fish and Game measured the water temperature as 57F (14C). On August 18, 1987, the Department of Fish and Game measured the water temperature as 82F (28C). *This may be a mistake.*

The Friends of the Garcia have been collecting summer water temperature data at the mouth of Rolling Brook since 1994. The 1994 data was collected from late August through mid October. It indicates that the maximum day time temperature was approximately 65F (18C) and the maximum night time temperature was approximately 56F (13C). Thus the diurnal range was approximately 9F (5C). The weekly average temperature ranged from approximately 54F (12C) to 58F (14C). The temperatures exceeded the upper limit of the preferred range for coho salmon, approximately 20% of the time.

The 1995 data was collected from mid June through early September. It indicates that the maximum day time temperature was approximately 62F (17C) and the maximum night time temperature was approximately 58F (14C). Thus, the diurnal range was approximately 4F (3C). The weekly average temperature ranged from approximately 54F (12C) to 59F (15C). The temperatures exceeded the upper limit of the preferred range of coho salmon approximately 25% of the time.

In 1995, Louisiana-Pacific Corporation also collected summer water temperatures. Their data was collected from mid July through late September. It indicates that the maximum day time temperature was approximately 63F (17C) and the maximum night time temperature was approximately 59F (15C). Thus, the diurnal range was approximately 4F (2C). The mean summer temperature ranged from approximately 57F (14C) to 60F (16C) with an average at approximately 59F (15C). The temperature exceeded the upper limit of the preferred range for coho salmon, approximately 50% of the time. The differences between FrOG's data and L-P's is not apparent from the temperature graphs themselves. They replicate each other pretty closely. However, the statistics differ, at least in part due to the differing measurement periods.

4. *Barriers*

During his 1967 stream survey, the Department of Fish and Game surveyor noted that only small log jams were observed in the lower 0.75 miles of Rolling Brook. There were no identifiable barriers.

5. *Population Composition and Distribution*

Live Population Survey Results:

The Department of Fish and Game in its August 1967 stream survey observed approximately 25 small steelhead-resident trout per 100 feet in the lower 0.75 mile of Rolling Brook. In August 1987, another Department of Fish and Game surveyor caught by electrofishing, 97 young-of-year trout and 3 steelhead yearlings. He calculated the steelhead density as 3.47 fish per square meter. The steelhead biomass was 76.94 kilogram per hectare. No coho salmon were seen.

In the summers of 1994-1996, Louisiana-Pacific Corporation conducted electrofishing surveys on Rolling Brook. All the sampling was conducted at the mouth of Rolling Brook in 1994 and 1995. In 1996, both the sampling station at the mouth of Rolling Brook and a station approximately 0.5 miles up the stream were sampled. In both 1994 and 1995, L-P found between 10-40 young-of-year and yearling steelhead. In 1996 they found greater than 40 0+, 1+ and 2+ steelhead at the mouth and 10-40 0+ and 1+ steelhead at the upper station. They found no coho salmon.

At the April 17, 1997 Limiting Factors meeting it was noted that Brook trout used to be rumored on Rolling Brook.

There are no known redd or carcass survey results for this tributary.

6. *Food Supply*

In its August 1967 stream survey, the Department of Fish and Game reported abundant caddis fly larvae on rubble and gravel, approximately 10 per fist-size rock.

7. *Water Quality*

The Air Force is undertaking a hazardous waste cleanup at the Point Arena Air Station. One of the cleanup sites is an old landfill which appears to be leaking. Surface water data has been collected from the springs immediately downgradient of this landfill where they have found the presence of trichloroethene (TCE) up to 7.4 ppb. This spring flows into a tributary to Rolling Brook. Surface water samples collected in Rolling Brook at the Air Force pumping station indicate no TCE present. As such, the conclusion is that TCE volatilizes in its path from spring to the Rolling Brook sampling station.

Lee Creek

Channel Morphology

1. *Slope*

The GIS calculates the slope in lower Lee Creek as 5-7%. Above the lower reach, Lee Creek cascades in a series of steps ranging alternately from 10-15%, 7-10%, 10-15%, greater than 20%, 10-15%, 7-10%, and greater than 20% at the upper perennial reach.

According to Louisiana-Pacific Corporation's Channel Sensitivity map contained in its Sustained Yield Plan (1997), Lee Creek generally slopes at greater than 12% with flatter sections ranging from 7-12%.

The Channel Network map contained in L-P's Sustained Yield Plan (1997) identifies Lee Creek as a transport stream, with the exception of a section below its upper fork which is identified as a source reach. The first order streams are predominantly classified as source reaches with the exception of two south flowing tributaries which are identified as transport reaches.

2. *Substrate Composition*

On October 19, 1989, the Department of Fish and Game conducted a stream survey on Lee Creek. The study reach was 98 meters long (323 feet) with an area of 491 square meters (5,347 square feet). The surveyor estimated that the substrate was 2% sand, 18% gravel, 60% rubble, and 10% boulder.

According to Louisiana-Pacific Corporation's Channel Substrate Predicted Particle Size map contained in its Sustained Yield Plan, the particles predicted for Lee Creek are greater than 256 mm (small boulder), with the exception of a very short segment at the mouth which is predicted to have particles ranging from 16-256 mm (coarse gravel to large cobble). While the predications are based on slope and discharge, the exact method by which these figures were derived is unknown.

3. *Width/Depth Ratio*

During it 1989 stream survey, the Department of Fish and Game surveyor calculated the mean width of his study reach as 1.5 meters (5 feet).

4. *Confinement*

According to Louisiana-Pacific Corporation's Channel Sensitivity map contained in its Sustained Yield Plan (1997), Lee Creek is confined.

5. *Bankfull Discharge*

During its October 1989 stream survey, the Department of Fish and Game surveyor measured the flow as 0.22 cfs. In its 1996 population distribution survey, Louisiana-Pacific Corporation estimated the flow as less than 1.00 cfs.

Aquatic Habitat

1. *Habitat Types and Distribution*

On October 19, 1989, the Department of Fish and Game conducted a stream survey. The study reach was 98 meters (323 feet) with an area of 491 square meters (5,347 square feet). The surveyor estimated that 15% of the study reach was in pools, 84% in riffles, and 1% in runs.

At the April 28, 1997 Watershed Advisory Group meeting, it was noted that instream structures were installed on the lower 1 mile.

2. *Instream Cover*

The Department of Fish and Game surveyor, in his 1989 stream survey, rated the instream cover. He rated turbulence as 40, instream objects as 50, undercut banks as 5, and overhanging vegetation as 1.

3. *Water Temperature*

On October 19, 1989, the Department of Fish and Game measured the water temperature in Lee Creek as 55F (13C). On August 2, 1996, Louisiana-Pacific Corporation measured the water temperature as 13.5C (56F).

The Friends of the Garcia have been measuring summer water temperatures at the mouth of Lee Creek since 1994. In 1994, data was collected from late August through mid October. It indicates that the maximum day time temperature was approximately 59F (15C) and the maximum night time temperature was approximately 56F (13C). Thus, the diurnal range was 3F (2C). The weekly average temperature ranged from approximately 54F (12C) to 56F (13C). The summer temperature exceeded the upper limit of the preferred range of the coho salmon 0% of the time.

The 1995 data was collected from mid June through early September. It indicates that the maximum day time temperature was approximately 61F (16C) and the maximum night time temperature was approximately 57F (14C). Thus, the diurnal range was 4F (2C). The weekly average temperature ranged from approximately 54F (12C) to 59F (15C). The summer temperature exceeded the upper limit of the preferred range of the coho salmon approximately 5% of the time.

4. *Barriers*-- There is no data regarding barriers on Lee Creek.

5. *Population Composition and Distribution*

Live Population Survey Results:

On October 19, 1989, the Department of Fish and Game conducted a stream survey. The study reach was 98 meters (323 feet) long with an area of 491 square meters (5,347 square feet). The surveyor counted 13 young-of-year trout, only. The steelhead density was calculated as 0.31 fish per square meter. The steelhead biomass was calculated as 20.39 kilogram per hectare. *This may be a mistake.* Crayfish, salamanders and frogs were also noted.

On August 2, 1996, Louisiana-Pacific Corporation conducted some population distribution surveying. L-P did not find any fish. But, they noted Pacific giant salamanders and yellow-legged frogs.

At the April 28, 1997 Watershed Advisory Group meeting, it was noted that Nick King used to be awakened at night by coho migrating up Lee Creek.

There are no known redd or carcass survey results on Lee Creek.

6. *Food Supply*-- There is no known data regarding food supply in Lee Creek.

7. *Water Quality*-- There is no known water quality data in Lee Creek.

Hutton Gulch

Channel Morphology

1. *Slope*

The GIS calculates the lower reach of Hutton Gulch as sloping 1-3%. At about where the first ephemeral tributary enters Hutton Gulch, the stream jumps to a slope greater than 20%. The mid reach alternates in slope from 5-10%. The upper reach alternates in slope from 10 to greater than 20%.

According to Louisiana-Pacific Corporation's Channel Sensitivity map contained in its Sustained Yield Plan (1997), the lower reach of Hutton Gulch ranges from 0-3% in slope. The lower mid reach slopes from 3-7% and the mid and upper reaches slope greater than 12%.

According to the Channel Network map contained in the Sustained Yield Plan (1997), Hutton Gulch is primarily a transport stream with a short response reach in its lower reach and a short source reach near its upper reach. Most of the first order streams are identified as source reaches.

At the April 28, 1997 Watershed Advisory Group meeting, it was noted that the upper reaches of Hutton Gulch are formed by a steep gorge.

2. *Substrate Composition*

On August 15, 1967, the Department of Fish and Game conducted a stream survey. The surveyor noted that the substrate in the lower 1 mile of Hutton Gulch had gravel, fine gravel and sand.

On June 26, 1978, the Department of Fish and Game sent a memo to the California Department of Forestry regarding timber harvest plan 1-78-518MEN. In the memo, the author said that the major stream course had "V" shaped banks with a cascading stream flowing over a bottom of boulders, buried logs, silted gravels, and small log jams. A tributary was described as having a boulder/rubble substrate and an intermittent stream.

On December 11, 1986, Bill Townsend of Save Our Salmon (?) wrote a memo to Norm de Vall in which he described sediments in the stream as highly angular with a high percent of fines indicating they were of recent origin and ranged from six to ten feet in depth.

On January 22, 1987, the Department of Forestry in Ukiah wrote a memo to Richard Ernest of CDF in Santa Rosa regarding the Save Our Salmon rearing ponds. In it the author says "It is very evident that this length of drainage has been heavily impacted by past logging, as well as by natural landslides. Evidence of old skid roads and what was probably a log landing are present, and the steam is still carrying rock and sediment downstream each winter. The old trails and landing are supplying angular rock to the system each year. Numerous log jams and root wads are present on most of the stream length. Natural slides are also contributing fresh material from the very steep slopes, some of which were measured at well over 100%." It goes on to say that "the stream course is now cutting down through heavy deposits of gravel and soil. It will take a long period of time before this damage is repaired by natural processes."

According to Louisiana-Pacific Corporation's Channel Substrate Predicted Particle Size map contained in its Sustained Yield Plan (1997), the particles predicted in Hutton Gulch are predominantly greater than 256 mm (small boulder) with the exception of the lower reach of the stream which is predicted to have particles ranging from 128 to 256 mm (large cobble).

At the April 28, 1997 Watershed Advisory Group meeting, it was noted that a lot of sediment has accumulated at the mouth of Hutton Gulch since the most recent big storms.

3. *Width/Depth Ratio*

The Department of Fish and Game surveyor, in his 1967 stream survey, estimated the average width of the stream as 4.5 feet, ranging from 2-10 feet. He estimated the average depth as 3-4 inches, ranging from 2-48 inches.

4. *Confinement*

According to Louisiana-Pacific Corporation's Channel Sensitivity map contained in its Sustained Yield Plan (1997), Hutton Gulch is confined.

At the April 17, 1997 Limiting Factors meeting, it was also established that Hutton Gulch is confined.

5. *Bankfull Discharge*

During his 1967 stream survey, the Department of Fish and Game surveyor estimated the August flow at 1.7 cfs, ranging from 1-2.5 cfs.

In his memo dated December 11, 1986, Bill Townsend reported that periodically, the surface flows in Hutton Gulch go underground due to the depth of aggradation. The Department of Forestry and Fire Protection in its January 22, 1987 confirms this observation.

<u>Aquatic Habitat</u>

1. *Habitat Types and Distribution*

In August of 1967, the Department of Fish and Game conducted a stream survey in Hutton Gulch. The surveyor noted that spawning was fair throughout the lower 1 mile. Pools, too, were fair in the lower 0.3 miles. The average pool was approximately 4 feet wide by 8 feet long by 2-2.5 feet deep.

2. *Instream Cover*

During his August 1967 stream survey, the Department of Fish and Game surveyor noted that there was adequate shelter for juvenile fish. The shelter, he estimated, was poor, however, for large fish, though he predicted it would improve in high water. Most of the shelter was form logs and undercut banks. He also noted some small boulders in the streambed.

3. *Water Temperature*

In August of 1967, the Department of Fish and Game measured the water temperature as 56F (13C). In its 1978 memo to the California Department of Forestry, the California Department of Fish and Game reports that the water temperature in Hutton Gulch did not exceed 58F (14C) during 1977.

In 1995, Friends of the Garcia collected water temperatures from the mouth of Hutton Gulch. The data was collected from mid June through early September. It indicates that the maximum day time temperature was approximately 61F (16C) and the maximum night time temperature was approximately 57F (14C). Thus, the diurnal range was approximately 4F (2C). The weekly average temperature ranged from approximately 56F (13C) to 58F (14C). The summer temperature exceeded the upper limit of the preferred range of the coho salmon approximately 5% of the time.

4. *Barriers*

In its August 1967 stream survey, the Department of Fish and Game surveyor noted that there were no absolute barriers in the lower 1 mile. Above 1 miles, however, he suggested that the steep gradient may be an effective barrier.

In the Department of Fish and Game, Department of Forestry and Fire Protection and Save Our Salmon memos mentioned above, all authors noted the periodic occurrence of subsurface flows during the summer months. They also note the presence of much woody debris in the channel.

5. *Population Composition and Distribution*

The Department of Fish and Game surveyor, during his August 1967 stream survey, observed many juvenile steelhead in the lower 1 mile of Hutton Gulch. The average size, he estimated, was 3 inches, ranging from 1.5 to 5 inches. He estimated their density at 20-25 per 100 feet. As the gradient steepened, he noted, the frequency of fish declined and no fish were observed above the portion 1 mile from the mouth.

At the April 28, 1997 Watershed Advisory Group meeting, it was noted that Save Our Salmon used to raise salmonids in ponds at the mouth of Hutton Gulch in the 1970s and 1980s.

6. *Food Supply*

The Department of Fish and Game surveyor observed caddis fly larvae on rocks in Hutton Gulch. He did not estimate their density.

7. *Water Quality*-- There is no known water quality data on Hutton Gulch.

Mainstem Garcia River from Mill Creek to downstream of Hutton Gulch

Channel Morphology

1. *Slope*

According to the GIS maintained by the Department of Forestry and Fire Protection, the channel gradient of the mainstem Garcia in Planning Watershed 113.70024 is less than 1% with the exception of a reach between Rolling Brook and Mill Creek which ranges from 1-5% in slope, particularly at the mouth of Rolling Brook.

2. *Substrate Composition*

On several days during the period of December 3, 1992 through May 6, 1993, the U.S. Geological Survey measured suspended sediment loads in the Garcia River mainstem from the Eureka Hill Bridge. These measurements were collected during discharges ranging from 103 cfs to 5040 cfs. Phillip Williams and Associates analyzed the data in the Garcia River Gravel Management Plan and developed an equation which best fit the suspended sediment data. That equation is $Q_s = (0.000004) \times Q^{2.65}$ where Q is the discharge rate in cfs and Q_s is the suspended sediment load in tons per day. As an example of its meaning, when the river is flowing at 100 cfs, the equation predicts 0.8 tons per day of suspended sediment will be transported in the flow. When the river is flowing at 1000 cfs, the equation predicts approximately 357 tons per day of suspended sediment will be transported in the flow. When the river is flowing 15,000 cfs, the equation predicts approximately 466,339 tons per day of suspended sediment will be transported in the flow.

On October 23, 1992, the U.S. Geological Survey measured the surface bed material along a transect in the Garcia River from the Eureka Hill Bridge. The measurements were collected during a discharge of 15 cfs. The median particle size was approximately 7 mm (fine gravel).

On several days during the period of December 10, 1992 through February 11, 1993, the U.S. Geological Survey measured the particle distribution of bedload in the Garcia River from the Eureka Hill Bridge. These measurements were collected during discharges ranging from 571 to 5,040 cfs. The data indicates, as predicted, that larger discharges move larger particles as bedload. For example, the median particle which moved during a 571 cfs discharge was approximately 0.375 mm (medium sand). The median particle moved during a 1,180 cfs discharge was approximately 6.5 mm (fine gravel). And, the median particle moved during a 5,040 cfs discharge was approximately 8 mm (medium gravel). It is worth noting that none of these flows were as large as the dominant channel forming flow which Phillip Williams and

Associates has predicted as 15,000 cfs-- a flow with a recurrence interval of approximately once every 2 years.

From the bedload data, Phillip Williams and Associates has developed an equation which best fits the bedload data. The equation is $Q_s = (0.0000004) \times Q^{2.6}$ where Qs is bedload in tons per day and Q is discharge in cfs. The dominant channel forming flow, then, is predicted to move 28,834 tons per day of bedload.

3. *Width/Depth Ratio*

Cross-sections above and below the Eureka Hill Bridge were analyzed by Dennis Jackson, a hydrologist formerly with the Mendocino County Water Agency in a report entitled "Analysis of the 1996 Garcia River Cross Sections." Mr. Jackson concluded that from 1993 to 1995 the thalweg rose 0.6 feet, the water surface rose 0.7 feet and the low water channel widened about 12 feet. The rise in water surface shows that material was deposited on the downstream control between 1993 and 1995. The material that was deposited on the downstream control may have come from the material lost along the cross section. Between 1995 and 1996 there was minor scour across most of the low flow channel but the thalweg elevation and cross section area remounted unchanged. However, the water surface dropped 1.1 feet between 1995 and 1996 indicating that the downstream control eroded. The data from the two cross sections above and below the Eureka Hill bridge appear to support he notion that the Eureka Hill bridge is in dynamic equilibrium for the period 1993 through 1996.

4. *Confinement*

Staff at the Regional Water Board and U.S. Environmental Protection Agency measured valley width and channel width from aerial photographs and concluded that the mainstem Garcia River through Planning Watershed 113.70024 is moderately confined from its eastern border to about Lee Creek and confined from Lee Creek to a point just past Hutton Gulch. From Hutton Gulch to the western border of the Planning Watershed, the channel was measured as moderately confined.

5. *Bankfull Discharge*-- See Flow, above.

<u>Aquatic Habitat</u>

Very little aquatic habitat data is available for this reach of the mainstem Garcia River with the exception of stream temperatures. Stream temperature data collected by Friends of the Garcia indicate that summer temperatures exceed the preferred daily range for coho salmon. In addition, they often exceed the maximum weekly average temperature established to protect salmonid growth.

Existing Data for
Planning Watershed 113.70025
North Fork Garcia River Sub-Basin

General Setting

Location

Planning Watershed 113.70025 contains a segment of the Garcia River mainstem from where it exists Planning Watershed 113.70024 just east of the North Fork Garcia River to where it enters Planning Watershed 113.70026 just east of Allen Gulch and the Manchester Rancheria. Planning Watershed 113.70025 also contains the North Fork Garcia River, the largest sub-basin in the watershed, as well as numerous small tributaries, including Olsen Gulch and John Olsen Creek. Planning Watershed 113.70025 is contained on the Eureka Hill and Point Arena quadrangles of the U.S. Geological Survey's 7.5 minute topographic maps. The sub-basin is further described by ; Township 12 North, Range 15 West, Sections 3-10; Township 12 North, Range 16 West, Sections 1-12; Township 13 North, Range 15 West, Sections 31-32; and Township 13 North, Range 16 West, Sections 26 and 34-36.

Soils

The soils contained in Planning Watershed 113.70025 include:

- Yellowhound-Kibesillah-Ornbaun complex; 30-50% and 50-75% slopes
- Ornbaun-Zeni complex; 9-30%, 30-50% and 50-75% slopes
- Woodin-Yellowhound complex; 30-50%, and 50-75% slopes
- Irmaulco-Tramway complex; 9-30%, 30-50%, and 50-75% slopes
- Squawrock-Witherell complex; 15-50% slopes
- Gube-Garcia-Snook complex; 30-50% slopes
- Riverwash
- Bigriver loamy sand, 0-5% slopes
- Dehaven-Hotel complex; 50-75% slopes
- Flumeville clay loam; 2-9% slopes
- Ferncreek sandy loam; 5-15% slopes
- Yorkville-Yorktree-Squawrock complex; 30-50% slopes
- Iverson loam; 2-15% slopes
- Vandamme loam; 9-30% slopes
- Shinglemill-Gibney complex; 2-9% slopes

Personnel at the Natural Resource Conservation Service reviewed these soil complexes and organized them into vegetative types. These types are described below.

Predominant Vegetation

The soils identified in Planning Watershed 113.70025 predominantly support redwood forest with stretches of redwood-type soils converted to cropland or pasture along the mainstem and patches of chaparral and oak woodland/grassland in the upper reaches of the North Fork Garcia River sub-basin. The soils associated with Olsen Gulch and John Olsen Creek are described as "other."

Land Uses

Major Land Owners

According to the County tax Assessor's rolls, Planning Watershed 113.70025 is predominantly owned by Coastal Forestlands, Ltd., an industrial timber owner, who owns 77% of the sub-basin. Louisiana-Pacific Corporation and Georgia-Pacific Corporation, the other two industrial timber owners in the watershed, own 4% and 8% of the sub-basin, respectively. The remaining property in the sub-basin is owned by small private land owners.

Historic Land Use

The 1952 aerial photographs indicate that there was logging activity in Planning Watershed 113.70025 prior to 1952. Some activity is shown in the small drainage to the east of the North Fork Garcia River, west of Eureka Hill Road. Additional activity is shown along the Eureka Hill Road, with substantial activity along the ridge separating Planning Watershed 113.70025 from Planning Watershed 113.70013 (Blue Waterhole Creek sub-basin).

In addition, the 1952 aerial photographs indicate that property along the mainstem Garcia River was cleared for agriculture prior to 1952. Similarly, a large tract was cleared on the northern ridge of the North Fork Garcia River just off of Mountain View Road.

In 1966, the California Department of Fish and Game published its "Stream Damage Surveys-- 1966" in which it rated the tributaries of the Garcia River as severely damaged, moderately damaged, lightly damaged or undamaged. The entire length of the North Fork Garcia River was rated as severely damaged as was the lower portion of Olsen Gulch. The reach of the mainstem Garcia River running through this Planning Watershed was rated as lightly damaged.

Road density in this Planning Watershed is reported by the California Department of Forestry and Fire Protection at 6.39 mi/mi^2.

Hydrology

Drainage Area

1. *Acres*

Planning Watershed 113.70025 contains 10,373 acres. Runoff through this sub-basin originates in all of the sub-basins upstream of it, as well as within Planning Watershed 113.70025, itself. As such, the total drainage area of Planning Watershed 113.70025 is 65,376 acres.

2. *Flows*

Flows for the basin have been measured at the USGS gaging station 11467600 located at Conner 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. The drainage area above Conner Hole is approximately 62,786 acres.

3. *Diversions*

According to a table included *in Gualala Aggregates Sand and Gravel Project Draft Environmental Impact Report* (1994), William Hay, Jr. has a riparian water right for gravel processing at the mouth of the North Fork Garcia River on the mainstem Garcia River at the end of Buckridge Road. He is permitted to divert a maximum rate of 0.134 cfs any time during the year.

Precipitation

According to the Fire Resource Assessment Program of the California Department of Forestry and Fire Protection, the average annual rainfall in Planning Watershed 113.70025 is 65 inches in the upper tributary reaches, 55 inches in the mid reaches, and 45 inches along the mainstem and on the east side of the coastal ridge.

Geology

Geologic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program, including the North Fork Garcia River sub-basin.

According the Division of Mines and Geology map, the mainstem Garcia River as it passes through this Planning Watershed is primarily defined by the San Andreas fault which forms the valley in which the mainstem Garcia River flows. The northeast side of the valley is composed of Coastal Belt Franciscan of the Tertiary-Cretaceous period. It is well consolidated, hard sandstone interbedded with small amounts of siltstone, mudstone and conglomerate; pervasively sheared; commonly highly weathered, and tends to easily disaggregated, resulting in numerous debris slides along creeks and roads within debris slide amphitheaters/slopes. The southwest side of the valley is predominantly composed of the German Rancho Formation (Paleocene-Eocene) and Galloway-Schooner Gulch Formation (Miocene) with outcroppings of Marine Terrace Deposits (Quaternary).

The German Rancho Formation is consolidated, moderately hard, coarse-grained sandstone interbedded with minor mudstone and less common conglomerate; overlain in many places by undifferentiated marine terrace sands; highly sheared and colluvial in appearance neat the San Andreas fault system. The Galloway-Schooner Gulch Formation is a moderately consolidated sandstone. And, the Marine Terrace Deposits are poorly to moderately consolidated deposits of marine silts, sands, and quartz-rich pea gravels forming extensive flat benches paralleling the coastline. It is probably much more extensive than is mapped and is in many places overlain by unconsolidated alluvial fan/colluvial deposits.

The valley bottom is composed primarily of San Andreas Fault Gouge of the Quaternary period. It is highly sheared, chaotic, and unconsolidated mixture of various pre-Quaternary rock types bounded by active or inactive strands of the San Andreas fault system. In association with this are alluvial deposits of the Quaternary and Holocene described as Alluvial Terrace Deposits, Alluvium and Stream/River Channel Deposits. these are deposits of silt, sand, and gravel both within and above the currently active channel.

Geomorphic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program, including the North Fork Garcia sub-basin.

According to the Division of Mines and Geology map, there at least two massive translational/rotational slides in the North Fork Garcia River with several other smaller translational/rotational slides and earthflows scattered throughout the tributary. There is also a translational/rotational slide near the mouth of Olsen Gulch. The Planning Watershed is otherwise characterized by numerous active slides, debris slides, and disrupted ground. Features identified as "disrupted ground" are particularly numerous on the west side of the Planning Watershed.

Below are excerpts of inspection reports written by staff at the Division of Mines and Geology and the Regional Water Board during pre-harvest inspections (PHI) of timber harvest plans (THPs) which pertain to the geomorphology of the region. Many of the locations identified were mapped by the inspector on maps included with the inspection reports. The map points are noted here for reference.

<u>Primarily in the North Fork Garcia River</u>

1. *THP 1-88-223*

This plan was located at T12N, R16W, 2, 3, 11. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- Excess sidecast or fill material placed on steep slopes (70%). A portion of a landing/road edge failed in a viscous debris flow which placed mud on the floodplain of the North Fork Garcia River.
- Sidecast failed into watercourse. Crossing filled with 20-30 feet of fill, approximately 30 feet wide. (Map Point 1T)

2. *THP 1-88-740*

This plan was located at T 13N, R15W, 31; T12N, R16W, 1; T12N, R15W, 4-9. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- Road gully 4 feet deep, 3 feet wide and 600 feet long (Map Point A)
- 75 foot road failure-- outside edge failed as debris slide from concentrated water flowed down the center of a slide.
- Road failure-- outside edge failed from concentrated water. (Map Point G)
- 100 foot wide debris slide leaving 100% bare slopes, probably from concentrated road drainage. (Map Point H)
- Road construction along 75-100 feet of Class III stream. (Map Point K)
- Earthflow into Class II stream. Side scarps 10-12 feet high and 1-2 feet deep with a channel draining the center of the slide of concentrated runoff from skid trail. (Map Point Q)
- Slope below road failed with debris slide along inner gorge of North Fork Garcia River. (Map Point V)
- Road reconstruction across the toe of a rotational slide into the North Fork Garcia. (Map Points BB and DD)
- Slope below road failed by rotational slumping into North Fork Garcia. (Map Points FF and GG)
- Debris slide below road. (Map Point 11)
- Side cast failed with debris slide below road into North Fork Garcia. (Map Point 22)

- Inner gorge (70% slopes) below road-- much of area has debris failures into North Fork Garcia. Cutbanks (80 feet +), wedge failures, debris sliding, and slab failures are common along and below road. (Map Points T-Z).

The Regional Water Board inspector further noted that numerous (5) instream WLPZ landings were reused.

3. *THP 1-89-105*

This plan was located at T12N, R16W, 2, 3. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- Inner gorge debris sliding below Watercourse and Lake Protection Zone landing "F."
- Large dormant rotational landslide coincides with eastern half of the plan (approximately 175 acres).
- Soils with low to moderate cohesion erode readily when there is a concentration of runoff directed along a compacted or disturbed surface.
- Soil susceptible to debris sliding.
- Gravely loam soils exposed on slopes >65% are prone to debris sliding.
- Several debris slides originating in sidecast or fill slopes below skid trails.
- Debris sliding originated in cut slope found tin full bench trails on slopes >95%
- Reconstruction of existing WLPZ road and landing along Class II channel is heavily impacted by past 1950-1060s logging. Instream logging left large deposits of soil and logs. (Map Points A-F)
- Debris sliding along inner gorge slopes above floodplain. (Map Points C and D)
- 100 feet of bank failed along road which was within a debris slide that caused the water course to move to the opposite side of the channel. (Map Point E)
- Debris slide from exiting skid trail slopes average 100%. (Map Point G)

4. *THP 1-89-744*

This plan was located at T12N, R16W, 1, 2, 11; T13N, R16W, 35, 36. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- Debris sliding common along road system constructed along inner gorge slopes of tributary drainages and North Fork Garcia River.
- Debris slides originating in sidecast material below the road system (Map Points A1, G1, B, M, P, and Z).
- Sidecast material from previous road construction remains perched, susceptible to failure if water is concentrated onto it.
- One mile wide dormant rotational landslide coincides with western two thirds of the plan (520 acres).

- Road erosion due to lack of proper drainage has resulted in gully 5 feet deep and 10-20 feet wide. (Map Point X)
- 50 foot road failure within inner gorge of North Fork Garcia (Map Point Z).

5. *THP 1-91-344*

The Regional Water Board inspector noted the following features during the preharvest inspection:

- A road fill failure caused gully erosion sufficient to prevent vehicle access. The gully was 5 feet deep and 6 feet wide, caused by improper landing and road drainage.

6. *THP 1-93-015*

This plan was located at T12N, R16W, 1, 2, 11; T13N, R16W, 35, 36. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- Nearly entire plan area (795 acres) is subject to debris slides.
- Class III instream landing, eroded through fill to form 3 foot high water fall at knick point. (Map Point L)
- Watercourse diverted down haul road at crossing, flowing 50 feet down grade to form a 4 foot high knick point waterfall which is eroding headward and delivering sediment to the stream. (Crossing 13)
- Most slopes within the drainage are naturally unstable, due to the fractured bedrock and regional uplift. The geomorphology of the watershed indicates that debris flows have been the dominant natural type of slope failure, along with translational/rotational landslides. The erosion of the naturally occurring debris flow deposits result in a relatively high background level of sediment yield to the Garcia River. Logging-induced soil erosion problems (such as the eroding fills and skid trails) result in sediment yields above background levels.

7. *THP 1-95-192*

The Regional Water Board inspector noted the following features during the preharvest inspection:

- Near stream road adjacent to the North Fork with no break in slope between the road and the watercourse.
- Eroding crossing discharged fill into the North Fork Garcia River. There are 6-8 feet of vertical banks at crossing F.

8. *THP 1-95-365*

The Regional Water Board inspector noted the following features during the preharvest inspection:

- Diverted Class II stream down skid trail onto seasonal road. This problem was corrected under the THP.

9. *THP 1-95NTMP-018*

The Regional Water Board inspector noted the following features during the preharvest inspection:

- A Class III stream was diverted down the road after the last operation.
- An old instream landing is in a Class II stream
- A Class II stream diverted down the road has caused severe gully erosion.

10. *THP 1-96-134*

This plan was located at T12N, R16W, 2, 3, 11. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- Debris slides in steeper canyons (noted in the 1984 aerial photograph review) were verified by reviewing 1992 aerial photographs and in the field.
- The entire plan area (566 acres) may consist of unmapped, very large landslides with another large unmapped landslide underlying the ridge to the southeast of the plan.
- Old debris flow scars are well vegetated.
- The channel at crossing 9 is filled with sediment which has diverted the stream down to crossing 10, causing a gully 2 feet wide by 2 feet deep on the road prism.

11. *THP 1-96-436*

This plan was located at T12N, R15W, 5-8. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- Debris slide slopes, small landslides, and disrupted ground noted throughout plan.
- Two recent slides triggered during storms of winter/spring 1995. They originated from cutbanks of lower truck road and deposited debris and vegetation on the road but not into the North Fork Garcia.

Primarily in Coon Creek

12. *THP 1-95-017*

The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- Steep concave, continuous inner gorge slopes 70-80% along incompetent weathered bedrock.
- Post tractor operations along steep slopes and within stream channel resulting in numerous debris slides. Most are beginning to stabilize and re-vegetate.
- A 60% channel gradient below the road channel is the result of a debris flow track with logs, rocks, boulders and debris. The road is 10 feet form the channel. Above the road, the channel forms a swale.
- An old road bed fill failure travels for 120 feet.

Primarily in Olsen Gulch

13. *THP 1-89-568*

The Division of Mines and Geology inspector noted the following features during the preharvest inspection.

- Geologic map and field observation illustrate a tendency for surficial mass wasting.
- Numerous dormant debris slides, active ? and soil creep.
- Some of the more recent debris slides are on contour skid trails over 60% slopes.
- Material sidecast below the trail failed. In some cases the exposed cut slope failed. The full bench trails remained stable.
- Many debris slides along Olsen Gulch are within the inner gorge, aggravated by near stream roads which were previously constructed and now abandoned.
- A new midslope road will be constructed to accommodate cable yarding and eliminate use of the near stream roads.
- There are stacked skid trails (50-100 feet apart) from past tractor logging.

14. *THP 1-91-344*

The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- Olsen Gulch is characterized by numerous debris slides and debris flows resulting from highly fractured bedrock. The original construction of midslope roads has caused additional debris slides due to undercutting of the hillslope above the road.
- A plugged 6 inch culvert caused the erosion of road fill in a 6 foot long, 15 foot wide gully.

- The inside ditch was plugged by bank sloughing which diverted runoff and eroded the road fill in a 10 foot wide, 4 foot long gully.
- A spring is draining down the road causing a 4 foot wide, 3 foot deep channel down the road shoulder.
- A landslide 50 feet wide and 90 feet long blocked the road and diverted runoff, forming an erosion channel of 10 feet wide, 6 feet deep, and 20 feet long over the side of the road.
- There is a road fill failure 2-4 feet wide and 100 feet long.
- The road prism is eroded due to improperly compacted fill and poor drainage.
- A through cut road drains onto a landing, eroding loose surface material and forming a gully 8 feet wide and 2-4 feet long.
- A previously installed Class III crossing was not pulled and has caused severe erosion.

A Class II Humboldt crossing has caused a channel 10 feet wide by 10 feet deep in the road prism.

North Fork Garcia River

Channel Morphology

1. *Slope*

The GIS maintained by the Department of Forestry and Fire Protection calculates the slope in the lower reach of North Fork as ranging from 1-3%, except where larger tributaries come in where the slopes range from 3-5%. About a third of the way up the North Fork Garcia River, the slope of the sub-basin changes at a waterfall above which the stream is relatively flat (1-3%) but punctuated with gradients exceeding 20%. The stream gradients in other identified Class I streams in the North Fork River basin are relatively steep, often exceeding 20%.

In its *Watershed and Aquatic Wildlife Assessment* (1997), Coastal Forestlands, Ltd. reports channel slopes at three locations in the upper, middle and lower North Fork of 1.3%, 4.3% and 1.0%, respectively.

2. *Substrate*

On October 3, 1967, the Department of Fish and Game conducted as stream survey of the North Fork Garcia River in which the surveyor noted that the channel substrate in the lower 4 miles of river was coarse gravel cemented together tightly with some mud near the mouth. From the headwaters down about 3 miles, the surveyor noted that the substrate was loose with small boulders and gravels.

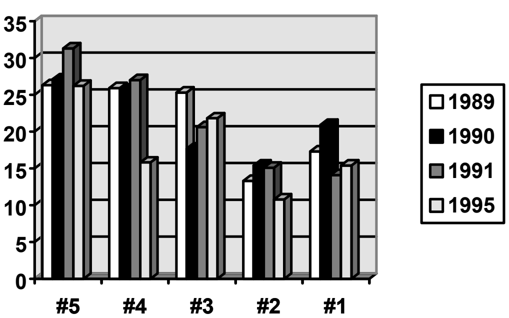
In a memorandum dated March 30, 1989 from the Department of Forestry and Fire Protection to Len Theiss, regarding an inspection of the North Fork Garcia River on March 24, 1989, Marc Jameson, Staff Forester, noted that the canyon bottom area near the mouth was a wide flood plain of over 300 feet in many locations. He said that the area would be categorized as a deposition zone for river borne sediments. There is evidence of considerable past deposition and disturbance.

Mr. Jameson stated that the substrate was composed primarily of cobble and boulders. Much of the rock was fairly angular with rounded edges, indicating that it was fairly new (under 40 years). He theorized that much of the material probably originated from debris slide activity upstream. He also observed fine sediments along the stream edges and in eddy areas, but concluded that these sediments did not appear to be recent since they were sandy in appearance and lack the orange color common in the local soils.

Mr. Jameson noted that the river runs in some segments through a narrow canyon. Numerous large boulders and occasional large woody debris have aided in the production of numerous pools. This river has apparently been cleared of woody debris in the past, but enough rock and debris remains to create pools.

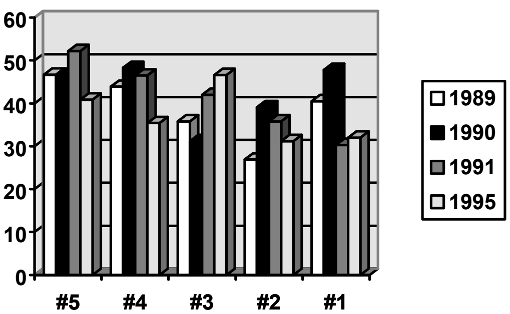
Under order for the North Coast Regional Water Quality Control Board, Coastal Forestlands, Ltd. collected McNeil samples at 5 locations in the North Fork Garcia River. The average values for each location in each of four years are given as follows:

Location	Year	<1.0 mm (%)	< 4.75 mm (%)
#1, lower river	1989	17.3	40.5
	1990	20.9	47.8
	1991	14.1	30.3
	1995	15.4	32.0
#2, mid-lower river	1989	13.3	26.9
	1990	15.4	39.1
	1991	15.1	35.8
	1995	10.8	20.3
#3, mid river	1989	25.3	35.8
	1990	17.7	31.2
	1991	20.6	42.0
	1995	21.8	46.6
#4, mid-upper river	1989	25.9	43.9
	1990	25.7	48.3
	1991	27.0	46.5
	1995	15.8	35.4
#5, upper river	1989	26.3	46.7
	1990	27.1	46.7
	1991	31.3	52.2
	1995	26.2	40.9



The mean percent fines are generally measured as < 1mm with the exception of those measurements collected in 1995 which were measured as < 0.85 mm. In all years, fine gravel is measured as < 4.75 mm.

The mean percent fines at each sampling location generally decrease from those sampling locations highest in the sub-basin to those in the lower river, with the one exception. At sampling station #1, the lowest sampling station in the watershed, mean percent fines appear to generally increase-- not unexpected in a depositional reach. In addition, there is a slight variation in the mean percent fines at each sampling location from year to year. The mean percent fines found in any one year are not consistently higher or lower than those found in other years.



A less discernible, consistent pattern is seen in the mean percent fine gravel (<4.75 mm) data.

In 1991, as part of the data collection to support the development of the *Garcia River Watershed Enhancement Plan* (1992), contractors to the Mendocino County Resource Conservation District collected habitat typing data in the North Fork Garcia River using the Department of Fish and Game's protocol for habitat typing. Substrate embeddedness measurements were made as part of the habitat typing exercise. In 20,199 feet of stream channel, the surveyors found that 6% of samples had an embeddedness value of 1 (0-25%), 33% had an embeddedness value of 2 (26-50%), 29% had an embeddedness value of 3 (51-75%), and 32% had an embeddedness value of 4 (76-100%).

In 1994, Georgia-Pacific Corporation collected McNeil samples at a location on the lower North Fork Garcia just below the confluence with the first tributary to the North Fork. G-P found 14.6% fines < 0.85mm and 46.1% fines <4 mm. This compares reasonably well with the data collected by CFL in the lower North Fork.

3. *Width/depth ratio*

Under order from the Regional Water Board, Coastal Forestlands, Ltd. collected cross-section data in the North Fork Garcia River beginning in 1989. The data was reported as profiles, rather than cross-sections. Coastal Forestlands, Ltd. concludes in its 1996 data report that "data from the channel cross-section profiles on six stations (#1-5, with and upper and lower station at #2) show that the profiles are equal or better in 1995 than in previous years. All pools deepened and/or became larger except for one pool (pool 2) which stayed the same. A width-to-depth ratio is not given.

In its *Watershed and Aquatic Wildlife Assessment* (1997), Coastal Forestlands, Ltd. reports width-to-depth ratios at three locations in the upper, middle and lower North Fork of 17.0, 11.3, and 23.1, respectively.

4. *Confinement*

In its *Watershed and Aquatic Wildlife Assessment* (1997), Coastal Forestlands, Ltd. reports confinement at three locations in the upper, middle and lower North Fork Garcia or 7.7, 1.1 and 4.5, respectively. Confinement is a ratio of the valley width to the bankfull width.

5. *Rosgen Stream Classification*

According to Rosgen's stream classification system, stream reaches with gradients less than 2%, a width-to-depth ratio >12, and a confinement >2.2 are C channels. Stream reaches with gradients between 4-10%, a width-to-depth ratio <12, and a confinement <1.4 are A channels.

- "A" channels are described as existing in areas of high relief with erosion, depositional and bedrock forms. These channels are entrenched and confined streams with cascading reaches. They have frequently spaced, deep pools in associated step/pool bed morphology. A channels are very stable if they are bedrock or boulder dominated.
- "C" channels are described as existing in broad valleys with terraces, in association with floodplains and alluvial soils. They are slightly entrenched with well-defined meandering channels and include a riffle/pool bed morphology.

<u>Aquatic Habitat</u>

1. *Habitat Types and Distribution*

The Department of Fish and Game surveyor noted in his October 3, 1967 stream survey that spawning was probably limited to the headwaters since the lower 4 miles were heavily damaged by past logging (see "substrate" above). The surveyor noted that pools averaged 16 feet long and 4 feet deep and ranged from 2' long by 2' wide by 1' deep to 25' long by 12' wide by 8' deep.

In 1983, the Department of Fish and Game conducted another stream survey of the North Fork Garcia River and determined that 60% of the surveyed reach was in pools, 0% in riffles and 40% in runs.

In 1991, as part of the data collection to support the development of the *Garcia River Watershed Enhancement Plan* (1992), contractors to the Mendocino County Resource Conservation District collected habitat typing data in the North Fork Garcia River using the Department of Fish and Game's protocol for habitat typing. The surveyors noted that in 20,199 feet of surveyed stream channel:

- the total pool mean depth was 1.2 feet
- the riffle/flatwater mean width was 17.1 feet
- 29% of the habitat was in pools
- 29% of the pools were greater than 3 feet deep
- 8% of the channel had large woody debris

On May 10, 1995, Jack Monschke reported on restoration he work conducted in Derby Creek, a tributary to the North Fork Garcia River. In a 130 yard reach of Derby Creek, Mr. Monschke established or modified 5 stream gradient controls, excavated instream stored sediment, and armored vulnerable areas in the stream bed and banks.

In its *Watershed and Aquatic Wildlife Assessment* (1997), Coastal Forestlands, Ltd. (CFL) reports that its Longview-North tract of property (Inman Creek, Signal Creek, mainstem Garcia River, and North Fork Garcia) include a total of 36.27 miles of Class I stream. According to CFL, stream gradients ranging from 0-2% exist in 15.50 miles of stream and are suitable for Chinook salmon. Stream gradients ranging from 0-4% exist in 26.39 miles of stream and are suitable for coho salmon. And, stream gradients ranging from 0-10% exist in 35.43 miles of stream and are suitable for steelhead.

Habitat quality indices collected by CFL in the North Fork Garcia include: canopy closure, % sand on riffles, the number of pieces of large woody debris per bankfull width and the bulk volume of large woody debris per bankfull width. CFL concludes that all indices of riparian canopy coverage indicate much better than average conditions. Percent sand on potential spawning riffles, however, was slightly above (worse than) average. Large woody debris indices were all better than average, especially bulk volume.

2. *Instream Cover*

The Department of Fish and Game surveyor noted in his October 3, 1967 stream survey of the North Fork Garcia that instream shelter in the upper 3 miles of the headwaters is abundant with rocks and stumps along the stream. The lower 4 miles of the river system, however, he noted that shelter was poor, with the exception of occasional log jams. In the Department's 1983 stream survey of the North Fork Garcia River, the surveyor did not measure instream cover.

In 1991, as part of the data collection to support the development of the *Garcia River Watershed Enhancement Plan* (1992), contractors to the Mendocino County Resource Conservation District collected habitat typing data in the North Fork Garcia River using the Department of Fish and Game's protocol for habitat typing. The surveyors noted that in 20,199 feet of surveyed stream channel:

- the dominant bank substrate was comprised of boulders
- the dominant bank vegetation was comprised of deciduous trees
- the vegetative cover was 44%
- the canopy density was 48%
- the mean shelter rating was 92
- the dominant shelter was from boulders
- large woody debris occur in 8% of the stream channel surveyed

In its *Watershed and Aquatic Wildlife Assessment* (1997), Coastal Forestlands, Ltd. (CFL) reported that there were 2.2 pieces of large woody debris per bankfull width in the three stream segments surveyed. They also reported a bulk volume of large woody debris in ft^3 per bankfull width of 205 without lag jams and 712 with logjams. These figures were reported to be above average for the 25 Planning Watersheds CFL surveyed.

The Mendocino Watershed Service placed several large woody debris structures in the lower North Fork Garcia River to provide shelter and channel diversity.

3. *Water Temperature*

Temperatures were reported by Georgia-Pacific Corporation to range between approximately 12 C and 16C during the summer of 1994. Their sampling location was in the lower North Fork just below the confluence of the first tributary with the North Fork mainstem. No other temperatures have been reported for the North Fork Garcia River.

4. *Barriers*

The Department of Fish and Game surveyor noted in his October 3, 1967 stream survey, a total of 8 log jams in the North Fork Garcia River, some as high as 4 feet. He noted that these log jams did not appear to produce absolute barriers as large numbers of fry were observed up-stream from the jams. He also noted that surface flows was intermittent 1.5 miles from the mouth of the river.

There is a waterfall about 2-4 miles from the mouth which is a fish migration barrier. Resident fish exist above these falls.

5. *Population Composition and Distribution*

Live population survey results

The Department of Fish and Game surveyor noted in his October 3, 1967 stream survey an abundance of rainbow or steelhead juveniles (50 fry per 100 feet) in the upper 3 miles of the headwaters. He noted very few juveniles in the lower river (10 fry per 100 feet). The juveniles generally measured from 2.5 to 5 inches in length.

The Department measured in its 1983 stream survey, a steelhead density of 2.19 fish/m^2 in the North Fork Garcia River. It also measured a biomass of 194.66 kg/hectare-- the largest biomass measured anywhere in the watershed over 12 years of surveys (1983-1995).

Georgia-Pacific Corporation measured in its 1994 stream survey in the lower North Fork Garcia, a density of 1.0 steelhead per m^2.

Redd survey results and carcass survey results

There are no redd or carcass survey results for the North Fork Garcia River.

6. *Food Supply*

The Department of Fish and Game surveyor noted in his October 3, 1967 stream survey a density of mayfly larvae of about 10 larvae per square foot of rock area. There is no other

7. *Water Quality*

Under order from the Regional Water Board, Coastal Forestlands, Ltd. measured turbidity, suspended solids, and settleable matter at several sites on the North Fork Garcia River. The data generally indicated 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 not established background levels for the North Fork Garcia against which to compare the actual results.

Olsen Gulch

Channel Morphology

1. *Slope*

The channel slopes in Olsen Gulch are reported by the California Department of Forestry and Fire Protection to range from 1-3% in the lower reach and climb from 3-10% throughout the rest of the mainstem channel.

2. *Substrate*

The Department of Fish and Game surveyor noted in his September 8, 1967 stream survey that the substrate was primarily gravel and rubble with underlying sand.

3. *Width/depth ratio*

The Department of Fish and Game surveyor noted in his September 8, 1967 stream survey that the width of Olsen Gulch was on average 3.5 feet and ranged from 2-6 feet. The depth was on average 4 inches and ranged from 2-24 inches.

4. *Confinement*

The Department of Fish and Game surveyor noted in his September 8, 1967 stream survey that at the mouth of Olsen Gulch, the canyon was bowl-shaped and upstream it was progressively U-shaped.

Aquatic Habitat

1. *Habitat Types and Distribution*

The Department of Fish and Game surveyor noted in his September 8, 1967 stream survey that the spawning areas were limited to quieter portions of the bed where adequate gravel was available. Pools were few and small (6'x8'x24" deep) and sometimes cluttered with debris.

On May 28, 1995, Jack Monschke reported on restoration work he conducted in Olsen Gulch. In a 620 yard reach of stream, Mr. Monschke excavated instream stored sediment, removed unstable log jams, established grade controls, unearthed buried large woody debris, and used some of the recovered large woody debris for bank stabilization and pool formation. Conifers, willows and alder were planted along the banks for bank and soil stabilization. Staff at the Mendocino County Resource Conservation District evaluated the work on November 20, 1995 and determined that the channel cross sections were significantly improved as a result of the restoration work. Staff also noted, however, a reach of tremendous downcutting, probably caused by earthquake activity. He hypothesized that anadromous fish are unlikely to be able to traverse this reach to gain access to the newly restored stream section. Resident fish were probably helped by the addition of habitat in the restored reach.

2. *Instream Cover*

The Department of Fish and Game surveyor noted in his September 8, 1967 stream survey that there were fair shelter in Olsen Gulch, including logs, under cut banks, and large rubble.

3. *Water Temperature*

The Department of Fish and Game surveyor noted in his September 8, 1967 stream survey that the shade in Olsen Gulch was fairly good due to vegetation throughout most of the riparian zone. He noted that there are alder, maple, bay, and redwood along the stream. Fern grow in the heavily shaded areas. The streamside varies from open areas with little vegetation to areas with abundant vegetation.

4. *Barriers*

The Department of Fish and Game surveyor noted in his September 8, 1967 stream survey that there were many small log jams in Olsen Gulch, but no absolute barriers. There were three waterfalls, no higher than 4 feet.

5. *Population Composition and Distribution*

Live population survey results

The Department of Fish and Game surveyor noted in his September 8, 1967 stream survey that there were approximately 25 juvenile steelhead/resident trout noted per 100 feet of stream. He was unable to distinguish steelhead from resident trout since absolute barriers were not perfectly distinct.

Redd survey and carcass survey results-- There are no known data identifying number of redds of carcasses.

6. *Food Supply*

The Department of Fish and Game surveyor noted the presence of caddis fly and stonefly larvae and adults. In addition, he noted insects available as food from overhanging terrestrial plants. He estimated 10-15 larvae per grapefruit-sized rubble.

7. *Water Quality*-- There is no known water quality data.

John Olsen Creek

There is little data relevant to John Olsen Creek. However, the following comments were recorded during the two-day meeting of technical experts on the subject of limiting factors in the Garcia River watershed:

- The channel slope ranged from 5% at the mouth to greater than 20% at the end of its Class I reach.
- There is a lot of good alder cover
- The stream temperatures are likely to be adequate for salmonid rearing.
- John Olsen Creek is a perennial stream.
- The stream channel appears to be confined in the lower reach.
- The substrate is primarily made up of silted gravels which may be adequate for spawning.
- There is likely to be adequate rearing habitat.

Mainstem Garcia River

Channel Morphology

1. *Slope*

The Department of Forestry and Fire Protection reports the channel slopes of the mainsteam Garcia River through this Planning Watershed to be less than 1%.

2. *Substrate*

In a March 18, 1997 assessment of cross-sectional data for the lower Garcia River mainstem, Dennis Jackson, formerly of the Mendocino County Water Agency, reported that the Garcia River is underlain by a clay layer in several locations. Jackson reported a layer of cemented aggregate just of upstream of Conner Hole. Downcutting has exposed the cemented aggregate and may expose clay, as well. Such exposure, said Jackson, would degrade aquatic habitat by reducing the area suitable for the production of benthic organisms and introducing fine sediment to the stream.

Jackson (1997) reported a decrease in stage required for 100 cfs of flow which implies that the reach below Conner Hole has been degrading relative to its condition in 1975. Further, he indicates that a wave of bed material passed Conner Hole during the period of January 1969 to September 1983 when the USGS station at Conner Hole was closed. The graph of the sediment wave indicates that it crested in 1975. Jackson (1997) theorized that between 1968 and

1975, when the sediment wave was cresting, there were probably several significant slides delivering material directly to the river. Between 1976 and 1983, when the sediment wave was waning, there were probably very few slides so the sediment supply to the river was greatly reduced. Furthermore, the weaker flows lacked the power to transport the larger size classes of the material delivered to the channel. Probably most of the material that was transported during the dry period was eroded from the bed of the channel.

3. *Width/depth ratio--*

In a March 18, 1997 assessment of cross-sectional data for the lower mainstem Garcia River, Dennis Jackson, formerly of the Mendocino County Water Agency, reported that the 1996 low water channel appeared to be 50% wider than the 1956 width. The increase in width has occurred at the expose of the gravel bar on the right bank. The erosion of this bar, relative to 1956, suggests a decrease in local availability of bed material from 1956 to 1996.

Three other cross sections evaluated in Planning Watershed 113.70025 by Jackson include one at a footbridge approximately 100 feet downstream of the cableway at Conner Hole, a second approximately 38 feet downstream of the footbridge, and a third at the Eureka Hill bridge. The footbridge cross section shows a 0.2 foot thalweg drop between 1991 and 1996. The water surface dropped 0.7 feet during this same period. Approximately 3 feet of bed material was eroded from the right bank gravel bare and some material was deposited on the leg bank.

The cross-section downstream of the footbridge shows that between 1991 and 1993, the thalweg dropped 1 foot and the water surface rose 1.3 feet. The drop in thalweg resulted in an 8% increase in cross section area. The thalweg migrated and lowered another 0.6 feet between 1993 and 1996.

The cross-section at the Eureka Hill bridge shows that from 1993 to 1995, the thalweg rose 0.6 feet, the water surface rose 0.7 feet, and the low water channel widened about 12 feet. The rise in water surface shows that material was deposited on the downstream control between 1993 and 1995. Between 1995 and 1996, there was minor scour across most of the low flow channel but the thalweg elevation and cross section area remained unchanged.

Jackson (1997) concludes that the overall channel width has remained constant at all of the cross-sections in Planning Watershed 113.70025. The overall trend is a decline in both water surface elevation and thalweg elevation, relative to 1991. The tendency of the water surface elevation to decline indicates that the downstream control riffles are being eroded. The drop in thalweg depth shows that the bed is scouring. the erosion of the control riffles and scouring of the bed may be an indication that less bedload is being supplied from above Eureka Hill bridge. Jackson (1997) further concludes that the 133.70025 cross sections indicated that the Garcia River is in dynamic equilibrium.

4. *Confinement*

The mainstem Garcia River was identified by staff at U.S. EPA and the Regional Water Board as: 1) moderately confined from the eastern border of the Planning Watershed to 2) confined from immediately upstream of the North Fork to Olsen Gulch and 3) unconfined from Olsen Gulch to the western border of the Planning Watershed.

Aquatic Habitat

1. *Habitat Types and Distribution*

In 1953, the Department of Fish and Game published a report entitled *Population sampling on Three North Coast Streams Closed to Summer Trout Fishing-- 1952*. the surveyor described the mainstem Garcia River downstream of its confluence with the North Fork Garcia. He said the north shore was steep and wooded while the south shore was a wide gravel flat. The pool where he conducted sampling was slightly constricted in the middle, with a riffle at the head end, and shallowing out to a shallow, wide gravel bottomed run at the downstream end. The bottom was partially composed of large boulders and cobbles on the north upper side and gravel and cobbles on the north lower side and whole south side. It was well shaded and had abundant cover in the form of projecting roots and crannies between boulders.

The 1996 *Garcia River Gravel Management Plan* evaluated the conditions in the lower Garcia River relative to gravel mining. Phillip Williams & Associates (the authors) identified the lower Garcia River from approximately 0.5 miles below the North Fork Garcia to 0.25 miles below No Name Creek ("Bentonite" Creek) as spawning habitat of special fishery concern. They also identified approximately 2/3 of this reach as rearing habitat of special fishery concern.

2. *Instream Cover--* There is no known instream cover data for the mainstem Garcia in Planning Watershed 113.70025.

3. *Water Temperature*

Stream temperature data exists for the water years from 1964 through 1979 at the USGS gaging station at Conner Hole. A water year is measured from October to September. The average of the daily maximum summer temperatures from July through September are reported here.

Year	July (C)	August (C)	September (C)
1964	20.4	---	18.5
1965	19.1	19.9	17.8
1966	18.7	---	18.6
1967	18.8	18.9	18.9
1968	20.0	19.6	18.3
1969	---	---	19.5
1970	19.4	19.2	18.6
1971	19.4	20.3	----
1972	19.5	19.6	18.6
1973	19.3	----	18.9
1974	----	----	----
1975	20.2	20.3	----
1976	20.4	19.7	18.9
1977	19.0	19.0	18.4
1978	20.6	20.4	19.3
1964-1978	14 year average of 19.6 varying 1.0 C	14 year average of 19.7 varying 0.8 C	14 year average of 18.7 varying 0.8 C

4. *Barriers*-- There is no known data regarding barriers on the mainstem Garcia River in this Planning Watershed.

5. *Population Composition and Distribution*

Live population survey results

In 1953, the Department of Fish and Game published a report entitled *Population Sampling on Three North Coast Streams Closed to Summer Trout Fishing- 1952*. At a sampling station 200 feet below the Buckridge Road, the surveyor tallied 107 steelhead and 36 silver salmon.

On May 12, 1993, Scott Cressey of Western Ecological Services Company, Inc. electrofished portions of the lower Garcia River and North Fork Garcia for Bedrock, Inc. At the bottom of Buckridge Road from the footbridge downstream for 200 feet, Mr. Cressey counted 5 steelhead fry. From the footbridge upstream for 200 feet, Mr. Cressey counted 20 steelhead fry. In a 120 foot reach located approximately 30 below the confluence with the North Fork, Mr Cressey counted 18 steelhead fry. No coho fry were observed among any of the fish captured.

Redd survey and carcass survey results-- There is no known data regarding the number of redds or carcasses in the mainstem Garcia River through this Planning Watershed.

6. *Food Supply* -- There is no known data regarding food supply in the mainstem Garcia River through this Planning Watershed.

7. *Water Quality*

The Regional Water Board collected dissolved oxygen data at Buckridge Road on April 18, 1989 and May 2, 1990. Dissolved oxygen levels of 10.4 and 11.5 mg/L were found, respectively. These are within the range identified as protective of water quality by the Regional Water Board in the Basin Plan.

Existing Data for
Planning Watershed 113.70026
Hathaway Creek Sub-basin

General Setting

Location

Planning Watershed 113.70026 contains Hathaway Creek, several other small tributary streams, the lower mainstem Garcia River and the Garcia River estuary. The Planning Watershed is primarily found on the Point Arena U.S. Geological Survey 7.5 minute topographic map. The headwaters of a small tributary stream within Planning Watershed 113.70026 are found on the Eureka Hill topo map. The Planning Watershed is further identified by Township 12 and Range 16, Sections 5-8; Township 12 and Range 17, Sections 1, 2, and 12; Township 13 and Range 16, Sections 27-29 and 31-34; and Township 13 and Range 17, Sections 26 and 34-36.

Soils

The soils contained in Planning Watershed 113.70026 include:

- Duneland
- Ornbaun-Zeni complex 9-30%, 30-50%, and 50-75% slopes
- Mallopass loam, 0-5%, 5-15%, and 15-30% slopes
- Flumeville clay loam, 0-5% and 5-15% slopes
- Irmulco-Tramway complex, 9-30%, 30-50%, and 50-75% slopes
- Vandamme-Irmulco complex, 50-75% slopes
- Dystropepts, 30-75% slopes
- Cabrillo-Heeser complex, 0-5% slopes
- Biaggi loam, 0-5% and 5-15% slopes
- Bruhel-Abalobadiah-Vizcaino complex, 9-30% slopes
- Bruhel loam, 2-9% slopes
- Crispin loam, 0-5% slopes
- Stornetta fine sandy loam, 0-2% slopes
- Bigriver loamy sand, 0-5% slopes
- Riverwash
- Ferncreek sandy loam, 2-9% slopes
- Windyhollow loam, 15-30% slopes

Personnel at the Natural Resources Conservation Service reviewed these soil complexes and organized them into vegetative types. These types are described below.

Predominant Vegetation

The soils identified in Planning Watershed 113.70026 predominantly support cropland and coastal prairie/scrub. Other vegetative types represented in Planning Watershed 11.370026 include: redwood forest, coastal cypress/pine, northern seashore, riverwash, pits and dumps, and "other."

Land Use

Major Land Owners

According to the County Tax Assessor's rolls, Planning Watershed 11.370026 is predominantly owned by the Stornetta family (28%). Georgia-Pacific Corporation (5%), Louisiana-Pacific Corporation (3%), and Coastal Forestlands, Ltd. (<1%) each own relatively small parcels within the Planning Watershed. The remaining is owned by two Rancherias and individual parcels.

Historic Land Use

The 1952 aerial photographs indicate that there was logging activity in Planning Watershed 113.70026 prior to 1952. Most of the activity is shown in a small drainage to the northeast of the Manchester Rancheria, south of Mountain View Road. In addition, the 1952 aerial photographs indicate that a substantial amount of property in Planning Watershed 11.370026 was cleared for agricultural prior to 1952.

In 1966, the California Department of Fish and Game published its "Stream Damage Surveys-- 1966" in which it rated the tributaries of the Garcia River was severely damaged, moderately damaged, lightly damaged or undamaged. The lower mainstem Garcia River was identified as lightly to moderately damaged.

Road density in this Planning Watershed is reported by the California Department of Forestry and Fire Protection at 4.82 mi/mi^2.

Hydrology

Drainage Area

1. *Acres*

Planning Watershed 113.70026 contains 7,847 acres. Runoff through this sub-basin originates in all of the sub-basins upstream of it, as well as within Planning Watershed

11.370026, itself. As such, the total drainage area of Planning Watershed 113.70026 is 73,223 acres.

2. *Flows*

The bankfull flows through Planning Watershed 11.370026 are unknown.

3. *Diversions*

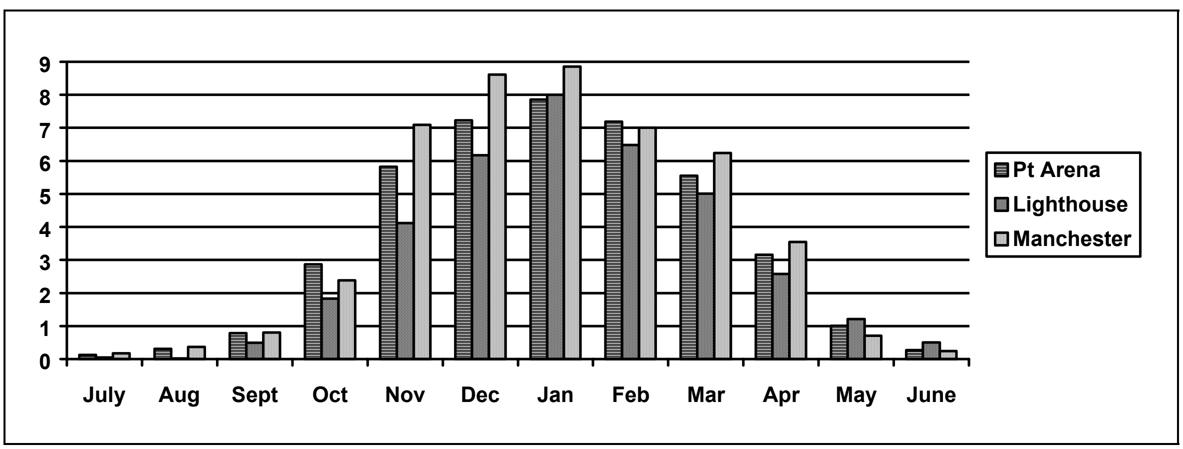
According to a table included in *Gualala Aggregates Sand and Gravel Project Draft Environmental Impact Report* (1994), the Point Arena Water Works has an appropriative water right of 0.220 cfs from Garcia River underflow. John Hooper has a riparian water right of 0.22 cfs from the Garcia River surface flow. The Stornetta's have a riparian water right of 3.0 cfs from surface flow and a total appropriative water right of 2.6 cfs from surface flow. Kendall has an appropriative water right of 0.22 cfs from surface flow. (See Appendix 15).

Precipitation

According to the Fire Resource Assessment Program of the California Department of Forestry and Fire Protection, the average annual rainfall in Planning Watershed 113.70026 is 45 inches with the headwaters of the most eastern tributary experiencing an average annual rainfall of 55 inches.

The average annual rainfall distribution in the vicinity of the Garcia River estuary indicates that the year's rainfall generally falls between October and April with the highest rainfall occurring in January.

Average annual rainfall distribution in the vicinity of the Garcia River estuary.



Geology

Geologic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program, including Planning Watershed 113.70026.

According to the Division of Mines and Geology map, the mainstem Garcia River as it enters Planning Watershed 113.70026, is primarily defined by the San Andreas fault which forms the valley in which the mainstem Garcia River flows. The northeast side of the valley is composed of Coastal Belt Franciscan of the Tertiary-Cretaceous period. it is well consolidated, hard sandstone interbedded with small amount so siltstone, mudstone and conglomerate; 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 southwest side of the valley is predominantly composed of the Galloway-Schooner Gulch formation from the Miocene-- a moderately consolidated sandstone.

The mainstem Garcia River takes a sharp left turn out of the San Andreas fault zone before crossing the coastal plain and entering the ocean at Point Arena. The coastal plain is composed of Marine Terrace Deposits of the Quaternary, Stream/River Channel Deposits of the Holocene, Alluvium of the Holocene, Dune Sand of the Holocene, and Galloway-Schooner Gulch Formation of the Miocene.

The Marine Terrace Deposits are poorly to moderately consolidated deposits of marine silts, sands, and quartz-rich pea gravels forming extensive flat benches paralleling the coastline; probably much more extensive than mapped; and in many places overlain by unconsolidated alluvial fan/colluvial deposits. The Stream/River Channel Deposits are composed of silt, sand, and gravel within the active stream channel and are characteristically unvegetated. The Alluvium is unconsolidatd silt, sand and gravel deposited by stream above the active channel; characteristically vegetated and locally includes stream/river channel deposits and undifferentiated valley fill. The Dune Sand is unconsolidated deposits of silt and fine sand, characteristically vegetated.

Geomorphic Features

The Division of Mines and Geology mapped geologic and geomorphic features of the Garcia River basin under its 1984 Watershed Mapping Program, including Planning Watershed 113.70026.

According to the Division of Mines and Geology map, there are a few small translational/rotational slides and earthflows. The Planning Watershed is otherwise characterized by periodic slides, numerous springs, disrupted ground, and extensive faults.

Below are excerpts of inspection reports written by staff at the Division of Mines and Geology and the Regional Water Board during pre-harvest inspections (PHI) of timber harvest plans (THPs) which pertain to the geomorphology of the region. Many of the locations identified were mapped by the inspector on maps included with the inspection reports. The map points are noted here for reference.

Primarily in Hathaway Creek

1. *THP 1-91-202*

This plan was located at T12N, R16W, Sections 4-5 and T13N, R16W, Sections 32-33. The Division of Mines and Geology inspector noted the following features during the preharvest inspection:

- Two possible landslides identified in the 1984 aerial photo review were verified with 1988 aerial photographs and in the field.
- Along the Garcia River there is an undercut northeast facing slope, oversteepened the slopes, and several ancient rotational landslides.
- The hillslopes affected by past debris flows are generally stable and well-vegetated.
- There is a Class III instream landing. The channel has eroded with the new channel constructed through the landing.
- An earthflow 100 foot long and 50-100 foot wide damaged a haul road.
- There is a shallow debris slide from undercutting of the embankment by stream erosion.
- Two rotational slides occurred in the Galloway-Schooner Gulch Formation. The first is 30 feet wide and extends downhill to the Class III watercourse and has a headscarp 5 feet high. The second is approximately 60 feet wide at the headscarp, 5 feet long and has a scarp 10 feet high.

2. *THP 1-96-423*

This plan was located at T12N, R16W, Sections 5,6 and 8. The Division of Mines and Geology inspector noted the following features during the PHI:

- No active landslides.
- Debris slide slopes mapped along the main Class I and II streams.
- The slopes between 60-75% are densely vegetated.
- There are signs of past debris sliding along the stream channel.
- An old road failed as a rotational slump which toes into the watercourse. The slide about 40 feet wide with sidescarps 4 to 5 feet high. (Map point F)
- A bank slump covers an old road covering 40 linear feet of trail. (Map point 6A)

Hathaway Creek

Channel Morphology

1. *Slope*

The GIS maintained by the Department of Forestry and Fire Protection calculates the slope in the lower reaches of Hathaway Creek to be less than 1%. Slopes gradually increase to 3% with short segments in the Class I stream exceeding 15%.

2. *Substrate Composition*

The Department of Fish and Game surveyor noted in his September 25, 1986 stream survey that 100% of the substrate evaluated in Hathaway Creek was silt.

3. *Width/Depth Ratio*--There are no known cross sections for Hathaway Creek.

4. *Confinement*

A team of technical experts from various local, state, and federal agencies concluded in their discussions of limiting factors in the Garcia River watershed, that Hathaway Creek was confined in its upper reaches and unconfined in its lower reaches.

5. *Bankfull Discharge*-- There is no known flow data for Hathaway Creek.

Aquatic Habitat

1. *Habitat Types and Distribution*

The Department of Fish and Game surveyor noted in his September 25, 1986 stream survey that the stream segment surveyed in Hathaway Creek was 75% pools, 5% riffles, and 20% runs. He concluded that there was good rearing habitat, but no spawning habitat for salmonids.

A wetland survey conducted on February 16, 1973 described a large freshwater marsh along the northeastern edge of Hathaway Creek just east of the Highway 1 crossing. The surveyor said that marsh vegetation was characterized by cattails, sedge, cow lily, and bur red interspersed with open water areas. Along the creek to the east and west of the marsh were riparian areas providing habitat of value to the wildlife, including willow and alder. To the north of the creek were gently rolling grasslands with steep hills to the south covered with coastal scrub community. The surveyor concluded that portions of the wetland area may dry up during the summer.

2. *Instream Cover*

The Department of Fish and Game surveyor noted in his September 25, 1986 stream survey that in the stream segment surveyed in Hathaway Creek, turbulence was rated as 5, instream objects were rated as 30, undercut banks were rated as 5 and overhanging vegetation was rated as 80. The instream cover ratings are based on the quality of the cover and the area of each cover component.

3. *Water Temperature*

According to the stream temperature data collected by Friends of the Garcia, stream temperatures in Hathaway Creek are within the preferred daily temperature range for coho and well below the maximum weekly average temperature criteria.

4. *Barriers*-- There is no known data regarding barriers in Hathaway Creek.

5. *Population Composition and Distribution*

Live Population Survey Results:

There are no known live population survey results for Hathaway Creek. However, anecdotal evidence suggests that there have been both steelhead and coho in Hathaway Creek in the past.

Redd survey and carcass survey results-- There is no known redd or carcass numbers for Hathaway Creek.

6. *Food Supply*-- There is no known food supply data for Hathaway Creek.

7. *Water Quality*-- There is no known water quality data for Hathaway Creek.

Mainstem Garcia River and Estuary

Channel Morphology

1. *Slope*

The GIS maintained by the Department of Forestry and Fire Protection calculates that the channel slope of the Garcia River mainstem through Planning Watershed 113.70026 to the ocean is less than 1%.

2. *Substrate*

Pebble counts were collected as part of the *Garcia River Watershed Enhancement Plan* (1992) but do not appear to have been analyzed. However, habitat typing conducted as part of this project indicate that 20% of the samples collected in the estuary had an embeddedness value of 1 (<25% embedded) and 80% of the samples had an embeddedness value of 2 (between 25-52% embedded). Further, the dominant bank substrate was identified as silt/clay/sand.

In a report issued by Pacific Watershed Associates on December 12, 1994 entitled "Sediment Sampling and Analysis, Lower Garcia River, Mendocino County, California," the consultants to Huffman and Associates and AT&T found that in none of the samples collected in 1994 did the clay sized particles exceed 0.4% of the total sample weight. In the control reach, clay sized particles ranged from 0.1-0.3% while in the impacted reach (impacted by a bentonite spill), clay sized particles ranged from 0.0-0.4% of the total sample weight. Fine sand (<0.063 mm) averaged 12.3% of the total sample weight. Fine pebbles (< 8 mm) averaged 47% of the total sample weight. The D_{50} for the control reach was 7.9 mm (fine pebbles) while the D_{50} for the impacted reach was 10.7 mm (medium pebbles).

Phillip Williams & Associates report in the *Garcia River Gravel Management Plan* (1996) very little change from 1991 to 1995 in the dominant substrate particle sizes in the lower Garcia River in the vicinity of Windy Hollow Road. Gravel was dominant in most habitat units except corner pools where sand was dominant.

3. *Width/depth ratio*

The *Garcia River Watershed Enhancement Plan* (1992) noted that major changes have occurred in the configuration of the estuary over the past 120 years. By 1929, historical maps show a widening of the estuary. Cross-sections collected in 1991 confirm that the estuary is generally more shallow than it was in the memories of old-timers interviewed. However, excavation to examine sediment strata showed some stratification but not thick layers that could be identified as major flood deposits.

Luna Leopold and Scott McBain under contract to Moffat and Nichols conducted a geomorphic investigation of the Garcia River estuarine reach. The results of their study were included in the *Garcia Estuary Feasibility Study* (1996). According to their report, cross-sections surveyed in 1991 and 1995 indicate that in the upstream reaches beyond the estuarine zone, deep scour holes had been eroded by high flows and when the flood was over, the holes filled again to about the elevation that had previously existed. The measurement on the estuarine zone, however, shoed that the channel responded in a slightly different manner. Most of the cross sections showed a lower thalweg, higher point bar, and narrower bankfull channel , such that the width-to-depth ratio decreased as a result of the two floods since 1991. Leopold and

McBain concluded that these results indicated channel "healing" (a lower width-to-depth ratio) suggesting that the estuary is responding to a more stable sediment load.

4. *Confinement*

The mainstem Garcia River is measured as unconfined in the reach past the Manchester Rancheria, moderately confined west of the Manchester Rancheria and confined from the Windy Hollow crossing to the Highway 1 bridge.

Aquatic Habitat

1. *Habitat Types and Distribution*

In support of the development of the Garcia River Watershed Enhancement Plan (1992) consultants to the Mendocino County Resource Conservation District conducted habitat typing in the Garcia River estuary. In a survey reach of 2,820 feet, the consultants found that

- Pools made up 56% of the stream reach
- 100% of the pools were greater than 3 feet
- 3% of the stream reach surveyed had large woody debris

In addition, the Department of Fish and Game surveyor noted in his 1987 stream surveys that an average of 22% of the stream reach surveyed was in pools, 14% in riffles, and 58% in runs.

Phillip Williams & Associates reports in the *Garcia River Gravel Management Plan* (1996)

- a reduction in the percentage of low gradient riffles from 1991 to 1995 (40% to 0%, respectively)
- an increase in the percentage of glides from 1991 to 1995 (20% to 47%, respectively)
- an increase in the percentage of runs from 1991 to 1995 (20% to 27%, respectively)
- no change in the percentage of corner pools from 1991 to 1995 (13%)
- an increase in the percentage of lateral scour pools from 1991 to 1995 (0% to 13%, respectively)
- a decrease in the percentage of secondary channel pools from 1991 to 1995 (7% to 0%, respectively)

2. *Instream Cover*

The Department of Fish and Game surveyor rated the instream cover in his 1987 stream surveys. The average shelter rating for turbulence was 4, for instream objects was 5, for undercut banks was 14, and for overhanging vegetation was 22. Instream cover is rated based both on the quality of the cover and its area.

Phillip Williams & Associates reports in the *Garcia River Gravel Management Plan* (1996) that the mean shelter rating for the lower Garcia River in the vicinity of Windy Hollow road was 35.9 in 1991 and 52.9 in 1995.

3. *Water Temperature*

Temperature data collected by the Friends of the Garcia indicate that temperatures in the lower mainstem and estuary exceed the preferred daily range for coho and hover around the maximum weekly average temperature for coho.

4. *Barriers*-- There is no known data regarding barriers in the lower mainstem and estuary.

5. *Population Composition and Distribution*

Live population survey results

Reported in the *Population Sampling on Three North Coastal Streams Closed to Summer Trout Fishing-- 1952 Season* by the Department of Fish and Game, 96 steelhead were counted at the Highway 1 bridge. No coho salmon were found. On August 22 and 23, the Department of Fish and Game seined the river just upstream of the Highway 1 bridge and counted 298 steelhead

Phillip Williams & Associates report in the *Garcia River Gravel Management Plan* (1996) the following changes in steelhead densities in the lower Garcia River in the vicinity of Windy Hollow Road. No coho were found. In 1991, 35% of the steelhead caught were 0+ fish, 57% were 1+ fish, and 8% were 2+ fish. In 1995, 31% of the steelhead caught were 0+ fish, 66% were 1+ fish and 3% were 2+ fish.

Habitat type	1991 (fish/mi)	1995 (fish/mi)
Runs	3,689	0
Glides	4,251	0
Corner pools	2,700	9,851
Lateral scour pools	3,351	1,414

Redd survey and carcass survey results-- There is no known data regarding redds or carcasses in the in lower Garcia River.

6. *Food Supply*

Benthic surveys conducted as a result of the AT&T bentonite spill in 1992 have found an abundance of benthic organisms in the lower Garcia River. (See Huffman and Associates 1993, 1994 and 1995).

7. *Water Quality*

The North Coast Regional Water Quality Control Board collected water quality samples at the Highway 1 bridge in 1989 and 1990. None of the parameters exceeded the limits established in the Basin Plan or by the U.S. EPA for dissolved oxygen, total dissolved solids, or total ammonia.