# *Watershed Assessment*

# *and*

# *Cooperative Instream Monitoring Plan*

# *for*

# *The Garcia River*

# *Mendocino County, California*

**Compiled for the Mendocino County Resource Conservation District and the California Department of Forestry and Fire Protection**

**by**

**Forest, Soil & Water, Inc.**
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**Executive Summary**

This report develops an Instream Monitoring Plan for the Garcia River watershed, Mendocino County, California. In so doing, it (1) estimates sediment sources through a remote analysis, (2) synthesizes impact and sensitivity data, (3) evaluates present information and data collection needs in the watershed, (4) proposes data collection protocols, an implementation plan and a budget, and (5) suggests sites for conjunctive hillslope-instream monitoring.

The report includes maps and tables of mass wasting and road-related sediment sources, based on aerial photography and Department of Forestry mapping, covering the entire watershed. Unadjusted estimated erosion rates range from 120 to over 800 tons per square mile per year. Mass wasting erosion was found to correlate at a greater than 99% significance to relative watershed relief. Sediment delivery rates for shallow rapid mass wasting features were assumed to be 50%, but may be higher.

Synthesis of watershed information found no areas of low sedimentation, some areas with no fisheries, and no areas insensitive to land management. Synthesis also found disagreement among evaluators about relative conditions and sensitivities of several watersheds for several factors, principally canopy and sediment effects. A number of tributaries were affected by deep sedimentation, presumably from logging and road construction in the 1950's and 1960's, to which the streams continue to respond. The San Andreas fault zone also exerts a significant influence on sediment condition in some sub watersheds.

Evaluation of data sources found that, while some streams had many studies and others had little effort at data collection, few studies were quantitative. Sites for instream monitoring were selected by evaluating where data are most critically missing, where further monitoring will build a useful record from past studies and where cooperative monitoring will be most effective.

Protocols selected were chosen to evaluate water quality, gravel quality, channel quality, riparian function, causal mechanisms and fisheries. The connection from stream to hillslopes, to determine the effectiveness of site controls in forestry practices, may best be found in watersheds with present and future timber harvest, the best fisheries and salmonid habitat, and the most clear examples of watershed problems. Control sites should also be established. Long-term analysis of the effectiveness of harvest controls, as measured through instream, airphoto and forensic methods, will work to validate present methods of understanding the watershed effects of logging.

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APPENDIX **A.** LOCATION AND VOLUMES OF MASS WASTING SITES (in a separate volume)

APPENDIX **B.** MATRIX OF RESOURCE CONDITION AND SENSITIVITY (in a separate volume)

APPENDIX **C.** INVENTORY HISTORY IN THE GARCIA RIVER WATERSHED (in a separate volume)

APPENDIX **D.** SELECTED PROTOCOLS (not included in this, KRIS edition of WA)

## 1. Introduction

The Garcia River watershed drains 113 square miles of rugged forest and grasslands in southwestern Mendocino County, California. Part of the Coast Range, the watershed includes the San Andreas fault zone, down which the Garcia and its South Fork run. The watershed contains over 150 miles of perennial streams, including 40 miles of the Garcia mainstem, and drains directly into the Pacific Ocean. There are more than 25 named streams within the watershed, draining individual watersheds of greater than one square mile each. The land is the setting for modern activities of timber harvesting, cattle ranching, dairy, gravel mining and residence, among other uses. Landowners include timber companies, independent ranchers, an Air Force base, a Rancheria, and residential and non-industrial holdings.

This report includes a watershed assessment and instream monitoring program (IMP) for the Garcia River. The goal of this project has been to develop an instream monitoring approach for the evaluation of hillslope conditions and actions, their causal impacts in receiving waters, and best management practices (BMPs) which reduce those effects. The targeted use of this report is the evaluation of California's Forest Practice Rules and their implementation in the Garcia River watershed.

This report has been prepared by Forest, Soil & Water, inc. of Healdsburg, California (FSW), under a contract with the Mendocino County Recourse Conservation District (MCRCD). The MCRCD itself has contracted with the State of California's Department of Forestry and Fire Protection (CDF) to implement a cooperative monitoring program on the Garcia, to assess "the effectiveness of... [CDF's] Forest Practice Program... in protecting the beneficial uses of water." (MCRCD 1997)

The implementation of instream monitoring in the Garcia watershed is an outgrowth of the Department of Forestry's Monitoring Study Group (MSG) and its Pilot Monitoring Program (PMP). The PMP recommended a long-term monitoring program (LTMP) in order to:

- "Provide an ongoing assessment of the effectiveness of the [Forest Practice] Rules, as implemented, in protecting the most sensitive beneficial uses of water (i.e. coldwater fisheries and domestic water supplies) through implementation monitoring, effectiveness monitoring and project monitoring.

- "Provide the results to the BOF [Board of Forestry] and the public in a timely manner to contribute effectively to the BOF's program for reviewing and, where necessary, strengthening the Rules' performance as BMPs."

(Lee, 1997)

The Garcia watershed was selected as a site for the LTMP. Its landowners were willing, several of its subwatersheds are dominated by timber harvesting, and its history of impacts made it a good candidate for trend monitoring.

The urgency of developing monitoring protocols which fit the Garcia River and the North Coast is underscored by the listing process for coho salmon and steelhead trout currently underway for this region. The National Marine Fisheries Service (NMFS) has listed coho as *threatened under* the Endangered Species Act (ESA) south of the Mattole, and is expected to expand the listing *of threatened to* steelhead in the near future. This project is of the utmost urgency for regulatory implementation by the host of agencies who protect fisheries in the region, and for the adaptive management of land use impacts to reduce their causal effects on coho and steelhead populations.

The most important goals of this report are to articulate objectives for sampling, protocols to meet those objectives, and tributary streams which are priorities for evaluation. To do this, we have reviewed relevant literature, identified studies which have been conducted in the Garcia, calculated erosion rates for the watershed, synthesized impact and sensitivity data, and reviewed air photos. In this report, we identify who has conducted monitoring, what monitoring appears to be important for continuation, who should conduct that monitoring, and how and where it should be done.

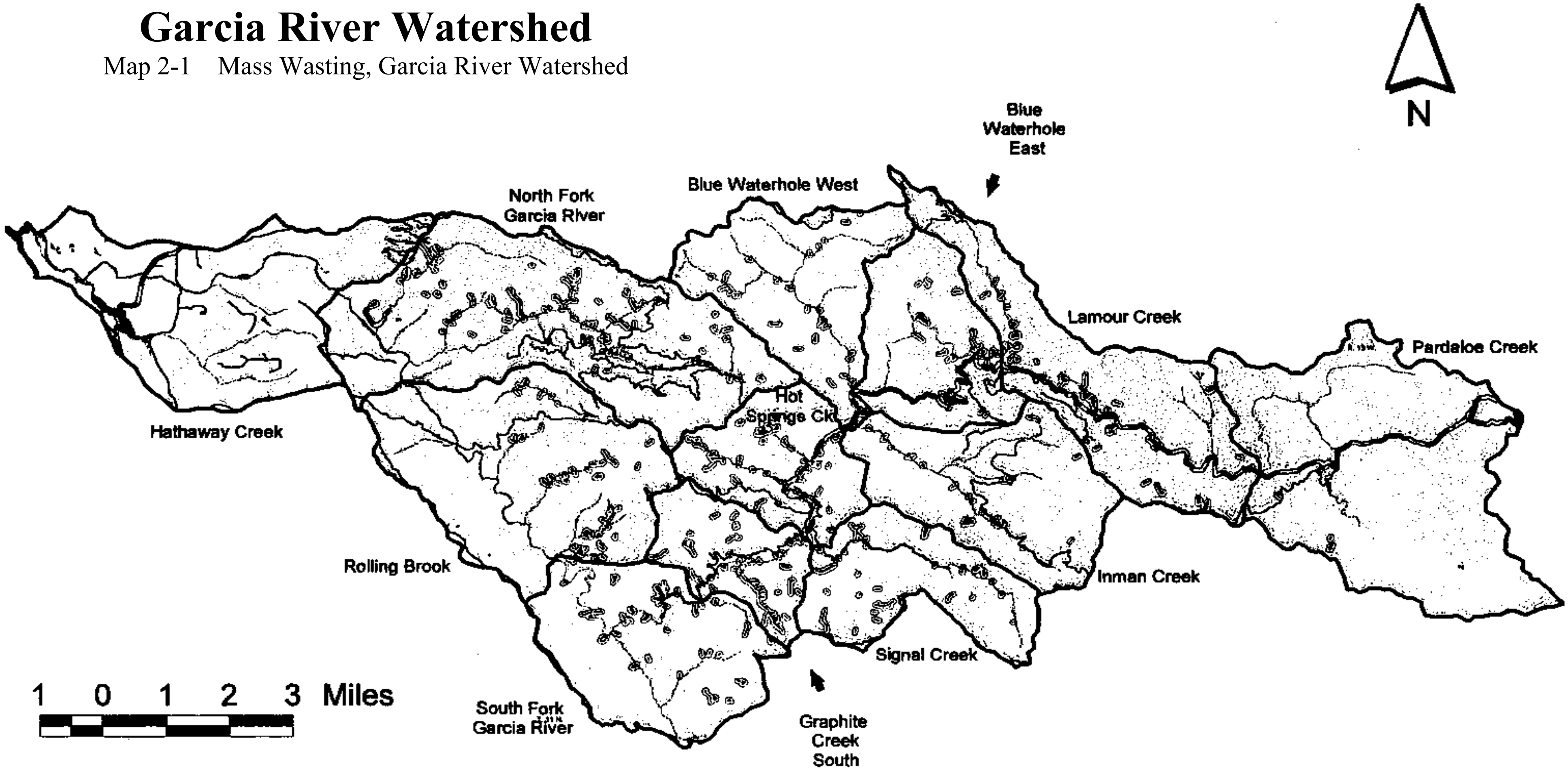
## *2. Maps of Watershed Assessment Areas*

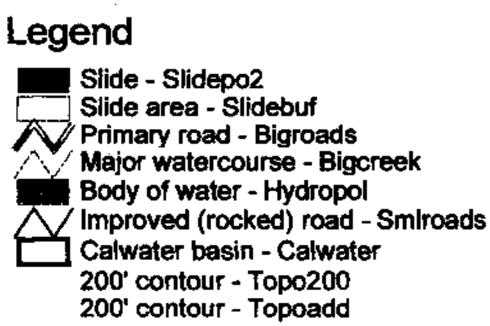
Maps of the watershed are included as Maps 2-1 and 2-2. Both maps are of the entire, 74,000 acre watershed. The whole watershed was included to assure uniformity in assessment, so that equal levels of effort and identical assessment processes were used for the development of Task 2, mass wasting and surface erosion modules.

Map 2-1 focuses on landslides, Map 2-2 on road systems. These data were included in Mass Wasting and Surface Erosion Modules, developed and put forth in Chapter 3.

# Garcia River Watershed

Map 2-1    Mass Wasting, Garcia River Watershed



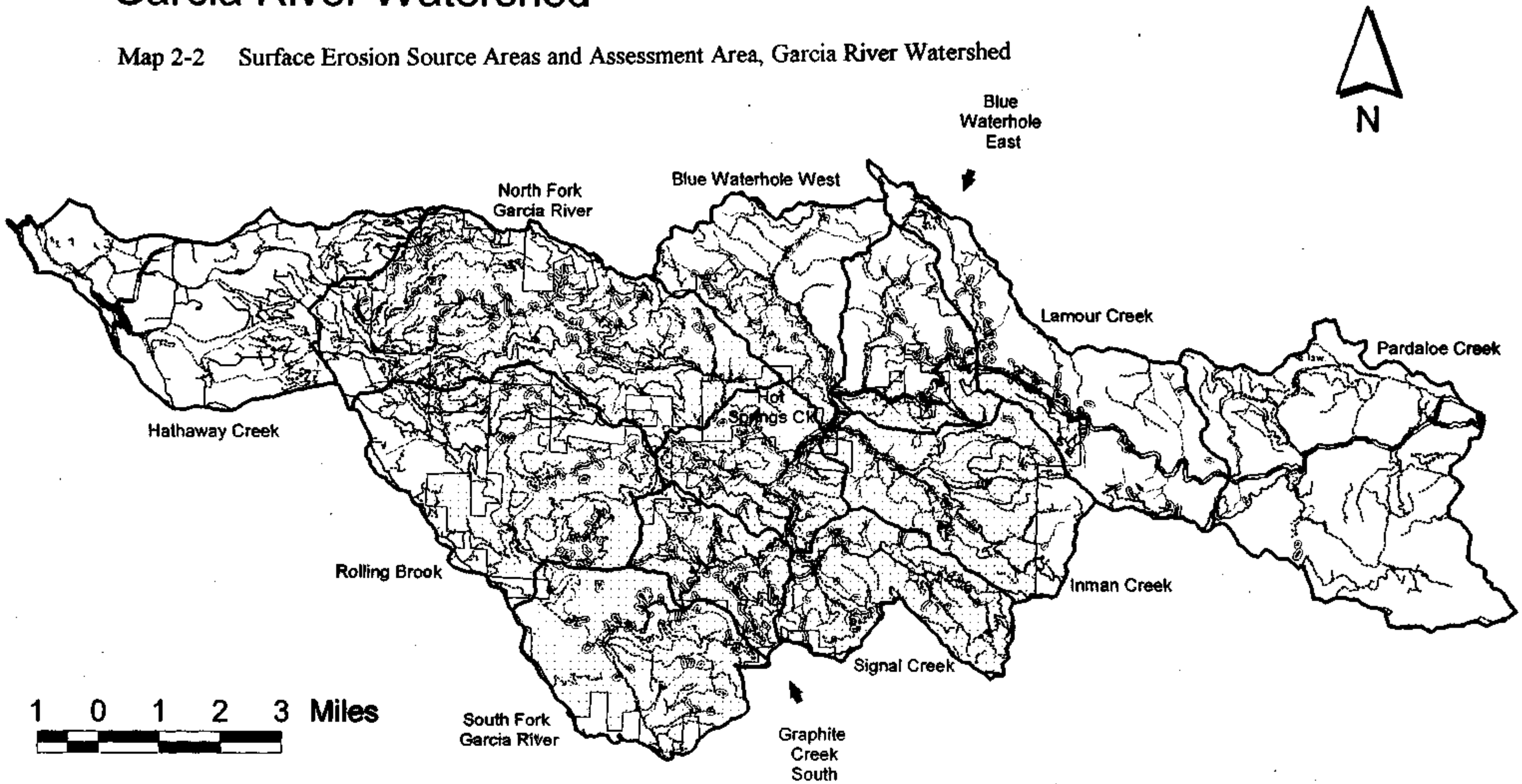




**Level I Mass Wasting Assessment**
**Prepared for Mendocino County Resource Conservation District**
**by**
**Forest, Soil & Water**
**East-West Forestry**
**O'Connor Environmental**
**December 1997**

Sources: CDF GIS database (Santa Rosa) & field/aerial survey data by O'Connor Environmental, Inc

# Garcia River Watershed

Map 2-2 Surface Erosion Source Areas and Assessment Area, Garcia River Watershed




## Legend

- Primary road - Bigroads
- Major watercourse - Bigcreek
- Body of water - Hydropol
- Class II watercourses Smlcreek
- Improved (rocked) road - Smlroads
- Slide area - Slidebuf
- Slide - Slidepo2
- Mapped unimproved & temporary roads - Tmproads
- Calwater basin - Calwater
- Assessed Area -- Coastal Forestlands - Cflbnd
- Assessed area -- Louisiana-Pacific - Lp

Level I Mass Wasting Assessment
& Areas Assessed by Other Parties
Prepared for Mendocino County Resource Conservation District
by
Forest, Soil & Water
East-West Forestry
O'Connor Environmental
October 1997

Sources: CDF GIS database (Santa Rosa) & field/aerial survey data by O'Connor Environmental, Inc.

### 3. *Mass Wasting and Surface Erosion Modules*

#### *A. Mass wasting assessment*

**i. Introduction**

This analysis of mass wasting (landslide-related erosion) was conducted in accordance with guidelines of the Washington Department of Natural Resources (DNR) Standard Methodology for Conducting Watershed Analysis, Version 3.0 (WFPB, 1995). Under the terms of the contract with the Mendocino County Resource Conservation District, the analysis was conducted at "Level 1". This lower-level of analytic intensity, and the limited funds available for the analysis, provides only for preparation of a map of historic landslides based on aerial photo interpretation and development of estimates of historic sediment delivery to the Garcia River and its tributaries.

Some of the estimates presented in early sections of this assessment were revised on the basis of new data. These modifications are presented in the section of this assessment entitled "Suggestions for Further Work." Quantitative estimates of sediment production presented in that sections are considered likely to be more realistic. The prior estimates are preserved to record the assessment process and the impact of new data.

The initial Request For Proposal (RFP) and subsequent contract provided for an analysis to complement analyses prepared for the large commercial forest ownerships (MCRCD 1997). During the inventory phase of the project, the scope was expanded to include the entire Garcia River watershed.

**ii. Limitations**

This analysis was prepared to provide data on historic sedimentation and erosion in the Garcia River watershed. The method specified by the RFP is an established procedure of the State of Washington that has been used for watershed analysis in other western States, including Montana and Oregon. O'Connor Environmental, Inc., has performed two prior Level 2 mass wasting assessments in Washington, and is certified in Washington as qualified to perform the assessment. This assessment is not intended for purposes related to the prediction of future mass wasting or development of mass wasting hazard maps; the results of this assessment are only intended for the uses specified under the scope of the RFP. In addition, the scope of work for the project did not allow for significant field time to check the accuracy of photo interpretation. Therefore, conclusions must be regarded only as generalizations valid in the context of assessing erosion and sedimentation in the Garcia River watershed over a period of about the last 40 years.

**iii. Watershed Conditions**

The general history of land-use and past and present conditions in the Garcia River watershed have been described elsewhere. Among the previous sources reviewed during this assessment were geomorphic maps of portions of the watershed prepared by the California Division of Mines and Geology (CDMG, 1984), the Garcia River Watershed

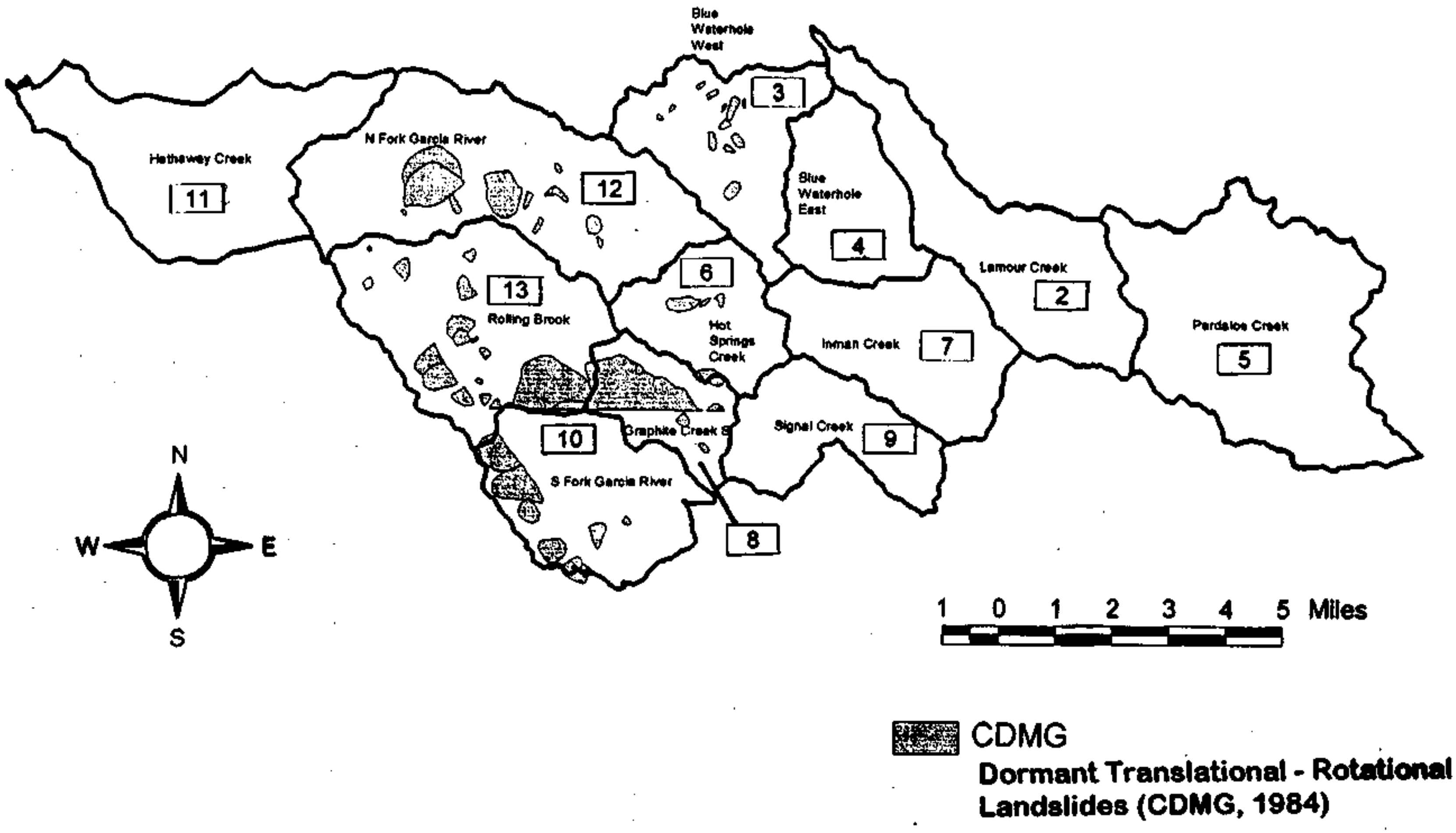
Enhancement Plan (MCRCD, 1992), the Garcia River Gravel Mining Plan (Philip Williams & Associates, Ltd., 1996), Sustained Yield Plan documents and other watershed assessments prepared by Louisiana Pacific Corporation and Coastal Forestlands, and published soil surveys for the region (USDA, 1972).

### iv. Methods

Historic erosion in the Garcia River watershed was assessed by an inventory of mass wasting sites visible on historic aerial photographs of the area. Photo sets utilized were from 1965, 1978, and 1996. All photography was black and white, and approximate photo scales determined by scaling photos to U.S.G.S. topographic maps were 1:20,000, 1:24,000, and 1:13,000. Aerial photos were inspected using a mirror stereoscope under 3x magnification. Mass wasting sites were mapped on U.S.G.S. topographic maps from the location of the site in relation to stream channels, valleys, ridges and roads visible in both the stereo image and the topographic map. In addition, transitional/rotational landslides and earthflows mapped by the California Division of Mines and Geology (1984a, 1984b) were considered in mapping mass wasting sites (Map 3-1).

Mass wasting processes at inventoried mass wasting sites were interpreted and classified in one of three types: shallow rapid, debris torrent, and persistent deep-seated. Shallow rapid mass wasting typically occurs in areas of shallow soil with a relatively impermeable substratum during rainstorms when soil pore water pressure rises rapidly. Where the topography concentrates subsurface water (e.g. convergent slope form), pore pressure tends to rise more rapidly, increasing the potential for mass wasting. These mass wasting events are more likely on steeper slopes, generally in excess of 60%. Under natural (unmanaged) conditions, shallow rapid landslides frequently occur on steep slopes on inner gorge landforms adjacent to stream channels, but may be found almost anywhere soils are present and slopes are sufficiently steep. Sediment production by shallow rapid landslides typically includes the material overlying the failure surface. Sediment flows downhill varying distances, typically on the order of hundreds of feet. Delivery of sediment to streams depends largely on the proximity of the mass wasting site to a channel and conditions of the intervening slope.

Debris torrents (also referred to as debris flows) are initiated by shallow rapid landslides (described above), but have the potential to scour additional material from steep stream channels and narrow headwater valleys, greatly enlarging the volume of sediment produced. Debris torrents typically are initiated near a channel head or adjacent to a headwater stream during rainstorms; the failure mechanism is similar to that of a shallow rapid mass wasting site. Debris torrents commonly originate on steep slopes with convergent topography that funnels failed material into a steep, narrow headwater valley. Most of the sediment is delivered to a stream channel, but much may also be deposited in channel margin terraces and in fan deposits at the mouth of tributaries.




Map 3-1. Garcia River Planning Watersheds and Large, Dormant Landslides

Persistent, deep-seated landslides are typically larger, deeper mass wasting features that are usually adjacent to stream channels. These mass wasting sites may be dormant for long periods, and can be reactivated or initiated when sufficient quantities of water enter the soil column, increasing pore pressure and weight, typically during relatively wet water years. Periods of high stream flow may undermine the toe of such landslides, triggering an episode of motion. Seismic events may also trigger or reactivate deep seated landslides. Typically, most of the material in a deep-seated landslide that moves remains on the slope, albeit displaced down slope. Erosion at the toe of deep-seated landslides usually accounts for most of the sediment delivered to stream channels.

A variety of other observations and interpretations were made for each identified mass wasting site. Confidence in interpretation of the mass wasting feature was stated as either definite, probable, or questionable. Whether sediment was delivered to a stream channel was assessed as affirmative or negative (no attempt was made to assess the proportion of delivery from the aerial photo image). The stream order to which sediment was delivered was estimated from the topographic map. Land use or uses associated with the mass wasting site were recorded as road-related (when the mass wasting site was adjacent to a road), harvest-related (when the site was in a recently-logged area, but the proximity of a road was not noted), or natural when evidence of neither road nor harvest was observed in the photo image. Harvest techniques in this watershed typically involve ground skidding of logs, so skid trails were abundant. It was not always possible to distinguish between mass wasting that may have occurred in relation to a skid trail from those related to harvest alone. Sites where a road bed or skid trail was clearly evident and proximate to the slide were attributed to roads, in part because it was not always possible to distinguish between roads and skid trails, and in part because landslide initiation mechanisms related to roads and skid trails would be expected to be similar. Harvest-related sites include an indeterminate number of sites attributable to skid trails. The shape of the slope in plan view at the top of mass wasting sites was observed and recorded as convergent, planar or divergent.

Finally, the size of each mass wasting site was either measured or classified according to size classes where small sites were <500 $yd^2$, medium were >500 and <2000 $yd^2$, large were >2000 $yd^2$ and <5000 $yd^2$, and extra large were >5000 $yd^2$. For debris torrents and deep-seated landslides, the areas of virtually all sites were measured on the photo, with dimensions of length and width transformed to estimate ground dimensions. For the more numerous shallow rapid mass wasting features, at least 20% of the mass wasting sites were measured (every fifth site). The purpose of measurements was to facilitate estimates of sediment production based on inventory data.

Mass wasting sites and other geomorphic features mapped by CDMG included shallow landslides and deep-seated (translational-rotational) landslides. The limited scope of this project made it infeasible to compare shallow landslides mapped by CDMG with shallow landslides mapped for this project. Larger, deep-seated landslides mapped by CDMG were predominantly classified as "dormant;" no sediment production or delivery was estimated for these mapped sites.

To estimate sediment delivery from mass wasting sites to stream channels, it was assumed that mass wasting sites that did not appear to deliver sediment to stream channels delivered zero sediment. For the mass wasting sites where photo-interpretation revealed evidence of sediment delivery to stream channels, assumptions were made regarding the depth of soil material affected by mass wasting and the proportion of sediment delivery according to Table 3-1.

Depths were based on conservative assumptions. Typical soil profiles for the dominant forest soils in the Garcia range from 3 to 5 ft depth (USDA, 1972). For shallow rapid landslides, the depth of failure is typically to the soil/bedrock boundary. However, the assumed depths of failure are also applied to estimate erosion of soil on hillslopes below landslide initiation sites as well as erosion of headwater channels by debris torrents. Given the range in variation of soil depth, and prior experience regarding depth of erosion of hillslopes and channels, the conservative value of 3 ft was selected.

For persistent deep seated landslides, soil depths are generally several times greater than those found in areas with shallow soils underlain by bedrock. The assumed value of 15 ft is based on observed minimum heights of deep-seated landslide toes adjacent to stream channels in mountainous terrain. This height determines the assumed landslide geometry and resulting estimates of landslide volume; it generates a conservative, minimum estimate.

Delivery rates are based on previous experience with delivery rates for these mass wasting processes as observed in other watershed analysis projects (e.g. West Satsop Watershed Analysis, 1996), and are conservative. These delivery rates should be considered as contributing to a minimum estimate of sediment delivery from mass wasting sites observed on aerial photographs.

*Table 3-1. Assumed depth of soil material subject to mass wasting and assumed percentage of sediment delivered to stream channels by mass wasting process.*

| Mass Wasting Process | Assumed Depth of Mass Wasting (ft) | Assumed Delivery Rate (%) |
|---|---|---|
| Shallow Rapid | 3 | 50 |
| Debris Torrent | 3 | 75 |
| Persistent Deep Seated | 15 | 25 |

Sediment volumes delivered to stream channels were then calculated for each mass wasting site based on the measurements of surface area and the assumptions in Table 3-1. In cases where the area of the mass wasting site was not measured (i.e. it was classified according to size), the median area of mass wasting sites in that size class and process category was used as an estimate of area. In cases where a mass wasting site persisted from one set of photographs to the next, additional sediment production and delivery was assumed to occur only if the size of the mass wasting site increased. If an increase in size occurred, sediment production and delivery was computed as the increment of increased mass wasting area.

The mass wasting sites were assigned to designated CALWAA subwatersheds. This allowed for sediment production from mass wasting to be estimated for smaller areas within the watershed.

**v. Results**

Aerial photography revealed 447 mass wasting sites that were inventoried. Of these, 85% were classified as shallow rapid, 11% as debris torrents, and 4% as persistent deep-seated. One-third (33%) of the mass wasting sites were first observed on the 1965 photographs, while 40% first appeared on 1978 photography, and the remaining 27% were first observed in the 1996 photography. About 38% of the mass wasting sites first observed on 1965 photos remained visible in 1978 photos, and 7% remained visible in 1996 photos. Another 3% of sites first observed in 1965 photos were not visible in 1978 photography but reappeared in 1996 photography. Of the mass wasting sites first observed in 1978 photography, about 24% remained visible in 1996 photographs. About 83% of inventoried mass wasting sites were classified as delivering sediment to stream channels.

Among shallow rapid mass wasting sites, about 60% were associated with roads (i.e. they occurred near a visible road or skid trail), about 22% were associated with harvest (i.e. they occurred in an area where timber harvest had occurred, but were not near a visible road or skid trail), and about 18% were inferred to be of natural origin (they were not observed to be in close proximity to either roads or skid trails, nor did they appear to be in a previously-harvested area). The distribution of debris torrents was similar, with about 63% associated with roads, 16% with harvest, and 11% natural causes. Inferences regarding the influence of land management on persistent deep seated mass wasting sites are subject to greater uncertainty. About a quarter of observed active persistent deep seated landslides appeared to have occurred in areas where no recent management activities were evident, while the remaining three-fourths occurred in areas where roads and/or harvest had occurred. Note that the techniques used to inventory mass wasting sites did not include significant field observations, making inferences regarding cause and effect highly tentative.

Slope form at shallow rapid mass wasting sites was predominantly planar (42%) and convergent (41%), with distinctly fewer sites on divergent slopes (17%). Debris torrents occurred primarily on convergent slopes (64%), with a significant number occurring on planar slopes (31%), and few (4%) on divergent slopes.

Maps of inventoried landslides and inventory data are provided in map 2-1 and Appendix A. Roads are shown on Map 2-2. Full size maps also accompany the master of this report.

### vi. Sediment Delivery Estimate

As described in the methods section, the dimensions of a large number of mass wasting sites were measured on aerial photographs to estimate their area. Shallow rapid mass wasting sites were by far the most numerous; 34% of these features were measured on photographs. These data were then used to estimate the area of sites that were classified according to size, but not measured. In case of debris torrents and persistent deep-seated mass wasting sites, a much higher percentage of inventoried sites were measured (89% and 83%, respectively). Table 3-2 provides a summary of data used to estimate the area of mass wasting sites which were classified according to size but not measured.

Estimated sediment delivery was converted to units of tons (English) from units of cubic feet based on assumed average bulk density of 1.5 Tons/$m^3$. The sediment delivery estimates are reported for each CALWAA sub-basin; the sub-basins are shown in Map 3-1. The estimates are expressed in terms of total tons of sediment delivered in each time interval (Figure 3-1), and in terms of the sediment delivery rate in each time interval (Figure 3-2). The former provides perspective on the total sediment contribution by mass wasting process over the period of record. The latter provides a comparison of the intensity of mass wasting in each subwatershed.

*Table 3-2. Mass wasting site area sample statistics. The median area rather than the mean area was used to estimate areas of sites that were classified according to size, but not measured.*

| Process-Size | Number of Observations | Median Area ($ft^2$) | Mean Area ($ft^2$) | Coefficient of Variation (Std. Error/Mean) |
|---|---|---|---|---|
| SR-S | 17 | 3400 | 3400 | 0.053 |
| SR-M | 57 | 9450 | 10000 | 0.050 |
| SR-L | 46 | 25400 | 28500 | 0.045 |
| SR-XL | 9 | 55000 | 57100 | 0.052 |
| DT-S | 3 | 3700 | 3730 | 0.048 |
| DT-M | 14 | 9850 | 10800 | 0.110 |
| DT-L | 17 | 26000 | 27700 | 0.062 |
| DT-XL | 8 | 59900 | 61400 | 0.270 |
| PD-L | 4 | 37900 | 37900 | 0.016 |
| PD-XL | 11 | 87000 | 137000 | 0.300 |

To calculate rates, it was necessary to have a time period over which observed landslides occurred. For the first set of photos from 1965 it was assumed that mass wasting occurred beginning in 1957 (i.e. over a period of 8 years). For the 1978 photographs, the time interval between 1965 and 1978 (13 years), was used. Similarly, for the 1996 sets of photographs, the time interval of 18 years was used. The first interval of 8 years is a conservative estimate of the interval over which observed landslides occurred; it is likely that some of the observed sites were more than 8 years old. The 8 year period corresponds to the length of time required for half of the mass wasting sites that revegetated or became otherwise unnoticeable on aerial photos to attain that condition for the intervals between 1965-1978 and 1978-1996.

Figure 3-1 and Figure 3-2 suggest that mass wasting activity has abated significantly in the watershed as a whole since 1978, with subwatershed maxima occurring either in the interval prior to 1965 or the interval prior to 1978. Only in the case of Inman **Creek** did either the amount or rate of sediment delivery attain its maximum in the 1996 photo-interval.

Comparison of Figure 3-1 with Figure 3-2 highlights the differences between sub watersheds to which overall sediment delivery was high (Figure 3-1) with those in which the sediment delivery rate (Figure 3-2) was high. For example, the North Fork subwatershed has produced relatively high quantities of sediment in the 1978 and 1996 time intervals (Figure 3-1), but the rate of sediment delivery, which adjusts for both subwatershed area and the length of the time interval, is relatively low (Figure 3-2). In the case of subwatershed 8, which encompasses Eureka Hill on its northwest comer and Gualala Mountain on its southeast corner, the maximum sediment delivery rate by mass wasting occurred in the first time interval (Figure 3-2). In terms of the quantity of sediment delivered from sub- watershed 8, the amount was relatively large, but was exceeded in five cases (Figure 3-1).

Table 3-2 summarizes data from the mass wasting inventory over the full period of record, approximately 1957 to 1996. These data supplement Figures 3-1 and 3-2 and can be used to rank subwatersheds according to their contributions of sediment to the Garcia River watershed. For example, the three subwatersheds that have contributed the most sediment as the result of mass wasting are the North Fork Garcia, Larmour Cr., and #3. In contrast, the subwatersheds with the highest delivery rates are #8, #4, and #3. The subwatersheds with the lowest sediment delivery and delivery rates are the same: Hathaway Cr., Pardaloe Cr., and Signal Cr.

Figure 3-1. Volume of Sediment Delivery from Mass Wasting, by Subwatershed over Time.

**Figure 3-1. Sediment Delivery by Mass Wasting by Sub-watershed, Garcia River, c.1957-1996**

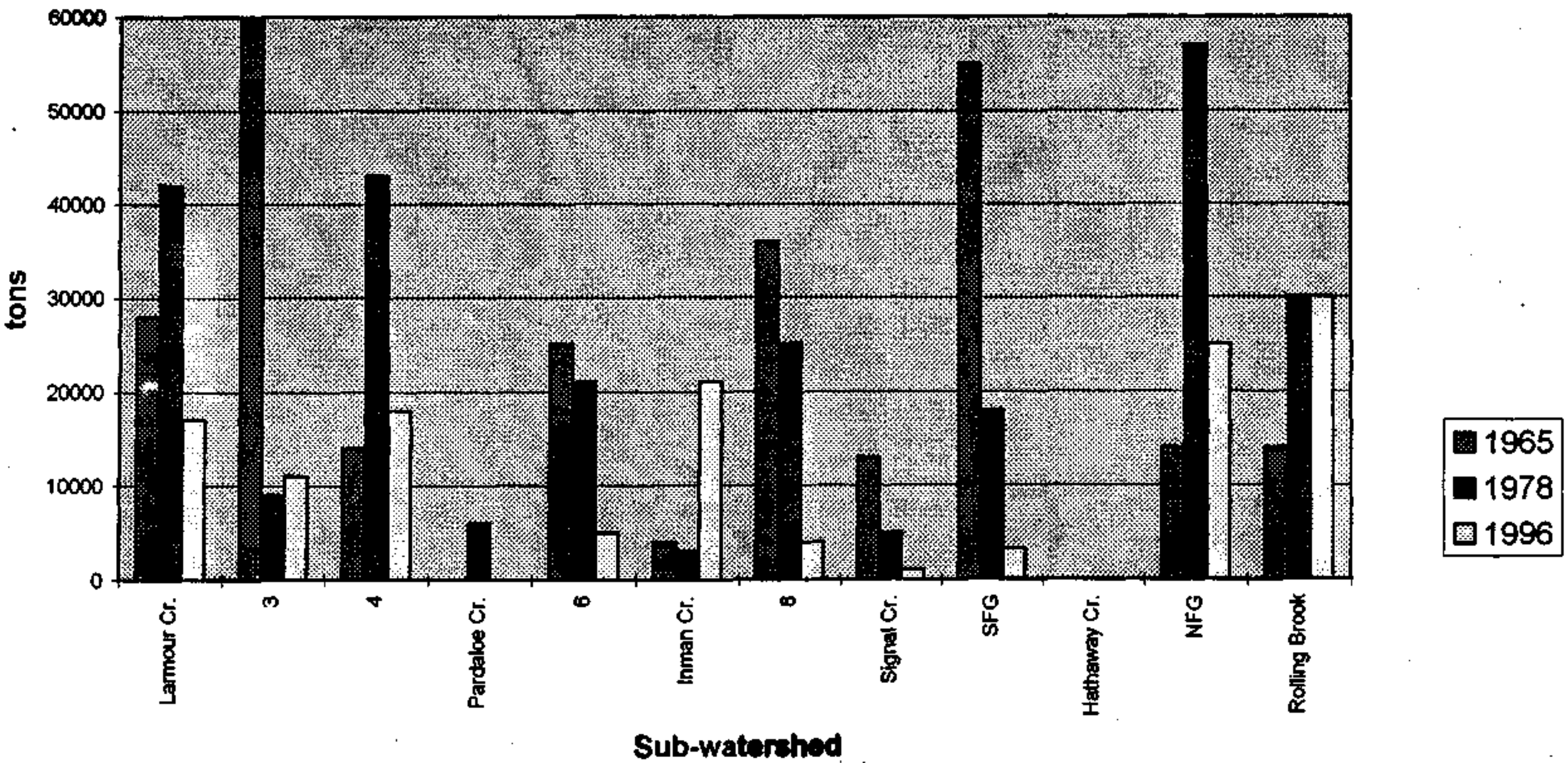


Figure 3-2. Rate of Sediment Delivery from Mass Wasting, by Subwatershed over Time.

**Figure 3-2. Sediment Delivery Rate by Mass Wasting, Garcia River, c.1957-1996**

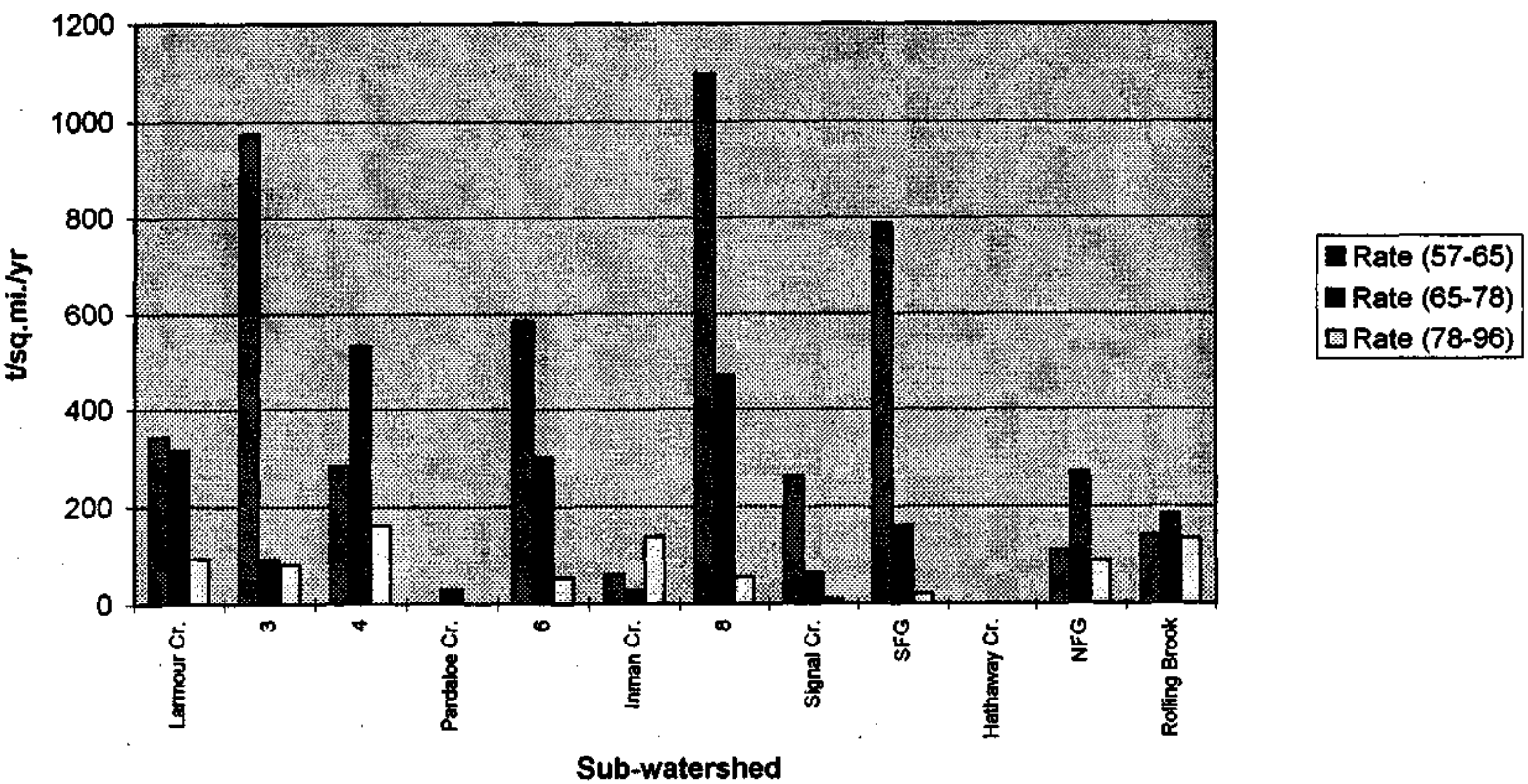


*Table 3-2, Estimated total sediment delivery and average sediment delivery rates from mass wasting over the period of record (approximately 1957 to 1996) for individual subwatersheds, Garcia River.*

| Sub-watershed | Area ($mi^2$) | Sediment Delivery (t) | Sed. Delivery Rate ($t/mi^2/yr$) |
|---|---|---|---|
| Larmour Cr. | 10.2 | 87,000 | 213 |
| 3 | 7.7 | 80,000 | 260 |
| 4 | 6.2 | 75,000 | 302 |
| Pardaloe Cr. | 16.4 | 6,000 | 9 |
| 6 | 5.4 | 51,000 | 238 |
| Inman Cr. | 8.6 | 28,000 | 82 |
| 8 | 4.1 | 65,000 | 396 |
| Signal Cr. | 6.2 | 19,000 | 77 |
| South Fork Garcia | 8.7 | 76,200 | 218 |
| Hathaway Cr. | 12.3 | 0 | 0 |
| North Fork Garcia | 16.2 | 96,000 | 148 |
| Rolling Brook | 12.5 | 74.000 | 148 |
| TOTAL | 114 | 657.000 | 144 (avg.) |

### vii. Interpretation and Implications of Results

The results reported above are put in context along with sediment delivery estimates from the Surface Erosion assessment in a subsequent section.

## B. Surface Erosion Assessment

### i. Introduction

This analysis of surface erosion was conducted in accordance with guidelines of the Washington Department of Natural Resources Standard Methodology for Conducting Watershed Analysis, Version 3.0 (WFPB, 1995). Under the terms of the contract with the MCRCD, the analysis was conducted at "Level 1". This lower-level of analytic intensity, and the limited funds available for the analysis, allowed only for preparation of a generalized road erosion assessment, and rough estimates of potential past and present skid trail erosion. The assessment was based largely on road data in a Geographic Information System (GIS) maintained by the CDF, shown in map 2-2, and information regarding skid trail density derived from aerial photographs. These data were used to assess erosion from existing and historic roads over a period of the past 40 years. It should be noted that the Washington Methodology (WM) only requires an evaluation of the existing road system, and does not specify that an assessment of historic roads be performed.

The initial RFP and subsequent contract provided for an analysis to complement analyses prepared for the large commercial forest ownerships. During the inventory phase of the mass wasting assessment, the scope was expanded to include the entire Garcia River watershed.

### ii. Limitations

This analysis was prepared to provide data on historic sedimentation and erosion in the Garcia River watershed. The method specified by the RFP is an established procedure of the State of Washington that has been used for watershed analysis in other western States, including Montana and Oregon. O'Connor Environmental, Inc., is certified in Washington as qualified to perform the assessment. The results of this assessment are only intended for the uses specified under the scope of the RFP. In addition, the scope of work for the project did not allow for significant field time to check the accuracy of assumptions required to complete the assessment. Therefore, conclusions must be regarded only as generalizations valid in the context of assessing erosion in the Garcia River watershed over a period of about the last 40 years.

### iii. Watershed Conditions

The history of logging in the Garcia River watershed is summarized in the Garcia River Watershed Enhancement Plan (Monschke and Caldon, 1992). Early logging (c. 1900) occurred in much of the North Fork watershed, and to a limited extent further upstream. The next major period of logging began in the 1950's when the use of caterpillar tractors allowed for what was primarily selective harvest in the more rugged terrain in the middle and upper watershed. Selective logging using tractors and skid trails has continued to the present. A few subwatersheds, however, were much less extensively logged, namely Hathaway Creek at the mouth of the watershed and at the easternmost headwaters in Pardaloe and Mill Creeks. Extensive networks of skid trails were visible in aerial photographs from 1965 and 1978 in much of the remaining area. Skid trails have, in general, been re-used during successive entries to the watershed for timber harvest. Beginning in 1974, forest practice rules restricted the locations in which skid trails could be used to yard logs. In recent years, skid trails have been excluded from stream channels (including the smallest Class III channels), and slopes > 65%.

### iv. Methods

The Surface Erosion assessment module of the Washington Forest Practices Board (1995) provides a detailed method for estimating sediment production from roads under a variety of conditions and use levels. The following discussion summarizes this method and highlights the key assumptions required to perform the assessment.

Road data were obtained in a GIS format from the CDF. This data set was generated from both existing road maps and Timber Harvest Plan (THP) maps. Roads were classified by CDF as secondary paved roads, gravel roads (both classified as "permanent roads" in the Forest Practice Rules (FPRs), seasonal roads (as defined by the FPRs), and temporary/4WD roads ("temporary roads" in the FPRs). Skid trails are not mapped. The GIS was used to compute the length of each type of road within each CALWAA sub-basin. Road length data are the primary data used to estimate sediment production (erosion) from roads. In addition, the GIS computed the length of mapped stream channel in each CALWAA sub-basin. These data are used to estimate the "background" or "natural" erosion rate caused by hillslope creep processes that deliver sediment to stream channels. Hillslope creep processes include various forms of gravity-driven, small-scale sediment delivery, for example, soil-throw by the root mass of fallen trees, spoils from animal burrows (Reid and Dunne, 1996; WFPB, 1995).

According to the WM, the erosion potential for roads is a function of the relative area of road in each component of the road prism (tread, cut slope, and fill slope), the inherent erodibility of the parent material (rock type or sediment type upon which soil forms and on which a road is constructed), and the protection from erosion provided by vegetation and surfacing materials. Actual erosion is a function of actual or assumed road conditions and the proportion of eroded sediment delivered to streams. Delivery is controlled by factors such as road drainage design and proximity of roads to stream channels.

Erosion potential calculations begin with selection of the appropriate basic erosion rate (Table B-5 in the WM, reproduced here as Table 3-4). The bedrock east of the San Andreas Rift Zone, which coincides with the Garcia River between the North Fork Garcia and the South Fork Garcia, is predominantly marine sedimentary rock of the Coastal Belt Franciscan Formation (Wagner and Bortugno, 1982). A northwest southeast-trending belt of Franciscan Complex melange about 2 miles wide runs parallel to and just to the east of Inman Creek. West of the San Andreas Rift Zone, marine sedimentary rocks of the German Rancho Formation, the Gualala Formation and the Gallaway-Schooner Gulch Formation are found. These rocks have been subjected to extensive faulting, folding and uplift. Annual rainfall is greater than 50 inches. Soils of the region, particularly those used for commercial forestry, are predominantly of the Hugh-Josephine complex which, on steeper slopes (> 30%), are generally described as having high to very high erosion hazard (USDA, 1972).

Given the foregoing bedrock and soil conditions, the most appropriate choice for the basic erosion rate in the WM is "highly weathered sedimentary" parent material, which is grouped in the high erosion potential category. According to the WM, the erosion rate is 110 metric tons/acre of road prism per year for the first 2 years following construction. Thereafter, the erosion rate declines to 60 metric tons/acre/year.

Because of the age of most of the road network in the Garcia River watershed (most logging roads were constructed in the 1950's), calculations of estimated sediment production were based only on the lower (> 2 year following construction) basic erosion rate. This simplified the calculations significantly, and reduced estimated erosion from road prisms by about 5% over the 40 year period for which sediment production was estimated. In addition, it was assumed that the calculated erosion rates for the presently existing road network are representative of past erosion rates, thereby providing a means to estimate sediment production from roads over a period comparable to the mass wasting inventory.

*Table 3-4. Basic erosion rates as described in Table B-5, Washington Methodology. Erosion rate is given in metric tons per acre of road prism per year. For the Garcia River, the "high" erosion rate category was chosen on the basis of bedrock geology and general descriptions of soil erosion hazard.*

| | | Erosion Rate (T/ac/yr) | |
|---|---|---|---|
| General Rate | Parent Material | Road Age 0-2 Years | Road Age > 2 Years |
| High | Mica schist, volcanic ash, highly weathered sedimentary | 110 | 60 |
| High/Mod. | Quartzite, coarse-grained granite | 110 | 30 |
| Moderate | Fine-grained granite, moderately weathered rock, sedimentary rocks | 60 | 30 |
| Low | Competent granite, basalt, metamorphic road, relatively unweathered rocks | 20 | 10 |

The 60 T/ac/yr (about 66 t/ac/yr) of potential erosion is then apportioned to the constituent components of the road prism for further adjustments. For the typical, or "reference" road 40% of the erosion is derived from the tread, 40% from the cut slope, and 20% from the fill slope. The reference road has the following characteristics:

- insloped road tread with inboard drainage ditch
- native surface road tread
- general duty traffic (mostly pickups and sedans)
- cutslope gradient of 1:1 and fillslope gradient of 1.5:1
- initial ground cover density of zero on cut and fill slopes
- grade of 5-7%
- cross-drain spacing of 500 ft.

Discussions with forest managers and field observations indicate that these assumptions are not valid for all roads. The limited scope and resources for this Level I assessment do not allow refinement of these assumptions at this time.

Road length is converted to road prism area, distributed in the road tread, the cut slope and the fill slope, based on widths assumed to be representative of each component. The assumed typical road prism cross section contains 10 horizontal feet of fill slope, 16 feet of road tread, and 14 horizontal feet of cut slope, for a total of 40 ft. Thus for each 1,000 ft length of road, it is assumed that there is 40,000 $ft^2$ (0.92 acres) of road prism. These dimensions are likely to either underestimate or overestimate road prism area for some roads. Some of the oldest roads constructed in the 1950's may have had tread widths of 24 ft (Spittler, 1998).

For an acre of road prism, the WM assumes that sediment production from the road tread accounts for 40% of the base erosion rate, that is, 40% of 60 T/ac/yr, or 24 T/ac/yr.

Similarly, the base erosion rate is apportioned to the cut slope (40%) and the fill slope (20%). These rates are then adjusted using correction factors as described below.

It was assumed that the vegetative cover for the cut slope and fill slope averaged 50%. Limited field observations suggest that the cover density is higher in some areas, and lower in others. Adjustments to this assumption are beyond the scope and resources of the current project. Table 3-5 shows the correction factor used as a multiplier of the basic erosion rate that corresponds to different levels of vegetative cover.

***Table 3-5. The correction factor for vegetative ground cover on cut and fill slopes reduces erosion as the percentage of cover increases. When cover is zero, the correction factor is 1 and the base erosion rate for cut and fill slopes is not modified by the cover factor. This corresponds to Table B-6 in the WM.***

| Ground Cover Density | Correction Factor |
|---|---|
| >80% | 0.18 |
| 50% | 0.37 |
| 30% | 0.53 |
| 20% | 0.63 |
| 10% | 0.77 |
| 0% | 1.00 |

The correction factors for the road tread component of the prism include a surfacing factor (Table 3-6) and a traffic/precipitation factor (Table 3-7). The surfacing factor reduces the erosion rate in a manner similar to the vegetation cover factor. The traffic/precipitation factor can increase or decrease the base erosion rate, with the degree of increase determined by the intensity of traffic.

***Table 3-6. The correction factor for road surfacing as presented in the WM, Table B-7.***

| Road Surface | Correction Factor |
|---|---|
| Paved | 0.03 |
| Dust-oil | 0.15 |
| Gravel, > 6" deep | 0.2 |
| Gravel, 2-6" deep | 0.5 |
| Native soil/rock | 1.0 |

The final correction factor deals with the proportion of road area that delivers drainage water and sediment to stream channels. This correction is best developed from field survey data; this was beyond the scope of this assessment. Consequently, it was necessary to develop an assumption regarding proportion of delivery from roads to streams. The WM suggests that roads draining directly to any channel deliver 100% of the eroded sediment, with the fill slope considered separately. For roads within 200 ft of streams, but not draining directly to a stream, the WM suggests that 10% of the material is delivered to stream channels. Finally, for delivery of sediment from roads to slopes > 200 ft from streams, the WM suggests that there is not sediment delivery. Because appropriate field data were unavailable to determine what the delivery ratio is for roads, it was assumed that 100% of sediment eroded from the entire road prism within 200 ft of streams was delivered to streams. These data were generated from the CDF GIS data base containing layers for road location and class and stream location and class.

***Table 3- 7. Traffic/precipitation correction factor as presented in the SM, Table B-8.***

| | Annual Precipitation | | |
|---|---|---|---|
| Traffic Use/ Road Category | <1200 mm (47 in.) | 1200 - 3000 mm (47 -118 in) | > 3000 mm (118 in.) |
| Heavy Traffic/ Active Mainline | 20 | 50 | 120 |
| Moderate Traffic/ Active Secondary | 2 | 4 | 10 |
| Light Traffic/ Not Active | 1 | 1 | 1 |
| No Traffic/ Abandoned | 0.02 | 0.05 | 0.1 |

In addition to roads used by heavy trucks and light vehicles, native soil surfaces in the Garcia River have been extensively disturbed by skid trails constructed by caterpillar bulldozers and tractors for the purpose of yarding cut logs to roads where they are loaded onto heavy trucks for transport to mills. The 1965 photography used in the mass wasting inventory revealed high densities of skid trails. Measurements of skid trail length were made in two relatively small areas, in Fleming Creek (a tributary of the South Fork Garcia), and in an unnamed tributary of the North Fork Garcia. In the former case, approximately 6.7 miles of skid trail (and an undetermined but small portion of road) were measured in an area of about 0.25 $mi^2$, yielding an estimated skid trail density of about 27 $mi/mi^2$. In the latter case, about 14.9 miles of skid trail (and an undetermined but small portion of road) were measured in an area of about 0.97 $mi^2$, yielding a density of about 15 $mi/mi^2$. The average of these two values, 21 $mi/mi^2$, is used to represent the average skid trail density in the watershed.

Based on 1965 photography and data from the CDF GIS on THPs filed in the past 10 years, it was assumed that skid trails were built at an average density of 21 $mi/mi^2$ over 100 % of all subwatersheds except Hathaway Creek and Pardaloe Creek. In these two subwatersheds, there appeared to be substantially less area logged in 1965. THPs over the past 10 years were filed for only 17% of Hathaway Creek subwatershed (much of which is not forest vegetation) and for only 12% of Pardaloe Creek. For these two subwatersheds, it was assumed that skid trails were "constructed" on only 15% of the drainage area (i.e. skid trail density of 21 $mi/mi^2$ was applied to only 15% of watershed area to estimate total length of skid trails). These assumptions are crude and undoubtedly in error in many areas, however, an estimate of the magnitude of the historic skid trail erosion is critical to the assessment of erosion and sedimentation in the Garcia River watershed.

Erosion from skid trails was estimated using the road methodology described above, but with smaller dimensions in the road prism (5 ft for both cut and fill slopes, and 12 ft for the tread). These dimensions, combined with the estimated average skid trail density, yield estimated area of skid trails equivalent to about 9% of watershed surface area. Based on systematic observations of skid trails in Mendocino County by CDF personnel, typical surface area in skid trails ranges from 12 to 20% of watershed area in commercial timber lands (Cafferata, 1997). This suggests that skid trail erosion may be underestimated with respect to assumed surface area occupied by skid trails.

In addition, because of the re-use of skid trails in successive harvests (there have been approximately 3 harvest cycles on much of the watershed), and because of the large area of skid trails, the base erosion rate for the 0-2 year age class of road surface (Table 3-4) was incorporated in the estimate to avoid potentially significant underestimation of historic skid trail erosion rates. The factors selected for calculating road erosion for each road and skid trail category are given in Table 3-8.

Background erosion rates were estimated according to the WM as a function of the average creep rate (natural erosion processes excluding larger-scale mass wasting) of soil material into channels. The average creep rate was assumed to be 2 mm/yr (about 0.007 ft), the average streambank height across which the creep rate applies was assumed to be 1 m (about 3.3 ft), and the stream length was estimated based on drainage density in subwatersheds where relatively complete data on the channel network were available in the CDF GIS (typical drainage density was 7 mi/mi$^2$). The product of creep rate, bank height, stream length and 2 (once for each streambank) is the estimated background erosion rate.

***Table 3-8. Summary of base erosion rate and correction factors applied to calculate estimated annual erosion from roads and skid trails. Skid trail delivery ratio (25%) is equivalent to the delivery ratio that results from delivering 100% of sediment eroded from roads within 200ft of stream channels.***

| Road Class | Base Erosion Rate (T/ac road prism/yr) | Cover Factor for Cut and Fill Slopes | Surface Material Factor for Road Tread | Traffic/ Precipitation Factor | Proportion of Sediment Delivery to Channels |
|---|---|---|---|---|---|
| Paved | 60 | 0.37 | 0.03 | not applicable | 100% for prism < 200 ft from channels |
| Rocked | 60 | 0.37 | 0.5 | 4 | see above |
| Seasonal | 60 | 0.37 | 1 | 1 | see above |
| Temporary | 60 | 0.37 | 1 | 0.05 | see above |
| Skid Trail (0-2 yr old) | 110 | 1 | 1 | 1 | 25% |
| Skid Trail (> 2 yr old) | 60 | 0.37 | 1 | 0.05 | 25% |

The time trend in sediment delivery rates that can be inferred from the estimated sediment delivery rates is shown in Figure 3-5. Here, all source processes are combined and the composite delivery rate is shown in the sediment delivery budget time intervals. This graph shows a generally declining rate of sediment delivery. Interpretation of this graph (and all results) should be conditional on the confidence discussion to follow.

The sediment delivery estimates shown above were also used to estimate the delivery rates of fine (< 2 mm diameter) sediment and coarse (> 2 mm diameter) sediment. This was accomplished in part by developing a composite soil profile for the dominant soil association in the Garcia River watershed as described in the Sonoma County Soil Survey (USDA, 1972). The particle size distribution in the Hugo/Josephine/Laughlin soil association was aggregated to develop a weighted mean particle size distribution. This procedure yielded a weighted average of about 30% coarse sediment and 70% fine sediment in the composite soil profile.

The Washington Methodology for road erosion assumes that only fine sediment is delivered from roads, so the distribution of coarse and fine sediment has no effect on the road estimate. All sediment delivery from erosion of the road prism is assumed to be composed entirely of particles <2 mm diameter. For mass wasting and background sources, the estimated delivery is 30% coarse and 70% fine. For skid trails, the Methodology was modified: it was assumed that 10% of estimated sediment delivery was in the coarse fraction and the remaining 90% was in the fine fraction. This assumption is intended to account for potential delivery of coarse sediment from skid trails in or adjacent to streams and steep skid trail in which gullies may have formed. These types of skid trail erosion are less likely to occur under existing forest practice regulations compared to practices in the 1950's and 1960's.

Figure 3-6 shows the estimated total fine sediment delivery while Figure 3-7 shows estimated total delivery of coarse sediment. In the case of fine sediment, the corresponding estimate for watershed average fine sediment delivery to streams is about 660 t/mi$^2$/yr. (Note to the reader: based on new information, these estimates were revised as described in the following section of the assessment "Suggestions for Further Work..." These original figures and estimates are retained to document the progression of the analysis and the impact of new data.) For coarse sediment, the estimated watershed average rate is about 90 t/mi$^2$/yr.

**Figure 3-4. Estimated Average Sediment Delivery Rates by Source Process, Garcia River, c.1957-1996**

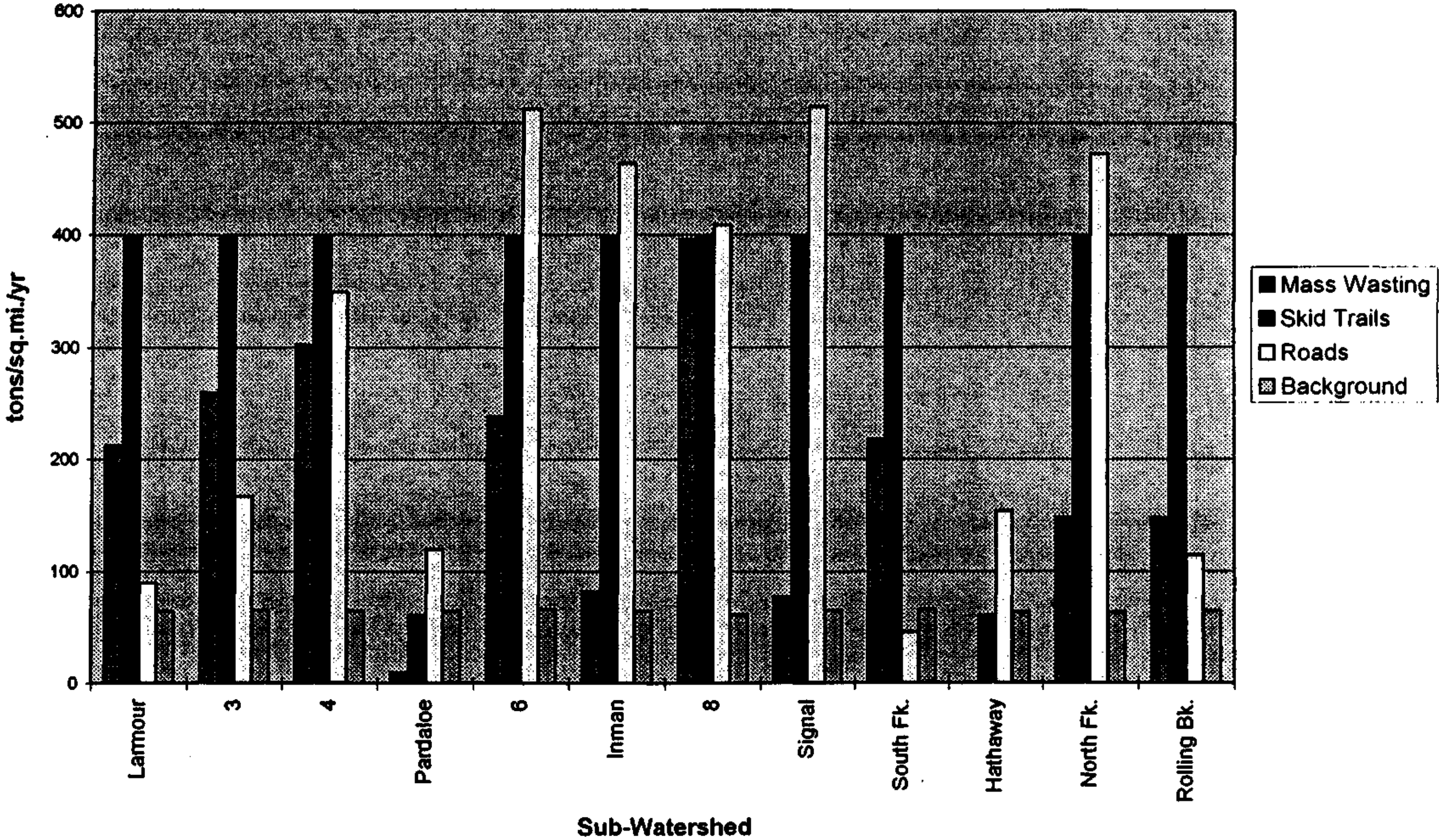
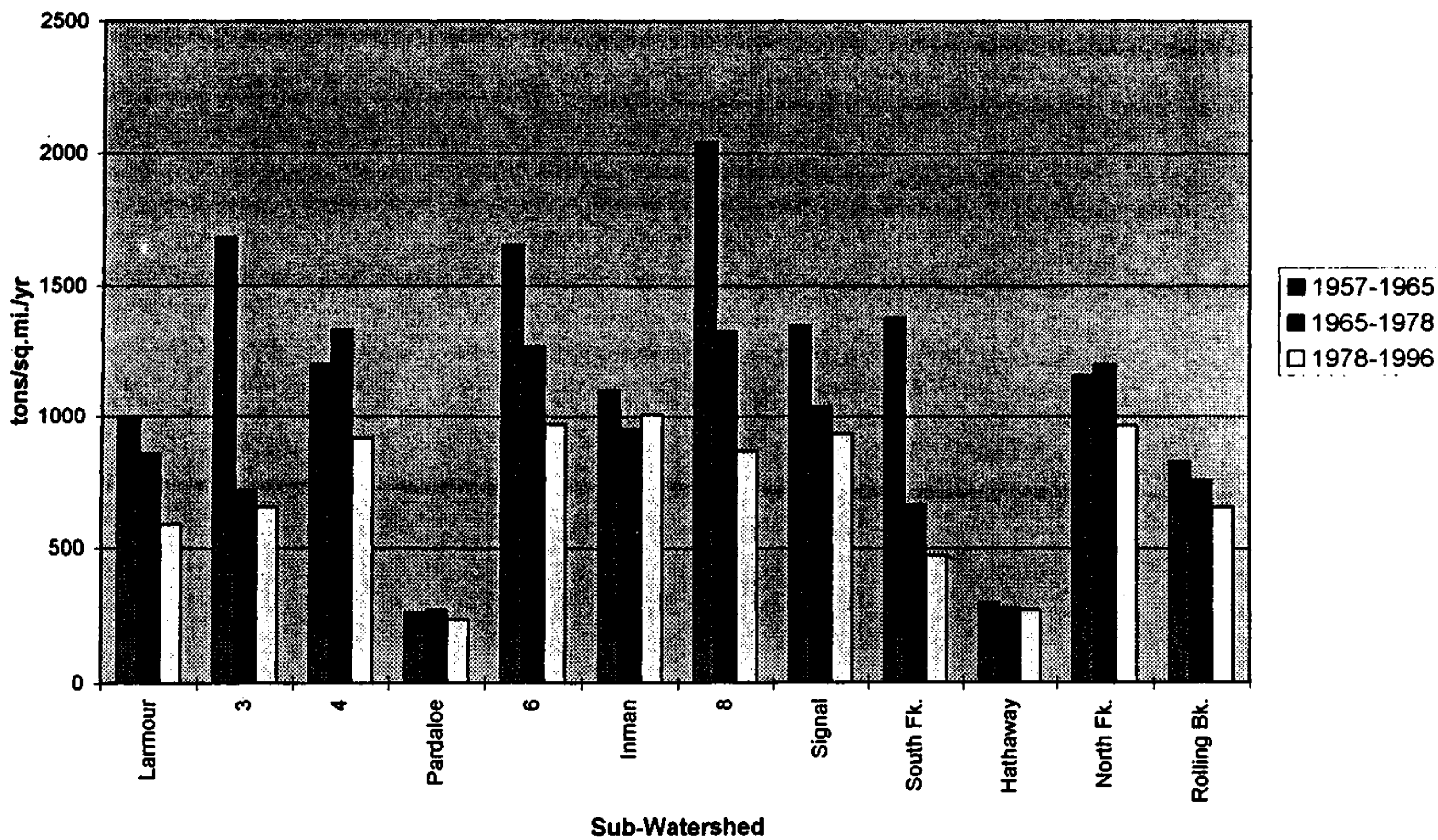


**Figure 3-5. Estimated Average Annual Sediment Delivery Rate By Time Interval, Garcia River, c.1957-1996**



### iii. Confidence in Assessment Results and Comparison With Other Studies

One means of checking the accuracy of the estimated sediment delivery rates is to compare these estimates to estimates of sediment yield developed or cited in other studies. The Garcia River Gravel Management Plan (Philip Williams & Associates, Ltd., 1996) developed and cited several estimates of sediment yield for the Garcia River.

USGS sediment discharge measurements and stream gauging data were used to estimate bedload and suspended load yield at Conner Hole, located on the Garcia River downstream of the confluence of the North Fork Garcia. Bedload and suspended load sediment are comparable to coarse and fine sediment, respectively. At this location, the estimated bedload transport rate in terms of mass per unit watershed area, was 160 t/mi$^2$/yr. The estimated coarse sediment delivery rate calculated in this study at the same location (which is approximated by excluding the Hathaway Cr. subwatershed) is about 100 t/mi$^2$/yr. The estimated suspended load based on the USGS data set and the Williams analysis (1996) is about 1800 t/mi$^2$/yr. The estimated fine sediment delivery rate from this assessment is about 740 t/mi$^2$/yr. Although the estimated average delivery rates are roughly half the estimated average sediment yield, the comparison suggests that the estimates in this assessment are not excessive, arid are of roughly the same magnitude.

***Table 3-10. Comparison of estimated sediment delivery rates for this study with other estimates of sediment transport or yield (adapted from Philip Williams & Associates, Ltd. 1996, unless otherwise noted). Rates are in units of t/mi$^2$ /yr.***

| Source/Method | Bedload | Total Load (Suspended load + Bedload) |
|---|---|---|
| This study-Estimated sediment delivery | 100 | 840 |
| Williams & Assoc./USGS-Extrapolation of sediment transport and stream discharge records (Garcia Gravel Management Plan best estimate) | 160 | 2,000 |
| Meyer-Peter, Mueller bedload transport equation | 115 | n.a. |
| Englund and Hansen total load equation | n.a. | 450 |
| Brownlie total load equation | n.a. | 105 |
| Lehre for Mad River | 309 | n.a. |
| Fugro West, Inc. for Redwood Creek | 532 | n.a. |
| PWA for the Gualala River | 87 | n.a. |
| Fugro West, Inc.; average sedimentation rate for California Coast Range reservoirs | n.a. | 442 |
| Napolitano (1996) for Caspar Creek, a managed redwood forest watershed | n.a. | 200 - 750 |
| Rice et. al. (1979) South Fork Caspar Cr., managed second growth redwood forest watershed | n.a. | 1,420 |

Further perspective on the accuracy of the estimates in this study are gained from Table 3-10. The bedload estimate of delivery rate is near the low end of the range of values presented, and is bracketed by local estimates for the Garcia River and the Gualala River. The estimated average total load delivery rate falls in the middle of the reported range. These comparisons further suggest that the sediment delivery estimates produced in this assessment are reasonable.

However, considering the best estimate developed in the Garcia River Gravel Management Plan, and assuming that the sediment delivery rate and the sediment yield should be equal over a few decades, the estimated sediment delivery rates in this study account for only about 40 percent of the yield. In other words, this study may underestimate sediment delivery by as much as 100% or more. Some portion of this underestimate may be accounted for by erosion of alluvial terraces in the lower Garcia River, thus removing sediment from storage. This type of sediment delivery is unaccounted for in this assessment.

Although the foregoing suggests that the estimated sediment delivery rates are reasonable, there are many assumptions that were necessary to develop the estimates. Field visits, discussions with forest managers, and other studies suggest several areas where improved assumptions (or additional data) would likely improve the level of confidence in the estimates.

The mass wasting inventory map for the North Fork Garcia subwatershed was compared to a similar map prepared for Coastal Forest Lands Ltd. (1997). The CFL map was based on similar photo-interpretation criteria, and utilized a single set of 1:12,000 scale color photographs taken in 1995. The CFL inventory found a landslide density of about 27/mi$^2$ in the North Fork Garcia, compared to about 5.7/mi$^2$ for this study. A substantial portion of this discrepancy can be accounted for by the different resolution of mass wasting sites in this study compared to the CFL inventory. Nevertheless, the CFL inventory suggests that this study underestimates mass wasting, particularly smaller features with areas of < 100 to 200 yd$^2$. This could compensate for some of the apparently missing sediment. In addition, smaller-scale streamside mass wasting not detectable on aerial photos is not accounted for in either study.

Another potential underestimate of sediment delivery may be from gullies that are generally too small to be detected on aerial photos, but cumulatively may represent a significant quantity of sediment. Delivery of sediment from roads is underestimated in several subwatersheds where the stream channel data in the CDF GIS is of lower quality (areas where THPs have not been recently prepared), hence some road segments that may meet delivery criteria are not accurately represented.

Potential errors in estimates of skid trail and road erosion include (at least) excessive assumed delivery from road fill slopes and inaccurate road and skid trail density and area. Other assumptions detailed above and inherent in the techniques used are also potential sources of error. The overall level of confidence in these sediment delivery estimates is low to modest. The lack of resources for a significant field component to this assessment is perhaps the greatest source of uncertainty undermining the assessment.

**Figure 3-6. Estimated Fine Sediment (< 2 mm) Delivery, Garcia River, c. 1957-1996**

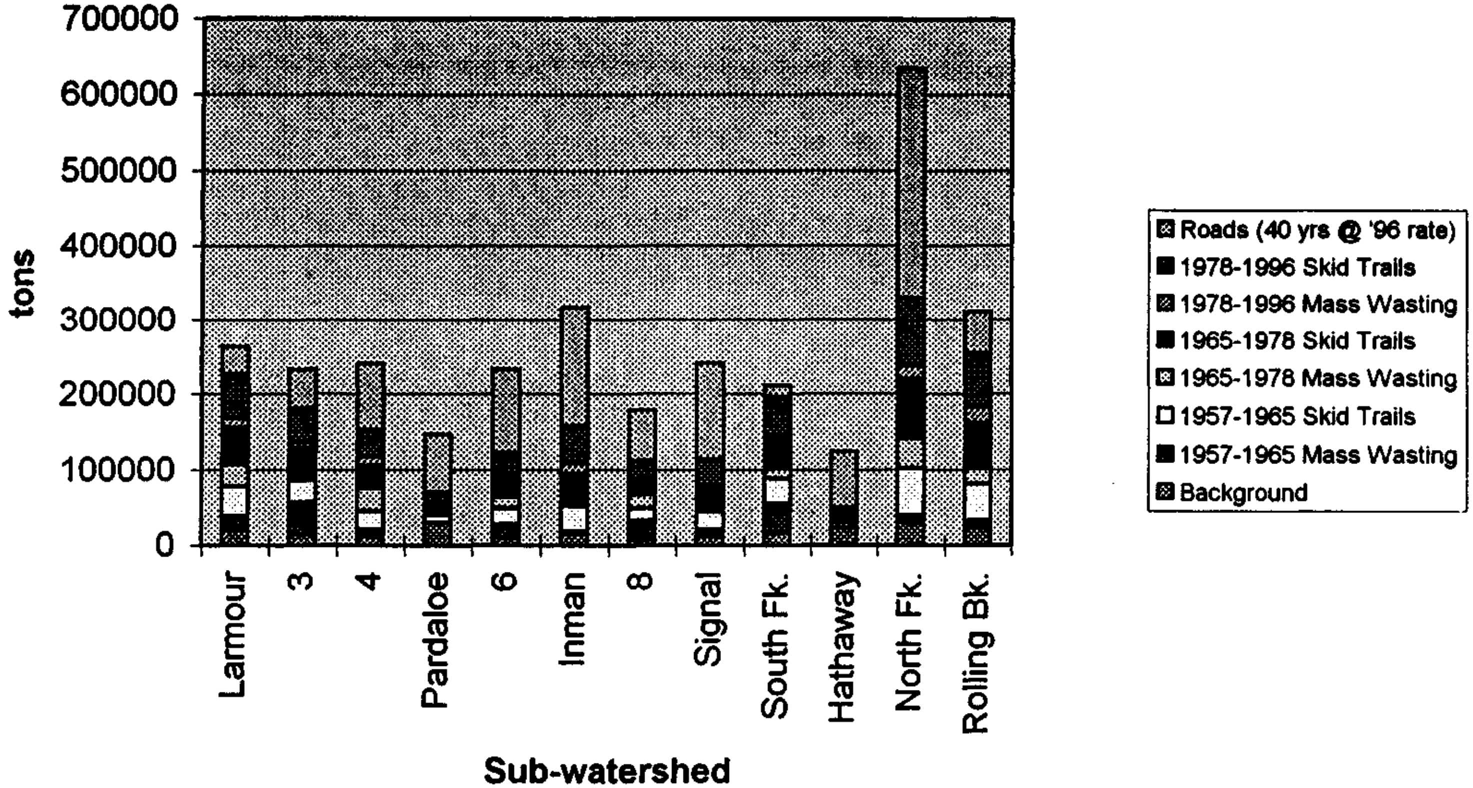


**Figure 3-7. Estimated Coarse Sediment (> 2 mm) Delivery, Garcia River, c.1957-1996**

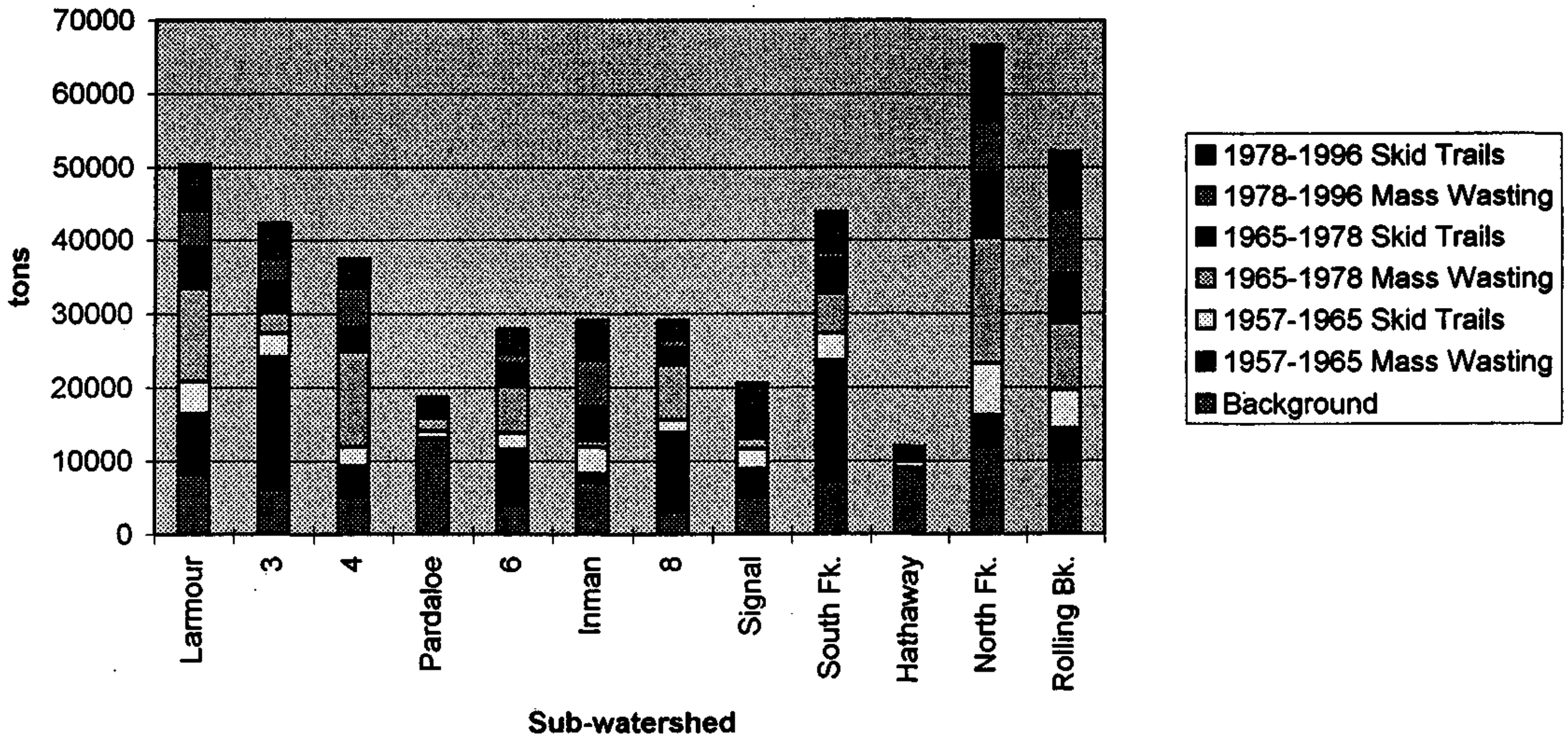


Table 3-11 summarizes the CDF data by subwatershed. Subwatersheds with low percentages of their area in recent THPs are most likely to underestimate the historic extent of the road network. In the cases of Hathaway Cr.(l 1) and Pardaloe Cr. (5), the low relative extent of coniferous forest vegetation and the known land use history suggest that these areas were not as intensively harvested. In these two sub-basins it was assumed that the current condition is reasonably representative of historic conditions with respect to forest roads.

***Table 3-11. Summary of selected data abstracted from the CDF GIS data base. The data base is built on information from THPs collected since 1986. Recent THPs have provided accurate maps for headwater stream channels not mapped on USGS topographic maps, hence the large differences between drainage density for areas with low and high percentage of THP. It is expected that drainage density should be fairly uniform. Drainage density correlates well with percent of area in THP. Extrapolating the correlation suggests that actual drainage density is about 7 mi/mi$^2$. Road density follows a similar pattern, but varies over a smaller range.***

| Sub-watershed | % Area in THP | Drainage Density | Road Density |
|---|---|---|---|
| Larmour Cr. (2) | 13 | 1.5 | 2.6 |
| 3 | 35 | 2.2 | 4.4 |
| 4 | 52 | 4.5 | 4.4 |
| Pardaloe Cr. (5) | 12 | 2.4 | 3.4 |
| 6 | 62 | 5.2 | 4.2 |
| Inman Cr. (7) | 76 | 5.7 | 4.2 |
| 8 | 76 | 5.3 | 4.2 |
| Signal Cr. (9) | 70 | 5.5 | 5.2 |
| South Fk. Garcia (10) | 15 | 1.5 | 3.5 |
| Hathaway Cr. (11) | 17 | 1.4 | 2.9 |
| North Fk. Garcia (12) | 82 | 5.6 | 4.8 |
| Rolling Brook (13) | 20 | 1.3 | 4.4 |

Road erosion rates were used to estimate sediment delivery rates to streams based on the assumption that roads within 200 ft of streams deliver 100 percent of eroded sediment and roads greater than 200 ft deliver no sediment. This assumption was developed from guidance in the DNR methodology that stated that, in general, for roads greater than 200 ft from streams, all eroded sediment would be deposited on hillslopes prior to reaching the stream. Delivery from road ditches was not addressed by this guidance. Hence, the Level 1 assessment may overestimate delivery of sediment across hillslopes to streams, but may well underestimate delivery from inboard road drainage ditches. The delivery issue is best resolved on the basis of site-specific field survey data for road drainage. This solution was beyond the scope of this Level 1 assessment.

Historic skid trail erosion was assessed by modifying the DNR methodology to treat skid trails as a type of road. This included using a high rate of erosion for a two year period following construction or re-use of skid trails, with much lower rates in subsequent years owing to lack of use. It was also assumed that skid trails were used only once in each of the three sediment production intervals. In some areas in the past ten years, forest entries for harvest have been more frequent.

Delivery of sediment eroded from skid trails to streams was estimated using reasoning similar to that for estimating delivery from roads. Basin-wide, about 25 percent of road length was within 200 ft of streams. It was assumed that the proportion of skid trail length within 200 ft of streams was that same as that for roads, and that the effective delivery rate from skid trails was 25 percent of the erosion rate.

Regarding skid trail erosion, it was further assumed that ten percent of the sediment produced from skid trails would be coarse (> 2 mm), whereas the DNR method assumes surface erosion from roads produces only fine sediment (approximately < 2 mm). This component of coarse sediment attempts to reflect historic erosion of small channel fills and the development of gullies in some skid trails. Although these erosion processes are likely to have contributed significantly to the sediment load of the Garcia River, the selection of ten percent as a component of coarse sediment is little more than a guess. The maximum value would be thirty percent—the estimated proportion of coarse sediment in the typical soil column.

The estimated quantity of skid trails, however, is probably the most sensitive factor in the estimate of erosion from skid trails. All estimates of historic skid trail erosion are based on skid trail density measurements from two areas in aerial photography from 1965. After the implementation of forest practice rules in 1974, skid trail density was probably reduced. Nevertheless, it was assumed that skid trail density was constant over time. This suggests that the estimated rate of erosion from skid trails may be too large. On the other hand, investigations of skid trail densities in other areas of coastal Mendocino County suggest that the skid trail density in terms of surface area are typically about 33% over 200% greater than that assumed in this assessment (Cafferata, 1997), suggesting that the estimated erosion rates may be too small. Observations on a few recent skid trails in the North Fork Garcia revealed virtually no sediment delivery to channels, but these observations were neither systematic nor extensive. It is clear that skid trail erosion was a major source of sediment in the Garcia River; it is also clear that estimating historic erosion rates from skid trails requires either several major assumptions or a detailed investigation based on existing data and additional field research.

### vi. Suggestions for Further Work

In general, a Level 1 assessment under the DNR methodology does not allow for sufficient field survey work to refine assumptions that would make the assessment product more accurate. The scope of this assessment limited field work to 3 field reconnaissance trips to become familiar with ground conditions. If time had been available to conduct field survey work, several tasks would have been useful.

With respect to mass wasting, field verification of a high proportion of mapped deep-seated landslides would be a high priority owing to their low occurrence but high sediment production (4% of slides, 36% of sediment). Field verification of a sample population of shallow rapid landslides and debris torrents would be aimed at comparing estimates of sediment delivery made from aerial photo interpretation with estimates made from field measurements. These data would be used to adjust the assumed delivery rate of sediment from landslides. In addition, field surveys would provide perspective on the proportion of landslides that exist on the ground but were not mapped from aerial photos.

Erosion caused by development of gullies and by smaller streamside shallow landslides cannot be estimated from aerial photographs because they are typically too small to see or are obscured by forest canopy. Estimates of sediment delivery from these processes should also be obtained from field surveys. These erosion processes are not well-accounted for in the Level 1 assessment. Gullies related to skid trails are conceptually accounted for in skid trail erosion estimates. Gullies caused by road runoff are not included, but a few were observed during field reconnaissance. Gullies are thought to be significant historic sources of sediment (Monschke, 1997).

Shallow streamside landslides occur naturally, but may also tend to increase in stream channels that become aggraded or are subject to unusually intense floods. These mass wasting sites appeared to be relatively common in some of the areas visited in the field. In this assessment, sediment delivery from this type of mass wasting is implicitly included in the background creep rate (Table 3-9). Sample data from a range of stream sizes could be used to estimate streamside landslide sediment delivery rates, or could be used to revise the creep rate.

Further work could also refine assumptions used in the road erosion assessment. Historic photography could also be used to more accurately estimate the distribution and density of skid trails in the Garcia River over the past 40 years. As noted previously, a field survey component would significantly improve the reliability of road erosion estimates. First, road segments could be surveyed to refine assumptions regarding road width, surfacing, cover on cut and fill slopes, drainage and delivery to streams. Existing (and possibly abandoned) skid trails could be surveyed for the same purpose.

### vii. Effects and Interactions of Climate and Management on Sediment Yield

The sediment yields estimated are gross averages. They have been developed for three different decade-scale time periods, but these do not necessarily reflect the interaction between land use and climatic fluctuations. In the Coast Ranges of California, significant increases in erosion rates occur during periodic wet winters when runoff rates are very high. Naturally-elevated erosion rates are often compounded when intensive management occurred, particularly in the era preceding regulation of forest harvest practices.

In the Garcia River watershed, there were at least two episodes of unusually intense winters prior to adoption of modern forest practice regulations. The first was in the mid-1950's when much of the Garcia was being logged for the first time. The second was in the early 1970's. It is likely that a high proportion of erosion and sedimentation occurred during these relatively short periods, and that sediment delivery and transport rates may have been on the order of 10 times greater during these periods. Consequently, the rates of sediment delivery presented in Figures 2, 6, 7 and 8 smooth a record that, if it could be displayed by annual time step, would have a few extreme peaks and valleys.

An example of how climatic fluctuation and management practices affect annual sediment yield in northern California was suggested by a Cafferata in his review of the assessment (Cafferata, 1997). Table 3-12 shows sediment yields measured at the Caspar Creek experimental watershed in Mendocino County. These data suggest that in some areas, natural processes under wet conditions produce significantly more sediment than management practices under more typical winter conditions, but that the combination of poor management practices and wet winters generate the highest sediment yields by far.

***Table 3-12. Sediment yield data for Caspar Creek, Jackson Demonstration State Forest Data for the "no recent harvest" condition after Napolitano (1996). The "modern practices" value is attributed to R Rice, (pers, comm.), by P. Cafferata (pers, comm.), and is considered to be a preliminary approximation. The "historic practices " value is after Rice et al (1979). Units are t/mf/yr.***

| **Management** | **Typical Winter (approx. <10 yr return period)** | **Wet Winter (approx. >10 yr return period)** |
|---|---|---|
| No Recent Timber Harvest | 180 | 680 |
| Timber Harvest, Modem Practices (late 1980's) | ~ additional 100 | ~ additional 100 |
| Timber Harvest, Historic Practices (early 1970's) | n.a. | 1420 |

### viii. Potential Influence of Franciscan Melange Formation on Sediment Yield

A major area of the Franciscan Complex melange occurs in the Garcia River basin, a northwest-southeast trending swath about two miles wide in Inman Creek and Blue Waterhole Creek (subwatersheds 3 and 4), covering roughly ten percent of the watershed. This formation tends to be vegetated by grasslands, and is typically dissected by significant gullies and prone to landsliding along stream channels. A sediment budget prepared for the Navarro River watershed (Trihey & Associates, Inc., 1997) reported sediment production rates for different geology-vegetation associations.

For melange-grassland, sediment production was estimated at 4,000 t/mi$^2$/yr, with about 90 percent coming from streamside landslides and gullies along third through sixth order streams. For first and second order streams, sediment production from bank erosion and shallow landslides combined was reported to be about 400 t/mi$^2$/yr. The magnitude of these natural erosion rates is high compared to other estimated source rates for the Garcia River (e.g. Figure 3-4).

These estimates could be loosely applied to the Garcia by adjusting the background rates for the affected subwatersheds (3, 4 and 7) based on the proportion of melange in the subwatershed and the distribution of stream in relation to the melange to reflect the nature of the rates for the Navarro River. Assuming that about half of each drainage is composed of the melange, and using the sediment production rate for first and second order channels only, the background rate could be increased to at least 230 t/mi$^2$/yr. Depending on the interpretation of the Navarro River rates and how they might be applied with regard to stream order, the background rate for these subwatersheds might be estimated at rates as high as 2,000 t/mi$^2$/yr.

**ix. Level 2 Watershed Analysis Data and Implications for Level 1 Results**

During the summer of 1997, Louisiana-Pacific Corporation (L-P) performed field work for Level 2 watershed analysis of portions of the Garcia River watershed under their ownership, primarily in the South Fork Garcia and Rolling Brook subwatersheds. Preliminary results of the mass wasting and surface erosion components were made available as part of L-P's comments on the Level 1 assessment. Elements of the L-P analysis that could be applied to the Level 1 assessment are discussed below.

Estimated sediment delivery rates have been recalculated to show how Level 2 field data could be used to revise Level 1 assumptions. Whether the revised estimates should be considered valid depends on whether field data from the Rolling Brook and South Fork Garcia subwatersheds are representative of the remainder of the Garcia River watershed.

L-P's mass wasting module included extensive field measurements of shallow rapid landslide and debris torrent sites. They estimated delivery rates of mobilized sediment to stream channels for shallow rapid landslides to be 76 percent. For debris torrents, L-P estimated 85 to 100 percent delivery. With respect to this Level 1 analysis, substitution of a delivery rate derived from local field data from shallow rapid landslides would be significant because about 85 percent of the inventoried landslides were of this type. Revising the delivery rate to 75 percent from 50 percent would increase the shallow rapid component by 50 percent. The assumed debris torrent rate is somewhat less than the L-P field estimate, but is in relatively good agreement. The effect of modifying the assumption of delivery rate from shallow rapid landslides is shown in Table 3-13. Overall mass wasting rates are increased about one-fourth.

L-P's mass wasting analysis field survey also collected data on streamside landslides that were not visible or two small to identify on aerial photographs. This component of mass wasting was not included in the Level 1 analysis. L-P's estimate for sediment delivery from small streamside landslides ranged from about 185 to 250 t/mi$^2$/yr, averaging about 210 t/mi$^2$/yr. These rates are generally consistent with rates reported by Trihey & Associates, Inc. (1997) for the Navarro River, although they do not specifically distinguish between shallow landslides that are visible on aerial photographs from those that are not visible.

The rates reported by L-P are roughly equivalent to about 30 yards of sediment per mile of stream length, a quantity that is physically reasonable, or even conservative, based on field observations in the Garcia River and in other mountain streams. The effect of incorporating L-P's streamside landslide rate is shown in Table 3-13. The total mass wasting rate is more than doubled with inclusion of small-scale streamside mass wasting. These two adjustments to the mass wasting sediment delivery rates would have the effect of increasing estimated total sediment yield from the Garcia River by about halt to 1,200 t/mi$^2$/yr. In the context of Table 3-10, these adjustments bring sediment delivery closer to the sediment yield estimated for the Garcia by Philip Williams & Associates (1996).

L-P also developed a Level 2 analysis of surface and road erosion. L-P developed a map of the road network developed beginning in 1952, and thus included many roads that were not in the CDF GIS data base. They also measured erosion from culvert wash outs, gullies, and small fill failures that delivered sediment to streams. L-P adapted the DNR methodology to estimate surface erosion from roads. They modified some assumptions to more accurately reflect the condition and usage of L-P roads. Since most of the log hauling on roads occurs during the dry season, they weighted the traffic/precipitation factor (Table 3-7) 85 percent toward annual precipitation < 47 in. and 15 percent toward the 47 to 118 in. category. In addition, they modified the road surface factor (Table 3-6) for native surfaces from 1.0 to 0.75 (halfway between "native" and "gravel, 2-6 in"), to account for the high proportion of rock incorporated in the bed of cut and fill roads that frequently excavate bedrock. These modifications would reduce estimated erosion rates.

Level 2 work by L-P in the South Fork Garcia and Rolling Brook estimated average sediment delivery from roads over the past 45 years to be 387 t/mi$^2$/yr and 238 t/mi$^2$/yr, respectively. The Level 2 estimates are consistent with the average rate (255 t/mi$^2$/yr) and the maximum subwatershed rate (514 t/mi$^2$/yr) for the Garcia estimated from Level 1 data. These estimates represent significant increases from the Level 1 estimates for these subwatersheds which were 45 t/mi$^2$/yr and 114 t/mi$^2$/yr for the South Fork Garcia and Rolling Brook, respectively. The relatively low rates predicted by Level 1 assessment are not due to very low road density compared to other subwatersheds (Table 3-11). L-P's work involved field measurements of proportions of roads that deliver sediment to streams and included local erosion such as gullies that are not accounted for by the DNR method. This suggests that the Level 1 road erosion estimates may be conservative, and might be more likely to increase rather than decrease should more detailed field investigations be performed.

L-P's Level 2 analysis also considered skid trail erosion. They adjusted the skid trail density over time to reflect lower rates of harvest in recent decades. (The Level 1 analysis assumed that the 1965 skid trail density was constant at its maximum level.) They also adjusted delivery rates from skid trails based on field data for the average length of contributing road adjacent to stream crossings (300 ft) and the number of skid trail crossings.

Despite significant methodological differences, L-P calculated skid trail erosion rates comparable to those calculated for the Level 1 assessment, about 350 t/mi$^2$/yr for the 1952 to 1966 period. These rates declined in subsequent time intervals to about 150 t/mi$^2$/yr. The average over their 45 year time period was about 220 t/mi$^2$/yr compared to 400 t/mi$^2$/yr from the Level 1 analysis. These data suggest that the Level 1 skid trail erosion rates may be overestimated by about half. However, the density and frequency of use of skid trails is likely to vary for areas under different ownership, and that is likely to affect estimated erosion rates.

***Table 3-13. Mass wasting rates for Garcia River subwatersheds based on selected Level 2 mass wasting analysis data; these estimates supersede those presented in prior sections. Shallow rapid delivery rate for photo-inventoried landslides is increased from 50% to 75%. Small-scale streamside mass wasting was estimated based on an average field-derived rate of 210 t/mi$^2$/yr. The Level 1 analysis did not include an estimate for streamside mass wasting. If accepted, these revisions increase the total estimated erosion rate for the Garcia Riverfront about 840 t/m$^2$/yr to about 1,200 t/m$^2$/yr, representing an increase of about 50%.***

| Sub-watershed | Area (mi$^2$) | Original Total Mass Wasting (t) | Revised Total Mass Wasting (t) | Revised Rate; Increased Shallow Rapid Delivery (t/mi$^2$/yr) | Estimated Streamside Shallow Rapid (t) | Total Including Estimated Streamside Shallow Rapid (t) | Revised Rate: Shallow Rapid Delivery and Streamside Shallow Rapid (t/mi$^2$/yr) |
|---|---|---|---|---|---|---|---|
| 2 | 10.2 | 86,000 | 103,000 | 252 | 85,700 | 188,700 | 463 |
| 3 | 7.7 | 81,000 | 96,000 | 312 | 64,700 | 160,700 | 522 |
| 4 | 6.2 | 74,000 | 82,000 | 331 | 52,100 | 134,100 | 541 |
| 5 | 16.4 | 5,500 | 8,000 | 12 | 137,800 | 145,800 | 222 |
| 6 | 5.4 | 51,000 | 69,000 | 319 | 45,400 | 114,400 | 530 |
| 7 | 8.6 | 27,000 | 34,000 | 99 | 72,200 | 106,200 | 309 |
| 8 | 4.1 | 65,000 | 79,000 | 482 | 34,400 | 113,400 | 691 |
| 9 | 6.2 | 19,000 | 23,000 | 93 | 52,100 | 75,100 | 303 |
| 10 | 8.7 | 76,000 | 87,000 | 250 | 73,100 | 160,100 | 460 |
| 11 | 12.3 | 0 | 0 | 0 | 103,300 | 103,300 | 210 |
| 12 | 16.2 | 102,000 | 141,000 | 218 | 136,100 | 277,100 | 428 |
| 13 | 12.5 | 78,000 | 98,000 | 196 | 105,000 | 203,000 | 406 |
| Total | 114.5 | 664,500 | 820,000 | 179 | 961,900 | 1,781,900 | 389 |

### x. Conclusion

Several potential improvements to the Level 1 analysis were suggested. Level 2 analysis by L-P on their ownership in the Garcia included some of these improvements. These improvements could serve as a basis for modifying the results of the Level 1 assessment. Modification of the mass wasting component of sediment production and delivery consistent with L-P's Level 2 analysis would roughly double the estimated rate of sediment delivery by mass wasting processes (Table 3-13). Most of that increase comes from adding small-scale streamside mass wasting to the sediment budget. Modification of the road and skid trail erosion components were also suggested by L-P's Level 2 work. However, the site specific qualities of roads and skid trails, and uncertainty regarding the historical distribution of skid trails make these modifications more difficult to incorporate with respect to Level 1 results. Application of any Level 2 data to revise Level 1 results requires the assumption that conditions in the South Fork Garcia and Rolling Brook subwatersheds are representative of other Garcia River subwatersheds.

### xi. Relevance to Proposed Monitoring of Channel Conditions

These estimates of sediment delivery to stream channels by various processes should be considered preliminary and in need of verification based on field observations. This should include field measurements of a sample of landslide sites. In addition, the assumptions regarding road and skid trail geometry and sediment delivery to streams should be examined in a systematic field investigation and revised as necessary. These activities are consistent with proposed monitoring presented in subsequent chapters of this report, which are structured to provide the opportunity to collect additional field data on hillslope sediment sources (e.g. identification of sediment transport corridors).

It is likely that monitoring efforts targeting instream conditions related to erosion and sedimentation processes will yield ambiguous or inconclusive results regarding the efficacy of forest practices regulations and erosion control efforts if a more refined estimate of sediment production is not prepared for drainage areas upstream of proposed monitoring sites. Interpretation of monitoring data for stream conditions, particularly related to erosion and sedimentation, is extremely challenging even with the best sediment budget data.

With regard to monitoring hillslope management activities for efficacy of forest practice regulations and their effect on instream sedimentation, efforts would best be focused on the finer fraction of sediment that is transported relatively rapidly through the channel network. Coarse sediment that is transported as bedload has a long residence time in channels (typically decades to centuries), and its dynamics and conditions are likely to be influenced as much or more by management practices prior to the adoption of forest practices regulations in 1974. In contrast, fine sediment that is transported in suspension or in intermittent suspension (silt, sand and fine gravel), is routed through channels on a time scale of years to decades. Monitoring this fine fraction of sediment is most likely to provide insights regarding contemporary management practices in a time frame of years to decades.

## *4. Synthesis of Information*

### A Matrix of impact certainty and resource sensitivity.

One large, inclusive matrix has been developed of present resource condition, by tributary and mainstem segment (Appendix B). Data have been taken from a variety of sources, principally the evaluations by O'Connor (1997), Mangelsdorf (1997) and Hagans (1997). Additional data were supplied by SYP documents (L-P, 1997; CFL, 1997), topographic and thematic mapping (USGS, 1991 and 1977; CDF, 1997), the previous watershed assessment prepared for the MCRCD (Monschke and Caldon, 1992), and input from people knowledgeable about the watershed. Qualitative and quantitative evaluations were transposed or interpreted from these reports and maps. Data were entered for as specific areas as possible.

Resource condition was interpreted from the evaluations of present condition relative to specific beneficial uses. We looked for specific interpretations of sedimentation, canopy, stream complexity, dissolved oxygen, temperature and fisheries. In some cases, the information was clear and unambiguous. In other cases, various interpretations were old, sketchy, unclear as to location, or given only in relative terms to other sites, in and out of the Garcia basin. In some instances, such as the canopy cover on Signal, Inman and Whitlow Creeks, data simply conflict.

Sensitivity to impact was evaluated by first establishing the presence of the resource to be protected, then determining if that resource was responding negatively to land management. For instance, where fish were specifically 'not present', an interpretation of 'no sensitivity to fisheries' was given, meaning no sensitivity within that tributary. If estimated erosion rates were high (>300 tons/sq.mi/yr) but did not result in a 'high' reported level of instream sedimentation, a value of 'no sensitivity to land use impacts' would have been given. Including a range of source material, no watershed within the Garcia basin was considered unaffected by sediment impacts.

Other beneficial uses, beyond fisheries, that have sensitivity to fine sediment, temperature, dissolved oxygen, channel complexity, and shade are domestic water, industrial and agricultural water and recreation. In the case of the Garcia, these other beneficial uses are limited in extent and, in general, track with fishery quality. Evaluating the watershed for fishery quality is therefore, in most cases, an evaluation for other beneficial uses. The most widely reported impact is fine sediment; other habitat impacts reported are lack of stream complexity and lack of riparian shade.

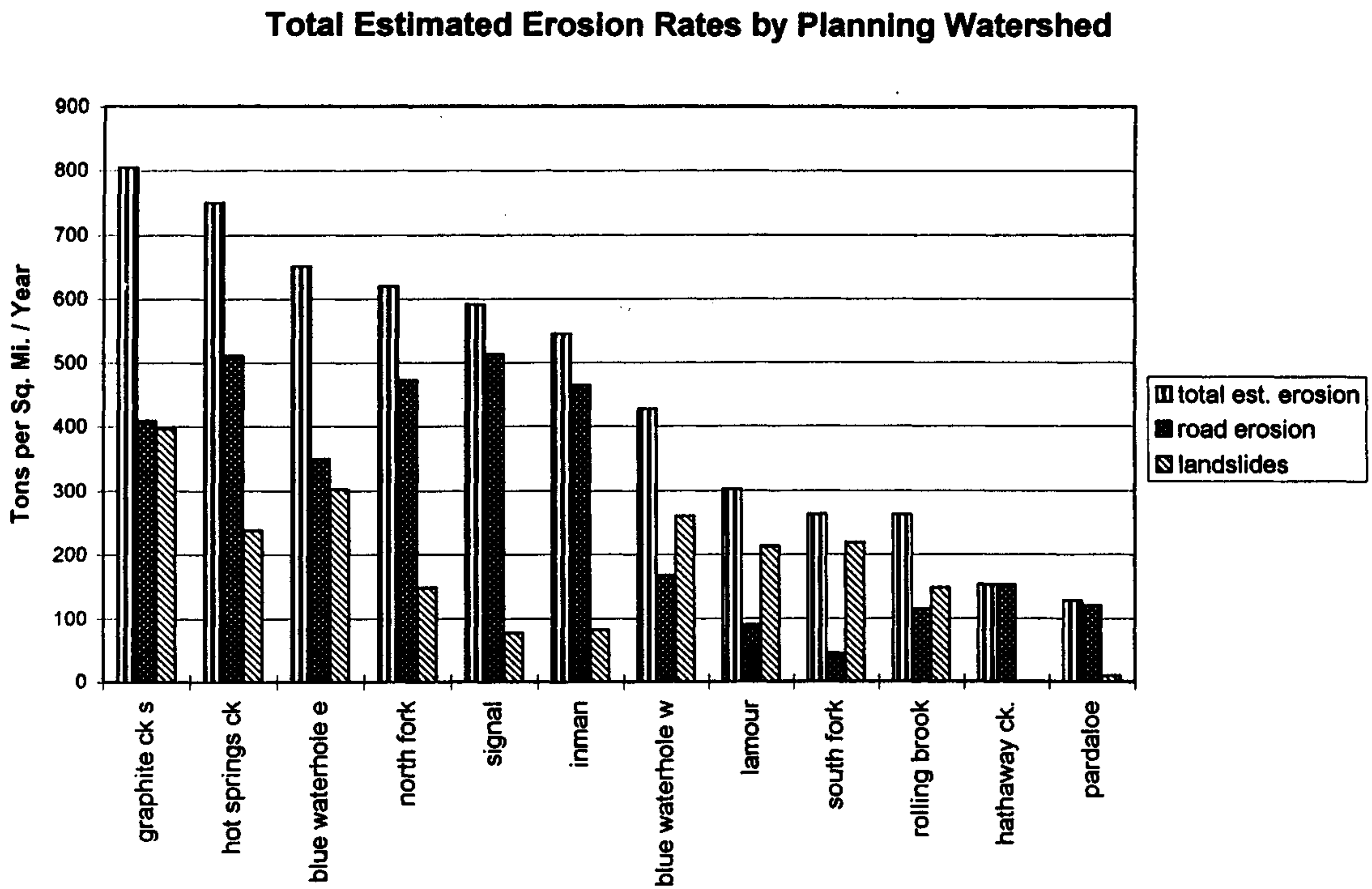
Sediment, lack of complexity and open canopies affect fisheries and streams in a profound manner. Sediment can adversely affect domestic water via inlet structure limitations and incorporation of a pollutant which must be filtered out before use; sediment also reduces recreational opportunities as it reduces pools important for fisheries. Complexity reflects the stability of a channel, or the mobility of sediment and specific functional elements. A loss of complexity affects the utility of inlet structures and the location and depth of pools. Shade restricts the growth of algae and reflects dissolved oxygen levels in the stream. A loss of shade and concomitant growth of instream vegetation affects the color and taste of water, its aesthetic quality and its pool utility for recreation.

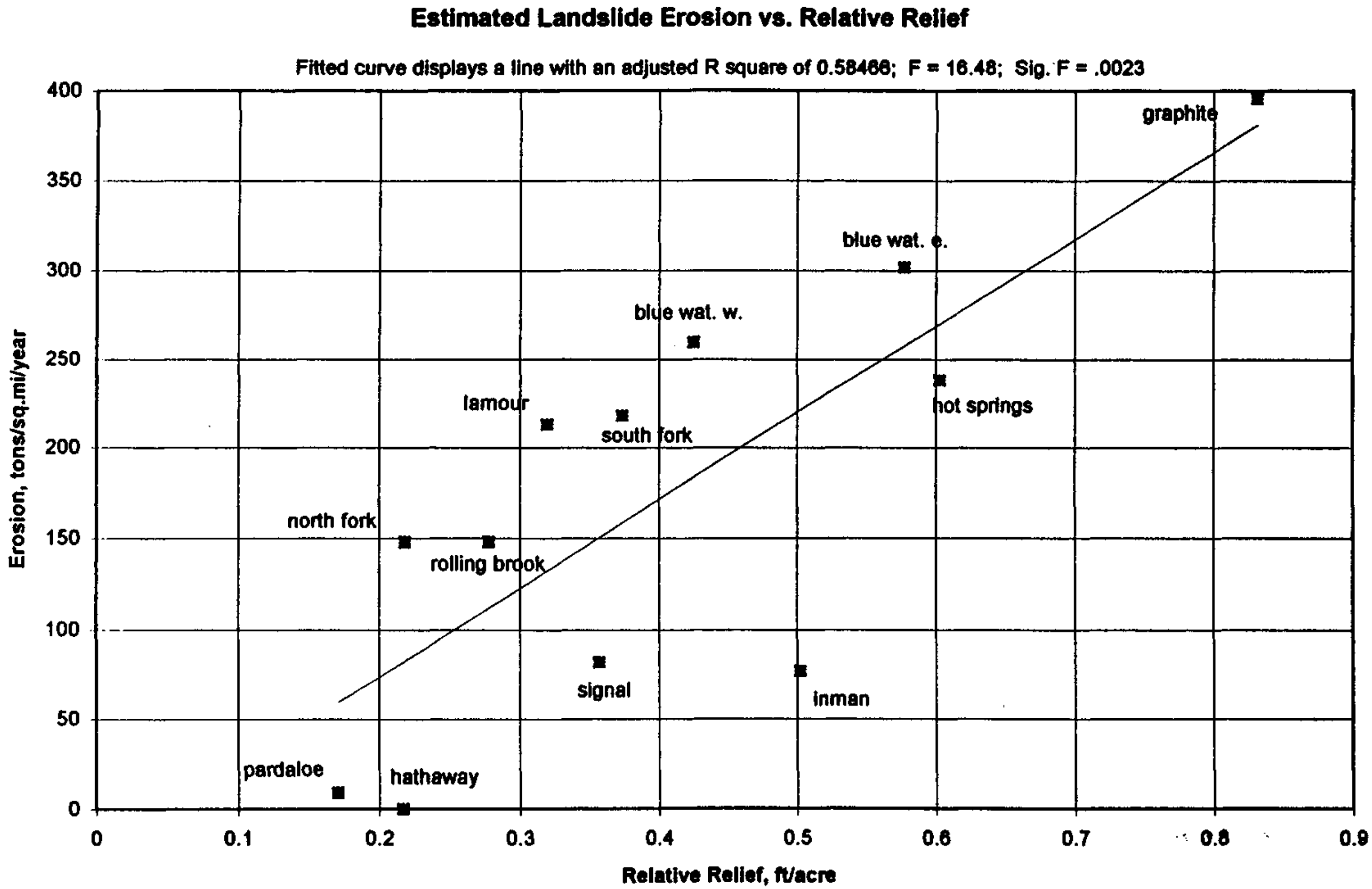
The matrix of tributaries and subwatersheds by resource condition and sensitivity is attached as Appendix B. Future data can be categorized within the matrix as the monitoring program is implemented and new data are gathered by basin stakeholders and agencies.

One approach to synthesis has been to look at estimated erosion generation from watersheds, both as a total and by its component parts. These data are derived from O'Connor's analysis given in Chapter 3 and shown in Figure 4-1. Using the Level 2 analysis conducted by L-P changes the sediment delivery ratio of streamside landsliding upward, from 50% to 75%, representing an increase in total landsliding of about 50%. Adjusted or unadjusted, the values demonstrate the importance of understanding processes in the small, steep planning watershed (PW) areas of Graphite Ck. South (PW 8) and Hot Springs Creek (PW 6). Graphite Ck. South, in particular, is an area with more landslide activity than any other basin in the watershed, and deserves appropriate protocol evaluations.

Another approach to synthesis is to develop a model of predicted erosion and evaluate present impacts to it. This synthesis found a significant correlation between landsliding (O'Connor, 1997) and topography, as shown in Figure 4-2. More than half the randomness of landslide volumes can be accounted for by the relative relief of watersheds (area/relief), with a significance of greater than 99%. This data is important because it points out subwatersheds in which high sedimentation is predicted, and where high sedimentation is anomalous (Appendix B). When compared with field data (Mangelsdorf, 1997; Monschke and Caldon, 1992) areas with low relief and high sedimentation indicate priority sites for understanding sediment delivery processes. Watersheds which stand out are Pardaloe Ck., Inman Ck., the North Fork subwatersheds and Hathaway Ck.

The synthesis element in this report should not be considered definitive, but rather a first cut. As researchers get more information in, as models are proven, and as data improves, synthesis will become more fully attainable. The first step in that process should be the implementation of protocols which demonstrate the nature of causal mechanisms within the Garcia River watershed.


Total Estimated Erosion Rates by Planning Watershed
Tons per Sq. Mi. / Year
900
800
700
600
500
400
300
200
100
0
graphite ck s
hot springs ck
blue waterhole e
north fork
signal
inman
blue waterhole w
lamour
south fork
rolling brook
hathaway ck.
pardaloe
total est. erosion
road erosion
landslides


Estimated Landslide Erosion vs. Relative Relief
Fitted curve displays a line with an adjusted R square of 0.58466; F = 16.48; Sig. F = .0023
Erosion, tons/sq.mi/year
Relative Relief, ft/acre
0
50
100
150
200
250
300
350
400
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
graphite
blue wat. e.
blue wat. w.
hot springs
lamour
south fork
north fork
rolling brook
signal
inman
pardaloe
hathaway

### *B. Causal mechanism statements*

Causal mechanisms are important for understanding the direct relationship between *actions,* in this case from timber harvesting, and *impacts,* in this case, restricting salmonid fisheries. The Washington State watershed analysis protocols (WFPB, 1995) describe causal mechanisms as the outcome of the resource assessment process, as shown in Figure 4-3a. The resource inventory is combined with resource analysis modules in a synthesis, described in process by a routing model, and culminating an analysis *of how* watershed actions occur, *what* impacts those actions generate, *what course* they take to the resource of consideration, and *how and when* they limit that beneficial use. The resource inventory allows adaptive management—to observe, act and observe again to best manage resources from documented experience.

This report is based on a Level 1 air photo analysis of the Garcia watershed and previous studies. These references do not allow the demonstration of causal mechanisms, but, instead, document likely sediment sources and instream resource conditions. We know, too, that the watershed has received significant timber harvest impacts over time, and we know the location and the nature of those impacts. We can presume that the watershed is presently recovering from these impacts. However, without documentation, we can only hypothesize that streams and the habitat they provide are recovering from the harvests of the 1950's to 1970's. We know that present conditions in these streams have embedded gravels, stored sediment, and poor shading, low complexity and reduced fish populations. Without causal data of *why* the old logging practices make present habitat poor, or how old logging practices continue to suppress fish populations, we cannot test the hypothesis that old practices are, indeed, at fault; we need quantitative, causally-oriented data to distinguish old problems from new ones.

A causal mechanism statement tracks impacts from the landscape to the beneficial uses affected. The clear statement of cause and effect allows both mitigation of impact and relaxed monitoring of innocent activities. A model statement from the WM is shown in Figure 4-3b.

The causal information that is needed from watershed studies in the Garcia should answer the following questions:

- Are streams presently limited in fish production by sediment, temperature or habitat?
- What mechanisms contribute fine sediment to the stream system?
- What mechanisms contribute heat to the stream system?
- What mechanisms reduce habitat quality of the stream system?
- Does the habitat quality limit fish productivity?

A causal analysis of the Garcia watershed would track specific units of water with elevated levels of fines or heat from their sources to the stream. Monitoring, however, is limited in scope, and cannot operate in all sites or at all times. Because we cannot directly quantify processes across the Garcia watershed continuously, we need to orient monitoring to observe and describe likely causal mechanisms which degrade habitat. To do this, we need to evaluate habitat quality through indices—individual parameters that reflect important overall conditions. These indices reflect the hypothesis that high habitat values derive from cold, clean water, gravels low in fine sediment, shade and complex habitat.

Causal mechanisms will, therefore, be determined through a combination of approaches: 1) forensic methods that find the sources of degradation; 2) indices that reflect habitat quality; and 3) indices that reflect fisheries quality. From these data, it will be possible to make causal mechanism statements.

Causal statements do not establish perfect linkages that reflect quantitative levels of degradation; this could only be done with continuous monitoring and a wide area, and would be extremely expensive. But causal statements, with their identification of important and major source areas will allow the implementation of BMPs to limit long-term habitat degradation.

The proof that this approach works—reduction of sources to improve instream habitat quality—will, ultimately, be an improvement in fisheries. But because fisheries are affected by so many factors, including previous years' instream success, weather, fishing, blockages, and predation, fish counts are very poor demonstrations of causality. We do, however, recommend fish counts as a monitoring tool. The IMP also anticipates other parties working with the RCD on fishery evaluation as well as continuing their range of surveys, including estimating escapement, redd counts, carcass counts, creel censuses, electrofishing and snorkel surveys, which will independently confirm or deny the validity of the IMP's monitoring approach.

Further, the IMP also recommends investigation blockages, specifically, to find areas unable to become successful fisheries due to causes not originating upslope. These data are important, because fishery success from good habitat elements is an underlying hypothesis of this IMP and causal analysis of the Garcia watershed.

From this site and stream data collection approach, the MCRCD can identify sources of degradation, reduces those sources' impacts, and see if fisheries improve. Combined with information on blockages and other non-site dependent limiting factors for fisheries, this IMP will test both: 1) if habitat improves by reducing impact sources; 2) and if fishery production correlates to habitat indices. This is adaptive management.

Figure 4-3 a. Washington Methodology Resource Assessment Process (WFPB 1995).

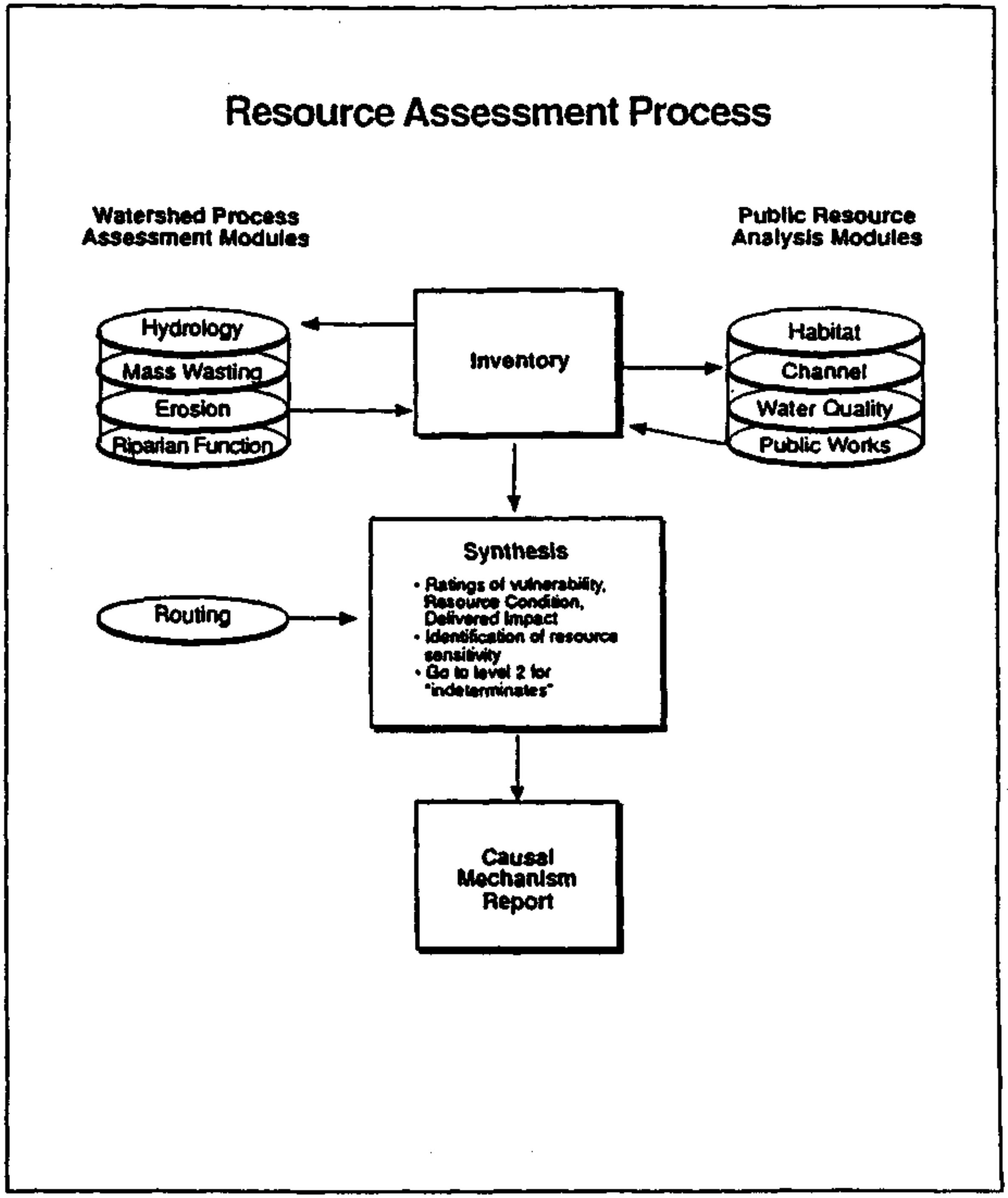
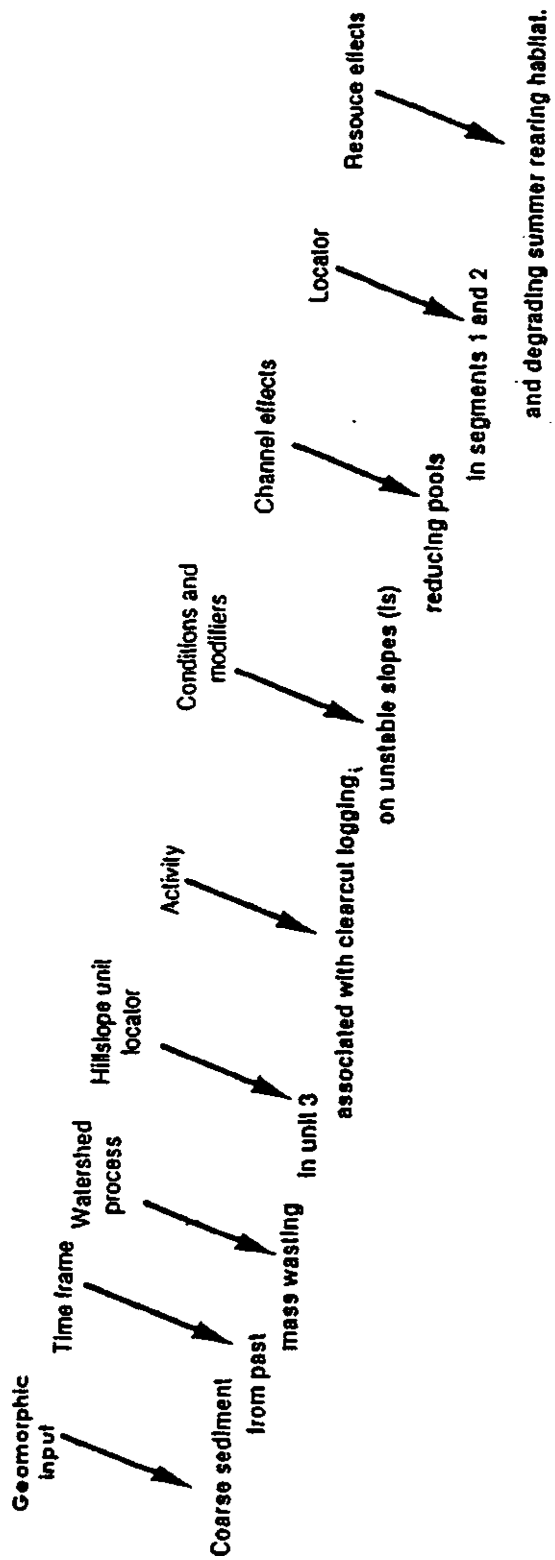



**Diagram of the Principle Elements of Resource Assessment**

Figure 4-3b. Washington Methodology Causal Mechanism Statement (WFPB 1995).

**Situation Sentence Syntax**



### i. Sediment

Analytical approaches to the assessment of the Garcia assume that present sedimentation rates in the Garcia are significantly higher than they would be in a control watershed. The methodology for road-related erosion using the Washington State methodology, described in Chapter 3, has this concept at its core. The impact of this sediment may be to reduce the effectiveness of gravels for salmonid egg placement, incubation and emergence. Relative to unaltered baseline conditions, sediment-affected streams may have aggraded their beds, having an effectively lower water table in low flow conditions and higher peak flows in flood conditions. Pools may be reduced in size and frequency, by both filling of pools and covering of pool-forming elements, respectively. Establishing causality between sedimentation and reduced salmonid production requires either establishing the validity of these links or acknowledging their assumption.

The relationship between sedimentation and its impact on fisheries is examined widely in established literature, such as Furniss, et al. (1991). The authors cite sediment as affecting streamflow, channel depth, fish passage, reduced spawning area, reduced egg-to-embryo success, reduced total habitat, and increasing further sedimentation through positive feedback mechanisms. Another source, Bjornn et al. (1977), describes the physical and social effects on salmonids in test channels, and states:

> The immediate effects of adding sediment to the channels were a reduction in available habitat (fewer pools and fewer interstices in boulder piles and cobble) and an increase in the turbidity of the water. The turbidity decreased within minutes after the addition of sediment The reduction in cover for fish (mainly in the pools) and habitat for insects (in the riffles) affected both organisms.
>
> * * *
>
> Fish exhibited hierarchical behavior in the channels with two-thirds or fully imbedded pools, but territorial behavior in the channels without fine sediment. As we increased the imbeddedness levels in the channels, the amount of cover decreased in both pools and riffles. The smaller age 0 steelhead utilized the riffles and pools in the control channels and in the test channels with one-third imbeddedness. As we increased the imbeddedness of the riffles, the age 0 steelhead using the riffles moved into the pools. As cover became scarce in the pools, hierarchical behavior predominated. The main holding areas for fish were at the upstream and downstream ends of pools.

Sediment monitoring should, therefore, be oriented towards problem areas, solutions for implementation and establishing connections between hillslope processes and instream impacts. A useful protocol for the evaluation of this site-specific evaluation of sedimentation is the 'Sediment Transport Corridor' protocol, which identifies sediment entry points along a specific stream segment, and traces the path to its source. This method is also called a 'forensic' approach. Instream protocols can make general statements regarding the disposition of that sediment, in terms of thalweg depth, pool filling and inter-particle deposition. It is probably not within the scope of the Mendocino County RCD to demonstrate causality between the lowering of stream habitat indicators and a concomitant lowering of salmonid productivity, but regular measurements of fishery productivity will confirm or deny the relative long-term importance of habitat variables in the Garcia watershed.

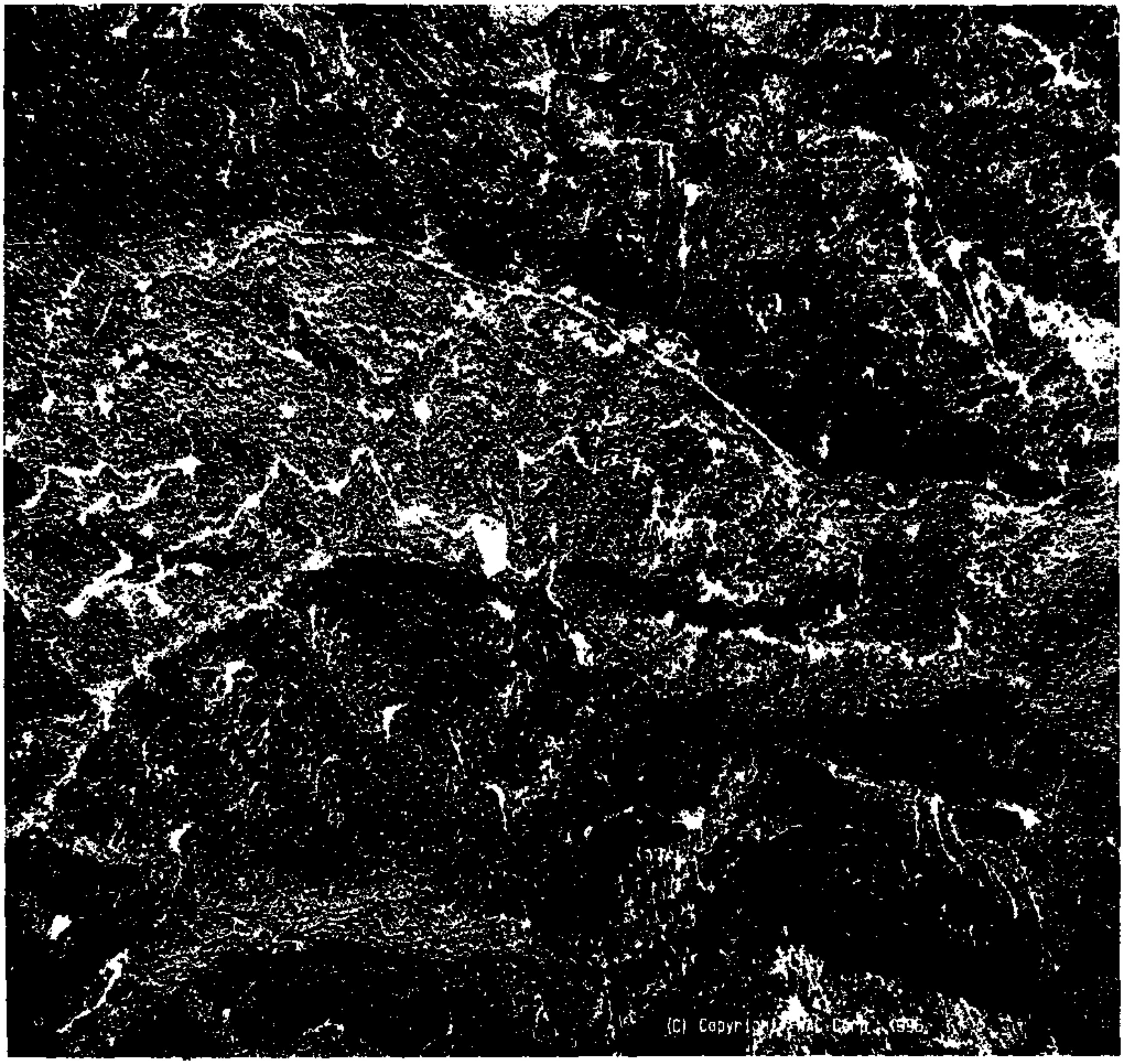
In the Level 1 watershed analysis (Chapter 3), the only causal mechanism paths identified in photos and on the ground is the delivery of unsorted sediment to the stream system through landsliding. Erosion of fine sediment paths from roads are not documented, they are presumed. Other causal mechanisms routing sediment presumed in this analysis are soil creep and delivery into channels, erosion of fine sediment from harvested areas.

Examination of the aerial photography of the watershed shows the following features as potential causal sediment contributors to the stream system:

1. roads, particularly those used as part of timber harvest activity;
    a. roads too close to streams to allow forest floor percolation to capture sediment from diverted water
    b. roads adjacent to streams, allowing loss of fill material through bank erosion processes
    c. roads crossing streams
    d. old roads up draws
2. power line right of ways;
3. tractor logging areas, principally through skid road networks;
4. cable logging areas principally through landings and cable roads extending downslope;
5. streamside bank erosion;
6. deep-seated, grassland landslides with associated gully systems; and
7. debris flows, often in association with road or skid trail networks.

These features have been identified as potential contributors of sediment to the stream system because, without on-the-ground confirmation of delivery, the impact of any transport mechanism within any specific watershed is postulated. Field notes, however, show definite contributory roles of road inboard ditches, crossings of small draws and the existing private road system, bank erosion, steep slopes with unvegetated fills, steep roadcuts and unstable geologic material at roads. Photo details of Olsen Gulch and Signal Creek are presented in Photos 4-1 and 4-2, showing extensive timber harvesting road networks. These photos identify tractor harvesting, landings, roads, cable roads and road crossings as likely problem areas, which need systematic field checking.

Photo 4-1 Olsen Gulch, North Fork Planning Watershed; 1996

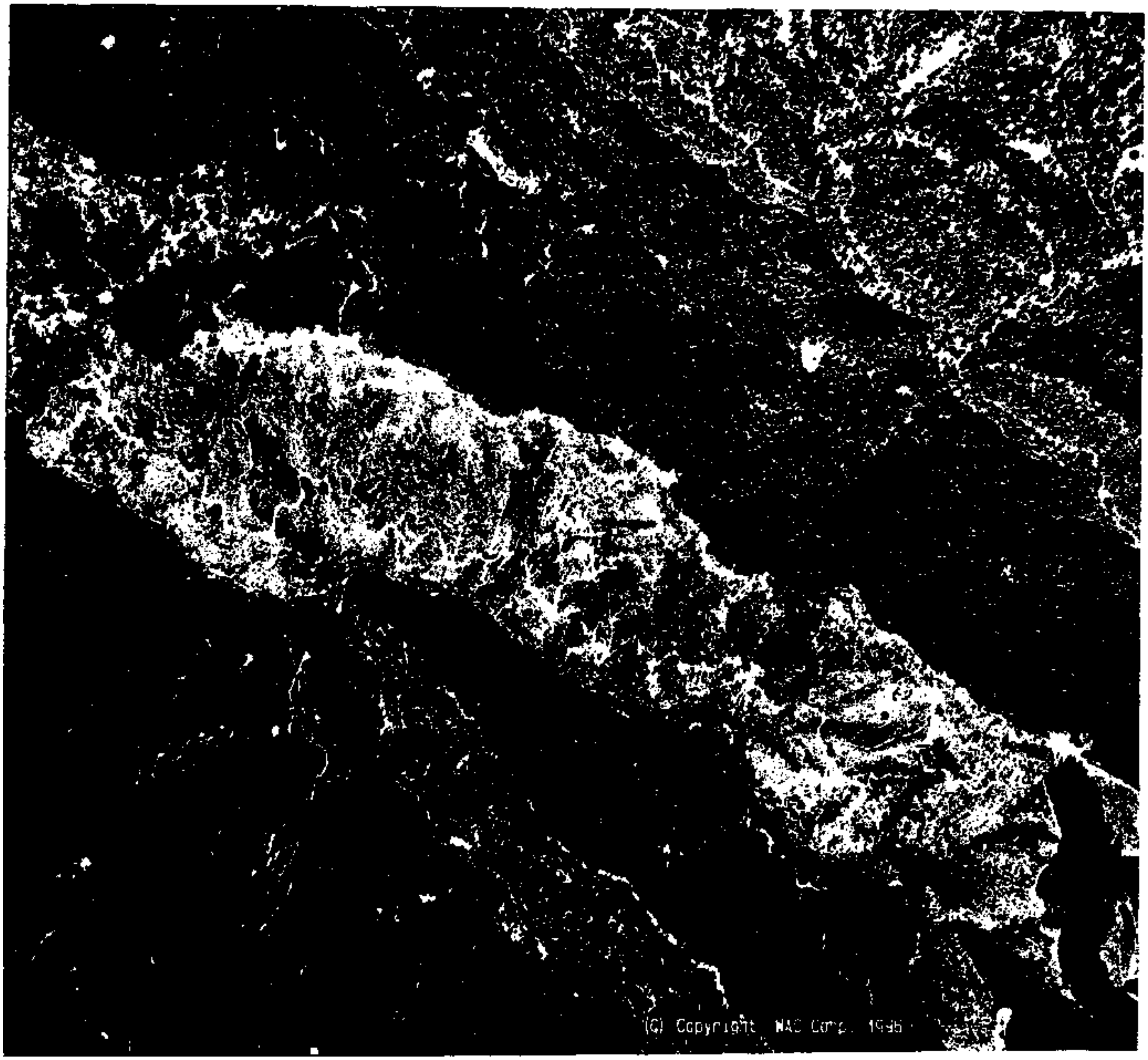


**Kilometers**
0 0.5 1.0

**Feet**
0 1000 5000

**Miles**
0 0.5 1.0

Photo 4-2 Signal Creek, Signal Creek Planning Watershed; 1996




**Kilometers**

**0 0.5 1.0**

|-----------------|-----------------|

**Feet**

**0 1000 5000**

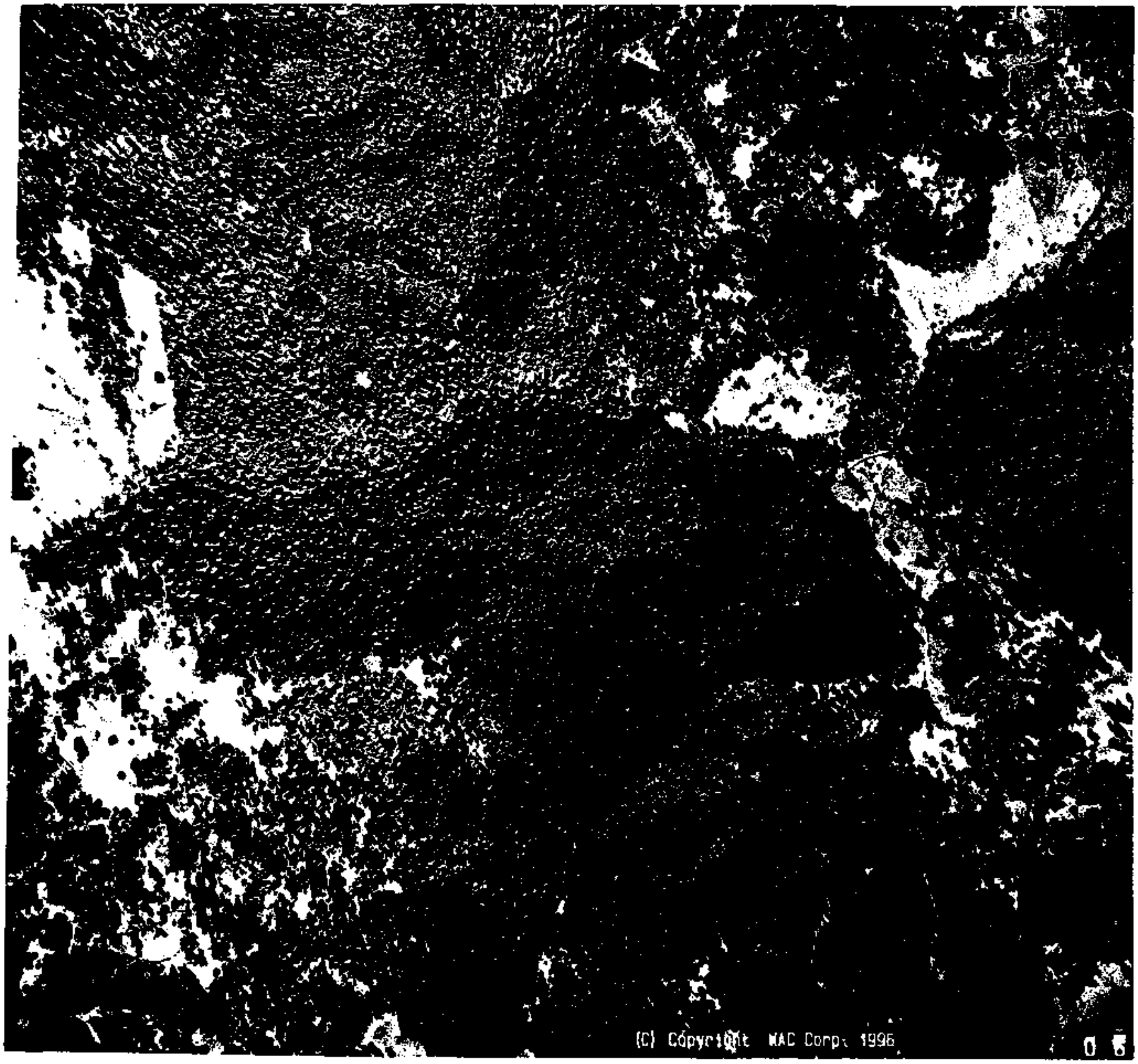
|----|----|----------|----------|----------|----------|

**Miles**

**0 0.5 1.0**

|-----------------------------|-----------------------------|

Photo 4-3 Mill Creek, Pardaloe Planning Watershed; 1996




**Kilometers**

0 0.5 1.0

|-----------------|-----------------|

**Feet**

0 1000 5000

|-----|-----|----------|----------|----------|----------|

**Miles**

0 0.5 1.0

|-----------------------------|-----------------------------|

Final determination of *how* and *from which areas* fine sediment enters the Garcia remains a needed outcome of this IMP and analysis effort. A specific field investigation looking for the direct input of sediment to sample areas of the stream system-forensic methods, in particular the sediment transport corridor methodology and watershed-wide turbidity and source area investigations—will allow a reasonable estimate of source areas, relative volumes, time spans, and specific fixes for an array of sediment sources. Ideally, this would be a Level 2 investigation, and should be considered by the RCD as a watershed-wide project.

Causal understanding of fisheries impacts from sedimentation will also require monitoring the disposition of sediment in the Garcia watershed following its entry into the stream system. Protocols should assess the *relative quantity* of sediment in pools and gravels, their *effect,* and their *rate of change.* This allows addressing the severity and persistence of impacts on fisheries created by sedimentation.

### ii. Canopy Cover

While canopy cover is specifically identified as a resource to be protected within the Forest Practice Rules (CDF 1974-1997), timber harvesting and related roads have reduced canopy cover in the Garcia watershed. The apparent reasons for low canopy values in the watershed are continuing engagement of roads and landings too close to the stream to allow for maintenance of significant canopy, roads which cross streams and reduce canopy on both sides of the watercourse, timber harvesting in previously cut, low basal area forests, and natural or historic openings in streamside forests. The areas of Photos 4-1 and 4-2, Olsen Gulch and Signal Creek, can be compared with near-natural levels of forest, such as in the Maillard State Redwood Reserve on Mill Creek, shown in Photo 4-3. The difference is more pronounced when assessed on site, where one can see it is not only the direct shade from the canopy which has been altered, but also the host of forest influences created by the canopy, such as wind speed, air temperature and humidity which have been changed.

Causal tracing of the loss of canopy is direct: cutting trees removes forest canopy. Tracing the impacts of that canopy loss is much more speculative. In places, canopy loss increases direct insolation. Canopy loss also reduces source areas for allocthanous deposition into streams, both of leaf litter and insect drop. Canopy reduction reduces deposition of woody debris into the stream system, of fine, coarse to very coarse materials. In indigenous forests, redwoods were capable of placing extremely long lasting, very large diameter boles into stream systems, complete with extremely large root wads. With harvesting, the addition of these very significant materials has been greatly curtailed, to the point of near cessation.

Causal tracing of increased insolation would evaluate the physical parameters of stream temperature, growth of algae and levels of dissolved oxygen. Biological measures would evaluate location and frequency of organisms with habitat affected by sunlight or other physical changes to the stream ecosystem.

At this time in the Garcia there are both established canopy and temperature monitoring sites, and a record of one-time canopy and temperature measurements, as shown in Appendix C. There are also stated goals within the Forest Practice Rules, SYPs, NTMPs and THPs for canopy retention and recruitment trees. Data have not been collected with the intention of demonstrating causality between physical parameters nor the connection to biological impacts. Future data must take this step, evaluating direct insolation, temperature changes (or not) related to that insolation, and the role of trees and canopy in creating habitat and providing nutrients to the stream.

### iii. Stream Complexity and Habitat Elements

As biological systems become increasingly complex, our knowledge of them retreats accordingly. There are some demonstrated relationships between stream complexity and salmonids, however. Salmonids prosper with pools and riffles; instream cover among rocks, logs or other submerged objects; shade; overhanging banks; diverse bottom structure; depth; bubble curtains; and turbulent flow down the channel (e.g. backwaters, eddies and cross-currents). The concept of complexity is evaluated as 'Stream Habitat Elements' within the California Department of Fish and Game protocols (Flosi and Reynolds, 1991). Complexity is also appreciated by fisherfolk, who cast for deep pools, converging waters, the break of water in front of rocks, the flat of water behind rocks, bubble curtains, towards logs and towards the shady area adjacent to banks.

Demonstrating the loss of complexity as causally linked to timber harvesting and related activities may take a few forms, starting with the quantification of the existing stream condition. Stretches of streams can be documented for frequency and size of pools, riffles and runs. Woody debris can be monitored for size and frequency. Thalweg profiles can demonstrate the effect of sediment covering, uncovering or filling habitat elements. Photographic stations can record changes in bank, bed and boulder placement and relative imbeddedness of substrates. Recruitment trees can be monitored for presence and induction into the stream system.

All of these evaluations require repeated visits to document *long-term* changes in the stream. Complexity takes years to develop and change. All of these evaluations also require specific ties to upslope activities to demonstrate causal linkages to timber harvest activities. Sediment transport corridors can document aggradation and imbeddedness sources. Sketch maps can document woody debris sources as well as the cutting associated with the loss of potential woody debris and recruitment trees.

Linkages of these elements to salmonid populations in the Garcia can be addressed by evaluating where fish use the stream during their life cycles. As habitat elements create diverse environments, so do those environments create opportunities for fish at varying portions of their lives. Fish surveys, using different techniques to evaluate the Garcia's mainstem and tributaries for different populations, can yield important information on spawning location, summer habitat, feeding sites and territoriality. Together with site data, fish data can show how the salmonid populations are causally affected by land management actions, over the long-term time frame of habitat elements.

### iv. Dissolved Oxygen

Both the Monschke and the Mangelsdorf reports documented low oxygen levels in the stream as a likely occurrence, particularly at the bottom of mainstem holes below Rolling Brook. If true, these levels would be reducing some of the best habitat in the system; the deeper holes are considered important as refugia as the coldest, darkest parts of the system.

It is not clear how timber harvesting could have a causal affect on receiving waters that would result in lower oxygen. One possible scenario is that increased insolation could increase both temperatures and algal growth, resulting in higher night time oxygen demand, when the algae respire, higher biological oxygen demand (BOD) when the algae die and decompose, and lower capacity of the water to hold oxygen, due directly to higher temperatures.

Investigation of this causal chain will require first, monitoring oxygen in mainstem pools, and, if it is low, determining its cause. While it may not be possible to establish causal links between mainstem conditions and timber harvesting impacts, the importance of oxygen levels in the mainstem Garcia demands monitoring and assessment of these conditions.

## *5. Instream Monitoring Plan*

### A. Objectives for the Garcia River Watershed IMP.

The Garcia Watershed Instream Monitoring Plan (IMP) will represent a cooperative data collection effort between individual landowners and agencies in the watershed, will complement the existing, continuing data set, and is described in 5.D. and in Appendix C. The primary objective of this plan is to test the capability and effectiveness of the California Forest Practice Rules to protect determined beneficial uses, in this case, the salmonid fishery of the Garcia River. A secondary objective is to create a long-term monitoring data set whereby the Garcia River can be compared to other neighboring rivers in the development of a regional standard. The third, and perhaps most important objective is to understand the Garcia River watershed and reduce its overall sediment load through adaptive management.

### i. Context

The context of monitoring is the most important consideration for implementation. The IMP will be implemented by a combination of landowners (in this case, forest owners), agencies and the RCD. All of these participants must recognize that their pieces of data unite to form a framework for adaptive management. Thus, all the protocols must be:

- relevant to both primary and secondary timber harvest impacts;
- shared among agencies for the creation of a functional database;
- conducted with agreed-upon protocols, so they can create that database;
- heuristic, so that protocols can fine-tune, and monitoring elements can change with greater knowledge of the system;
- ecosystem-oriented, so that they describe existing conditions relative to healthy, functioning redwood/Douglas-fir/grassland/anadromous fish ecosystem; and
- stewardship-oriented, so that results are of a meaningful scale and value for the protection of acknowledged resources, specifically anadromous fish and water supplies.

### ii. Objectives

Protocols must address this context of cooperation and long-term utility while evaluating the existing and potential salmonid productivity of the Garcia stream system. In other words, we must begin by testing those parameters we believe to be important. As stated above, those parameters are evaluated through indices which respond to particular characteristics of the stream system, and those characteristics are hypothesized to be important to fish in the Garcia. An outline of parameters, indices, characteristics and fishery values is shown in Table 5-1.

Table 5-1. Parameters, Indices, Characteristics and Fishery Values for Guiding Assessment of the Garcia River Stream System.

| class of parameter | index | measured characteristic | fishery values |
|---|---|---|---|
| water quality | turbidity | suspended sediment, sediment sources | incubation, juvenile rearing |
| | dissolved oxygen | oxygen saturation | incubation, summer refugia |
| | temperature | heat, potential oxygenation | incubation, summer refugia, juvenile rearing |
| gravel quality | percent fines <2 mm | substrate composition | spawning, incubation, emergence |
| | permeability of gravels | interstitial flow | spawning, incubation, emergence |
| channel assessment | cross sections | bed mobility, sediment transport | juvenile rearing |
| | V* | pool depth | summer refugia |
| | LWD survey | stream complexity | juvenile rearing, summer refugia, overwintering habitat |
| | longitudinal profiles | bed mobility, bed complexity, pool depth, sediment | juvenile rearing, summer refugia, overwintering habitat |
| riparian function | canopy measures | shade, allochthanous input | juvenile rearing, summer refugia |
| causal mechanisms | sediment transport corridors | sediment sources, delivery mechanisms | spawning, incubation, emergence, juvenile rearing, summer refugia, |
| | turbidity | suspended sediment, sediment sources | incubation, juvenile rearing |
| fish productivity | spawning surveys | escapement, spawning opportunity | potential productivity |
| | summer fish counts | utilization of pools and riffles | productivity of juvenile age classes |

Parameters for monitoring have been distinguished as *water quality, gravel quality, channel assessment, riparian function, causal mechanisms, and fish productivity.* These categories correspond to sets of metrics, or indices, for determining stream quality because they directly relate to fishery qualities. Some forms of pollution cross the borders of these parameters easily, such as sediment, the routing and consequences of which may be measured in many ways. In order to understand the 'life history' of sediment or other pollutants within the system, however, a set of metrics should be applied, combined and interpreted.

### iii. Sampling Framework

The application of any metric requires a sampling framework in which it is implemented. While there are plenty of good data on the Garcia, many measurements were taken as once-only; many were gathered at adventitious spots; some were biased by access considerations; some may have been biased by aiming at a specific result. Similarly, many protocols bring with them a pre-determined sampling frame that does not correspond to other metrics. A spawning survey, for instance, samples the whole stream width over a continuous length moving upstream from a fixed point. An airphoto canopy survey evaluates stream corridors with a grid. A recording thermometer is generally part of a relatively sparse network, placed purposefully in a stream segment with adequate depth (so it is covered) and relatively slow flow (so it does not pull away). These measurements may correspond, but they are not directly comparable.

In the following parameter descriptions, it is important for the reader to understand that *all* metrics must be applied within a regular framework. They can not be limited to single samples; they must include multiple or spatially continuous samples on streams which are monitored; they must be located for repeatability with permanent benchmarks; they must be located relative to each other so that multiple benchmarks address each site; and all samplers should be using *similar sampling frames,* so that data are comparable.

Repeating multiple protocols on a single reach of stream implies the establishment of a **"study reach,"** a length of stream where researchers place and measure a systematically (or 'mechanically') defined cluster of sample **plots,** or "reference sites" (Harrelson et al., 1994). Harrelson, Rawlins and Potyondy describe locating and measuring plots one meander (two bends) in length. FSW recommends placing clusters of four plots in one study reach, scaled so they capture approximately 15% of a study reach's total length. We have attached FSW's plot location guidelines for locating plots in study reaches (FSW 1997a). This approach will achieve a stratified systematic sample.

Study reaches on selected streams should be identified, as per the Washington or TFW methodologies, within strata that have relatively homogenous slope, geology, and long-term land use. Slopes of streams for long-term full protocol monitoring should, ideally, be less than 2.5%, an upper limit for coho, but can be up to 5 %, a limit for most steelhead, if no less steep areas are present (Trush 1997). The GISs of CDF, L-P and CFL are a good source for stratification and plot location, and will be useful cooperative information in site selection.

Plots should be one meander (two turns) long. The stream reaches should not be dominated by braided channels. Selected sites must be capable of having three to four plots, representing 15% of the stream reach. A meander length of 40 meters, therefore, would require 265 meters between plots, and a total length of 1220 meters (e.g. 40+ 265+ 40+ 265+ 40+ 265+ 40+ 265). Sites should be chosen to start the measurement which are more than 100 m upstream from confluences or blockages; calculations for inter-plot distance should be rounded down, to maintain a 15% minimum sample; the crews will have to use judgement to site the plots when they arrive at the pre-determined study area; and plots should not be sited with the stream in a culvert. Culverts and blockages should be monitored separately from the plot-oriented component of this IMP.

Within the plots, field crews should make site maps of plots, one meander (two turns) in length, as described in Harrelson (1994). Valley bottom morphology should be recorded, and the map should cover the alluvial segment of the stream. Monuments need to be installed, as well as a system of flagging that does not conflict with others used in the region. These procedures are also described in Harrelson, and are attached.

Once a stream reach of appropriate size and slope on a selected stream is located for a set of plots, it is important to implement the sampling frame on the study reach, both in plots and continuously along the stream reach. Suggested sampling intensities for all recommended protocols are shown in Table 5-2. Measurements which are appropriate for one or two points only (not including replication for quality control) are temperature and dissolved oxygen. Remonitoring of historic transects, keyed to a single point, is appropriate for cross-sections. Continuous samples, with data collection at multiple adventitious points, should be done for sediment transport corridors and fish surveys. A continuous sample centered on one plot is appropriate for a longitudinal survey. Data measured at pre-selected points in the larger plots are best for canopy coverage and shade. Measurement of pools and riffles, for V*, McNeil and permeability metrics are taken up to a target level, three gravel samples in riffles, and two pools per plot, when possible. Large woody debris is measured inside plot areas, only. Recruitment trees need a look up the slope, within the length but outside of the width of plot areas.

Table 5-2. Sampling Frames for Selected Protocols

| | **Sampling Frame** | | |
|---|---|---|---|
| **Protocol** | **site specific** | **plot** | **stream reach (3-4 plots)** |
| **sketch map** | | 1 | *3 to 4* |
| **large woody debris (LWD)** | | 1 | *3 to 4* |
| **recruitment trees** | | 1 | *3 to 4* |
| **V* of pools** | | 1 to 2 | *4 to 8* |
| **substrate composition** | | 3 | *9 to 12* |
| **permeability of gravels** | | 3 | *9 to 12* |
| **canopy measure** | | 3 | *9 to 12* |
| **longitudinal profiles** | | | 1 per reach |
| **sediment transport corridors (STCs)** | | | whole length |
| **spawning surveys** | X | | whole length |
| **fish counts** | X | | whole length |
| **temperature** | X | | 1 per reach |
| **aerial turbidity survey** | X | | as observed |
| **turbidity** | X | | |
| **flow** | X | | |
| **dissolved oxygen** | X | | |
| **cross- sections** | X | | |
| **barrier evaluation** | X | | |

### iv. Implementation

An objective for the IMP is that it can be implemented by the RCD. The budget for this IMP includes money for hiring an in-house or consulting coordinator for this program. That person must be able to:

- implement field studies, particularly instream protocols;
- train crews and cooperators in methodologies;
- schedule complex tasks over a wide geographic area, often in adverse weather conditions with a broad range of people;

- create a functional database for data accumulation, sharing and analysis.
- work well with cooperators to assure data quality; and
- help with protocol and equipment needs of cooperators.

The success of the Garcia IMP will hinge on effective implementation of protocols, both in the field and in the office. It is intended to be trend monitoring for conditions in the Garcia watershed, and is thus primarily a data analysis effort, with data collection as its foundation.

This IMP outlines protocols and a framework in which to implement them. It is not, in itself, a turnkey process. Only with a good on-the-ground leader, responsible for oversight of the varied elements of the study, including data entry and analysis, will the IMP effort be successful. FSW recommends that the RCD hire a masters' level project coordinator, experienced with instream and hillslope monitoring, at one-third time to be responsible for in-house coordination, cooperative monitoring participation, data entry and management, budgeting and reporting to the RCD and the MSG.

The coordinator's effort in implementation will make this a worthwhile program. Without a good coordinator, this set of protocols can not be effectively implemented, nor can the RCD or MSG derive value from the data.

## *B. Protocols*

### i. Water Quality

The water quality metrics which appear most relevant to the productivity of salmonids in the Garcia are turbidity, dissolved oxygen and temperature.

**Turbidity** is a proxy for suspended sediment, and would be most useful if collected simultaneously throughout the basin, to determine, in a forensic sense, which watersheds are the most rapidly contributing sediment to the mainstem. It is a relatively blunt instrument; watersheds cannot be truly corrected for precipitation, human or natural inputs that create turbidity. But because turbidity is clearly related to salmonid survival (through suspended sediment and its effect on smolts and fry), because it is bounded by legal requirements under the Basin Plan (NCRWQCB 1988), and because it is a useful forensic tool, turbidity should be monitored.

Generation sites of significant, timber-harvest related turbidity may be few, far between, and extreme. Dodge's (1976) review of 65 sample THPs found only two plots, or 3% of study areas with 'extreme' erosion rates; Lewis and Rice (1990) state that most studies find that "most of the erosion occurring on timber harvesting areas was from large mass wasting events found on a small fraction of the disturbed sites." Looking across the whole watershed for turbidity and its sources will serve to:

- aim monitoring tools at important sites, to determine causality of the few, extreme events that may dominate local sediment budgets;
- direct restoration efforts; and
- direct further studies for CDF's Long-Term Monitoring Project.

A classic monitoring strategy would be to implement mechanical turbidity and flow samplers at watershed-wide locations. This would cost $3000 to $5000 per station, plus data downloading and instrument checks. The Garcia's 12 planning watersheds contain more than 25 named tributaries of greater than one square mile, as well as the 40 miles of mainstem. Because turbidity is created by the cumulative output of the watershed above, while a set of stations would be useful monitors, they would not identify of causal effects.

An alternate approach, which FSW recommends, is looking for turbidity and its sources during the winters season, either from a hired plane, helicopter or by contracted aerial photography. This allows a broad view of the entire basin during the period when erosion is occurring, and is likely to find important erosion sites in the watershed. Monschke (1998) found a helicopter to be a useful tool for identifying streams with high turbidity in CFL's ownership, covering 60,000 acres in about 3 hours. A complete color airphoto set taken in winter of the whole basin would cost about $6000 (WAC, 1998). Limitations of airphotos may be canopy-restricted visibility, or the low sun angle creating shadows on important sites—these drawbacks should be evaluated following the first years' flight. Interpretation of the airphotos should look for slides, failing crossings, gullies and other significant sediment sources in the watercourses, as well as overall turbidity and its generation points.

Site specific data, in the form of grab samples during major storms at key, wet weather access locations are presently being taken public, private and volunteer agencies. This cooperative data should continue to be useful for instream data to accompany other information, and as an important, referenced record of the Garcia's condition. The IMP coordinator should check with these cooperators to assure that they are following acceptable, comparable protocols.

FSW recommends that the RCD cooperate with stakeholders who are presently taking grab samples at gaged sites, to make simultaneous flow and turbidity data available. In addition, the RCD should gather airphoto information for turbidity on a clear day immediately following a winter storm, well into the wet season. Cooperators with air equipment or interested in getting photographs of the basin in winter could be save significant costs for the RCD in the future. Small plane or helicopter flights would add significant information to the process, though they could not serve as a substitute for photogrammetry.

**Dissolved oxygen** (DO) measurements are not normally considered important for cold water systems, though concerns about DO levels have been voiced regarding the lower mainstem Garcia. Because these are important summer refugia, and because there are a set of causal reasons to be concerned about DO levels, we recommend formalizing DO surveys. Key measurement points are in the mainstem, deep in pools, and in warmer, sunnier and algae-affected tributaries. This is a summertime, low-flow survey. If, after several years of inconsequential data results, this metric appears irrelevant, it should be abandoned.

A protocol for sample collection needs to be established that is relevant to field sampling in the Garcia. As with turbidity, DO evaluation is within the NCRWQCB basin plan, and protocols must meet their requirements, which reflect national standards (APHA 1997; NCRWQCB 1988). Board staff Peter Otis has developed 'tailgate protocols' for DO sampling in the Laguna de Santa Rosa which may be applicable, and should be considered for the Garcia (Otis, P. 1997). FSW recommends the RCD pursue discussions with the NCRWQCB to agree upon protocols, using, if possible, the inexpensive Hach or LaMotte kits and a simple grab sampler (a one-liter bottle at the end of a pvc handle).

If an area tests positive for low DO, it would be reasonable to find the cause of that depression. Evaluation of that cause would be to evaluate temperature, flow and biological oxygen demand around that site and upstream. The methodology and search for causality should include consultation with the NCRWQCB; low oxygen strongly limits beneficial uses.

**Temperature** has been identified as a potential limiting factor in the Garcia stream system. Many of the streams in the watershed, as well as the mainstem, have documented high temperatures over 64, 70 or 80 degrees, so temperature is both an active concern and a metric for which there is a data history. Temperatures in Rolling Brook tributary greater than 64F are considered a "screening criteria to identify potential problem areas for salmonids" (L-P 1997). Temperature should be monitored with one protocol, similar sample sites, and a shared data pool. A useful protocol is being put forward by the FFFC (Taylor 1997), which includes testing, installation and programming of Hobo recording thermometers.

FSW recommends that the RCD implement temperature monitoring with placement according to the FFFC protocol, and no ice water calibration. We also recommend using pairs of recording thermometers, to get average values and secure data in case of instrument failure.

In review of this IMP, the people who are monitoring the river for temperature now considered the ice water bath calibration technique of the FFFC less prudent than calibration at room temperature. A representative from Onset Computing, the manufacturer of Hobos, states that the instruments are "factory calibrated," and the ice-water bath process is to determine if the device will fail at its low range; it is a stress test, not a calibration (Onset Computing, 1998). Further confounding the calibration of thermometers, Vicky Ozaki of Redwood National Park has found that Hobo XTs tend to vary about one degree Centigrade from each other at room temperature, greater than their listed specifications; and that different types of thermometers record with different biases to the warm or cool side (Ozaki, 1998).

FSW recommends using a network of two thermometers per stream reach, with an error of less than one degree, Centigrade. The Hobo XT's error at expected stream temperatures is approximately 0.2 degrees, though it may, in fact, be less. Two thermometers will account for variations in stream temperature along the course of the stream reach, at deep riffles near the centers of plots one and four, and give redundancy in the event one thermometer fails. Two thermometers will also point out any instrument giving erratic readings. The greatest danger with Hobos is that they stray beyond acceptable tolerances of temperature or time variation, and FSW suggests the coordinator stay up to date with the FFFC and the Forest Science Project of HSU, which are evaluating this problem.

### ii. Gravel Quality

Gravel quality is critical for the production of redds, the protection and oxygenation of incubating eggs and smolts, the emergence of fry, and the habitat for invertebrate fauna. Healthy gravels are critical for the production of salmonids in the Garcia, both in the mainstem and in tributaries.

Two gravel assessment strategies should be considered by the RCD, bulk samples and permeability samples. Because of the significant difference in effort in conducting the samples, the two methodologies should be tested side by side, to see if they strongly correlate. If this is true, the permeability sample should be continued, because it is much cheaper, faster and easier to accomplish. Other approaches to evaluating gravels may be useful tools in the Garcia, but at this time we do not have similar levels of confidence in their utility or repeatability. In particular, Dietrich et al. (1989) discuss the utility of q., a value reflective of the differentiation between surface and subsurface gravels, reflecting sediment input. While this value may be useful, it is not clear how to translate the flume work into a field protocol, nor how to correct for the high degree of spatial variability in stream sediment deposits. In addition, in order to develop $D_n$ values for any set of fine sediments, it is necessary to complete a bulk sieve analysis first. Thus, we recommend the McNeil because of its relatively long track record and established protocols. We believe, too, that the permeability approach measures the important qualities of gravel in spawning streams.

**Substrate composition** should be taken with a McNeil sampler, and evaluated by the gravimetric method. It can be presented as a cumulative frequency distribution (CFD). The CFD should be designed, through choice of sieve sizes, to report:

- Fines < 6.5 mm
- Fines < 2.0 mm
- Fines < 0.85 mm
- $D_{16}$, $D_{25}$, $D_{50}$, $D_{75}$, $D_{84}$

These metrics take into account the considerations of the North Coast Regional Water Quality Control Board (Mangelsdorf and Lundborg, 1997), the MSG (Lee, 1996), and the recommendations of this IMP. Readers should note that these extra pieces of data do not increase the cost of data collection, but are variations on reading and reporting the data that is collected.

**Fines < 2mm** appears to be a very important metric for evaluating the quality of gravels. Bjornn and Reiser (1991) document a set of studies which show significant drop-offs in percentage of fry emerging from redds with greater than 10-20% fines of 2-6.4mm. The critical values for the Garcia will change by species of salmonid (Kondolf & Wolman 1993), but documentation of sizes will allow understanding of relative gravel quality. The 'standard' methodology for this assessment is a McNeil sampler, which collects a bulk sample from the top 6-12 inches of spawning riffles. Platts et al. (1983) recommend a minimum 12" core depth. While Taylor (1996) puts forth Valentine's 1995 unpublished protocol as an appendix to the FFFC protocol package as a well documented, agreed upon protocol for the North Coast, Klein (1997) stresses the importance of choosing the correct screen sizes, and using the weight, not the volume of particles. Klein has developed a 'how-to' protocol for conducting gravimetric data analysis assessing the impact of the Caltrans work in Prairie Creek watershed, attached as an appendix. We also attach the TFW McNeil protocol, including site selection and sampling within the stream.

**Permeability of spawning gravels** is a corollary to percent fines. It is important to incubating fish because "During incubation, sufficient water must circulate through the redd as deep as the egg pocket to supply the embryos with oxygen and carry away waste products" (Bjornn & Reiser 1991). The waste products are organic material. If that material remains, it may consume oxygen in decomposition, and "if the oxygen is consumed faster than the reduced intragravel water flow can replace it, the embryos or alevin will asphyxiate" (Bjornn & Reiser 1991). While the permeability of the redds is different from unaltered gravels (Kondolf et al. 1993), unaltered gravels are an important index to the condition of the gravel and its suitability for redds. Barnard and McBain's 1994 protocol for measurement of interstitial flow is presently in use by L-P and CFL, and appears to be an appropriate choice for the Garcia. As stated above, if it tracks McNeil results with strong significance, it should be considered a more cost effective and direct-reading replacement for the more time consuming bulk sample approach.

### iii. Channel Assessment

This section provides protocols that are specifically designed to address channel size, shape, complexity and persistence. In choosing methods, we should note that, while 'habitat typing' has been used extensively to describe channel conditions for fisheries in the region, it may be, as an evaluation tool, relatively insensitive to human influences in watersheds in the Garcia and is not a repeatable monitoring tool to assess change over time (Poole et al., 1997). Alternatively, data keyed into fixed points leaves little room for doubt as to changes in depth, shape or profile of the stream. Coupled with photo points, airphotos and maps (see also Riparian Function), the channel assessment strategies of cross sections and longitudinal profiles answer many of the questions asked regarding river systems in general and the Garcia, in particular.

Channel assessments for pool filling and woody debris, both past and future, are more oriented towards fish habitat and habitat-forming elements. It is these elements which provide the stream with the niches used by fish, cover for hiding and for protection from the sun, low velocity areas for avoiding winter flows and a heterogeneous bank and substrate for a diverse, productive environment. Several protocol suites for evaluating the functional elements of stream channels have been put forward, in particular the TFW Ambient Monitoring Program Manual (Shuett-Hames 1994) and the Washington Forest Practices Board Standard Methodology for Conducting Watershed Analysis (1995) and the CDF Instream Monitoring Protocols (Lee, 1997). These protocol approaches variously include elements of sampling design, an array of specific protocols, such as V*, McNeil, large woody debris, debris jams, recruitment trees and habitat units. All approaches include a general approach to whole watershed analysis. All are designed in segments so that implementing agencies can use the protocols in logical sets.

This section bundles cross-sections, longitudinal profiles, V* and woody debris surveys together as 'channel assessment.' These are metrics which are useful to monitor the condition of streams-their physical shape and quantity of large wood interaction—relative to specific benchmarks. Channel assessment protocols are the heart of trend monitoring because, relative to other parameters, the elements they measure change slowly, over years and decades.

**Cross Sections** are a long-standing metric in the Garcia. Jackson's 1997 report on the Garcia evaluated the historical record of the Garcia with the addition of new data from 1996 and concluded that the river is not aggrading its mainstem. A 1996 report by Philip Williams and Associates also relied heavily on cross-sections in developing a gravel management strategy. In some ways, the best reason to continue monitoring with cross-sections is because the present data record is relatively complete. In addition, future monitoring will provide confirmation or denial of conclusions drawn to date from the data--whether the river is downcutting or aggrading on the mainstem, and whether gravel extraction is allowing maintenance of a 'steady-state' condition on the river. Protocols are well established throughout engineering literature, with differences based on equipment, choice of benchmarks, and spatial distribution of data collection intervals. We are hesitant, however, to give one protocol. Simple methods are described in Dunne and Leopold (1978) and Rosgen (1996a), which are appropriate for tributary streams and continuation of existing data records. Field methods are already established for the mainstem Garcia, such as at the Highway 1 bridge, Connor Hole and the Hooper Property, and have been documented by Caltrans and the Mendocino County Water Agency. Essentially, all cross-sections will be comparable if they start and end with the same benchmarks, use a tripod-mounted level, stretch a tape level across the span, and measure at intervals that reflect the change in topography.

**Longitudinal profiles** are a long-standing tool for stream assessment (Leopold et al. 1964; Morisawa 1968) to determine geologic boundaries, reactions to flow and particle size, and to track the deposition or erosion of sediment. They may also, on small streams, be used to evaluate pools and complexity (Trush, 1997a). Dunne and Leopold (1978) give a good description of the procedure, noting that profiles "should be no less than 30 times the river [bankfull channel] width." Trush (1997a) recommends no less than two meanders (four bends). The key is to locate the assessment area in a reach not affected by nickpoints above or below, and well above confluences with larger streams. The length of these plots is necessarily greater than other types of in-channel surveys, so they should be considered as part of a larger survey array. If, for instance, a stream reach were being evaluated at three plots for woody debris, pools and gravels, covering ten percent of the stream length, one longitudinal profile may be adequate when initiated downstream from the center of the middle plot, where it would cover an overlapping ten percent of the reach.

Trush (1997b) notes that an important criteria in the speed of longitudinal profiles is the choice of level; he recommends the Topcon dome head levels AT G-7 and AT F-2 for small and large streams, respectively, along with the Harrelson (1994) protocol. At this time, we have attached the Dunne and Leopold (1978) protocol, and a more complete description from the San Francisco Estuary Institute (Rigney et al. 1997).

**V*,** as described in Lisle and Hilton's (1992) is an approach to measuring the fine sediment volume deposited in pools. <u>Testing Indices of Cold Water Fish Habitat</u>, a study conducted for the North Coast Regional Water Quality Control Board in cooperation with CDF, (Knopp 1993), included sites within the Garcia watershed, and V*, along with riffle-armor stability index and median particle size, were found to be significant indicators of historical management activity. In our opinion, V* values are particularly important because they track the location of sediment outside of the thalweg but inside important fish habitat. Adequate training needs to be given to field crews to promote standardized measurement of mobile fine sediment in the pool, as distinguished from older sediments which may make up the bed.

**Large woody debris (LWD)** in the stream channel is a reflection of the health of streams relative to native ecological conditions. In the original landscape, large wood was lost only in very intense fires, and those did not consume very large redwood boles, particularly in streams. Salmonids have evolved with those conditions, and large wood to provide geomorphic stability, thermal consistency, and a variety of niches for themselves and other members of the stream ecosystem, on whom they depend. Direct measurement of woody debris is a useful, intuitively clear method to indicate complexity of small streams, and can be repeated easily. The most complete protocol for evaluating present LWD is in the TFW protocols (Shuett-Hames 1994).

### iv. Riparian Function

While the shape and the water quality of a stream and its channel are important, measurement of vegetation in and near the stream are important in producing present and future habitat. This section presents the use canopy indices of solar exposure and canopy closure. Collection of these data implies stratifying the stream system, developing a systematic survey within those strata, finding field sites, drawing site maps, taking site photos, and establishing permanent monuments. The approach should consider either long, continuous data sites or multiple data sites within identified stream segments for many of the riparian function metrics. This report will assume a shelled, multiple measurements within an identified reach approach, and support from topographic maps and airphotos.

**Canopy measures** determine either the total amount of overhanging vegetation at a point, generally above one meter, or the total amount of sun incidence at a given point. It is important to note that these are different measures and, while they may correlate at points of their distribution, do not measure the same functional elements. Shade may be provided by hillslopes on east-west trending streams. Canopy on north sides of stream may not contribute any appreciable shade, while providing abundant allocthanous material for instream invertebrate food. The two accompanying protocols are for canopy at waist level (one meter \+-), using a densiometer (Flosi and Reynolds 1991) and solar input using a Solar Pathfinder with a 'horizontal surface' grid (Solar Pathfinder 1995). Canopy monitoring for shade should be conducted during the hottest months with the lowest flows, probably June through October. While the solar pathfinder is designed with a tripod for use on dry, flat surfaces, we recommend purchasing the instrument without the tripod, attaching it to a board or box, and holding it above the center of the stream channel.

While the densiometer measures overstory cover and the Pathfinder measures shade, neither of these instruments can be used at only one point. It is critical to take multiple measurements along a stream system in a systematic plot array. These values can then be correlated with airphoto interpretation. Our experience reviewing the Garcia data suggests that airphotos consistently overestimate cover. This may be due to a lack of sampling strategy on the airphotos or due to the 'look' presented to the interpreter by many layers of vegetation. With ground truthing and a scale for evaluating interpretation results, it may be possible to extend canopy surveys far beyond plots with airphotos.

FSW recommends doing both the Solar Pathfinder and densiometer measurements, at the beginning, middle and end of each plot. These three measurements will be repeated four times in the stream reach, giving 12 data points for both Pathfinder and densiometer per selected stream.

**Recruitment Trees** are future woody debris and an important canopy component. The most complete protocol for recruitment trees is in the Washington State methodology (WFPB 1995). We recommend implementation of this protocol adjacent to plots within selected stream reaches. As with canopy, basic recruitment trees information comes from aerial photography. FSW recommends following the WFPB's on-the-ground protocol for plot areas within stream reaches, and its air photo methodology for the entire stream reach. This allows field measurement to correct a set of interpreted data, and a Garcia-specific, photo-flight specific key to develop for good interpretation results on other watershed sites.

### v. Causal Mechanisms

As discussed above, we have scant information connecting the propagation of timber harvest impacts into and around the Garcia watershed's stream channels. A specific goal of monitoring must be to evaluate the hillslope-channel connections. FSW has had good success simply following sediment trails which enter streams and their tributaries to their sources. Other forensic approaches also follow sediment trails, either through photography—specifically aerial photography following storms—or turbidity measures. In all cases, it is important to see the effects of storms, either during them or in the following year, before evidence is obscured. In planning for evaluating future impacts via causal mechanisms, we need to identify watersheds prior to harvesting, and continue observations ten to fifteen years following harvest. The long time frame is for the assessment of landslides which may be caused by harvest, and evaluate the predictive capability of unstable-area avoidance models, such as used by Louisiana-Pacific (L-P 1997).

**Sediment transport corridors (STCs)** are any areas, apart from the natural drainage system, which produce sediment and move it into stream systems. Debris flows, the faces of deep-seated landslides, gullies, failing roads, failing crossings, eroding streambanks, inboard ditches and flow from waterbars which do not adequately deposit sediment are all STCs. FSW developed a measurement approach in 1994 and 1995, which requires evaluating both sides of the entire stream reach. This is done when walking upstream between instream monitoring plots. The measurement of each site goes fairly quickly and each STC is noted for location and relative ease of access for restoration. When an STC is encountered, field crew measure the surface area of the eroding site, record the probable cause of the erosion and suggest a possible solution. Area is measured as an index of volume, but does not require the researcher to reconstruct the original or modified landscape which failed. In practice, STCs indicate high priority areas for restoration, and have been used for targeting restoration efforts on Greenwood Creek in Mendocino County and UC Berkeley Blodgett Forest, in the Sierra. Our present protocol (FSW 1997) is attached.

**Turbidity,** as discussed under *Water Quality,* is a useful forensic tool when applied to watersheds during and immediately after storms. As rainfall progresses, the watershed tends to produce significantly more sediment, as stable areas 'unravel'. Using turbidity to track causal mechanisms will require 'finding the sediment' as it enters the mainstem Garcia. This could be done via day-specific airphotos by flying the watershed and taking 'uncontrolled' photos from a small plane, or contracting for aerial photography on a specific day. Neither of these methods are inexpensive, but they both can give important, unexpected answers to the question "Where are the sediment sources to the Garcia?" This can direct future research and restoration efforts, and should not be downplayed as important causal mechanism research tools.

### vi. Fish Productivity

Fish habitat is an instream beneficial use of water. Because this is an instream monitoring plan, it must consider fish productivity as a test, albeit indirect, of habitat. The above sections concerning water quality and habitat elements have all been related to salmonid fisheries, and the causal mechanism section noted that, until proven directly related to fisheries, any element monitored is done so for reasons based on hypotheses. Unless we measure the fishery, we cannot know if other metrics, restoration programs or best management practices are truly working.

Unfortunately, while increasing fish numbers will suggest that BMPs are working, decreasing fish numbers will not necessarily mean that BMPs are failing. Too many other factors, from ocean conditions to genetic considerations, may dominate results. Despite this lack of direct correlation, this report recommends fishery research, particularly **spawning surveys** and **summer fish counts.** These have been done in the Garcia for many years. The IMP should continue this practice, with particular inclusion of stream reaches on which stream reaches have sets of reference sites.

Trush (1998) recommends spawning surveys in the few days following peak flows, during the recession of flow. Coho spawn about two days after the peak. Steelhead spawn significantly later than coho, and would require a separate set of surveys. Because coho are the threatened species in the Garcia, we recommend coho spawning surveys.

Summer fish counts are important indicators of spawning success, and need trained, calibrated individuals looking into pools with a mask and snorkel. These people should be calibrated with electrofishing surveys, so that they are aware of any distinct undercounting bias. Summer surveys can also be used to get relative populations of coho and steelhead juveniles. FSW recommends summer surveys to accompany stream reach surveys, as a way of partially testing the habitat hypotheses that underlie this research effort.

Fisheries protocols are a good point for cooperators to get involved with the IMP. Winter protocols need to be done in a relatively short amount of time, training is straightforward, there are many experienced individuals involved with the watershed, and it requires little instrumentation or benchmarking. Ideally, all streams with habitat monitoring should receive fishery surveys.

### C. Description and Map of Selected Monitoring Sites

The selection of monitoring sites for the Garcia River Instream Monitoring Program involved evaluating each sub-basin individually while keeping in mind a larger picture for data collection throughout the Garcia River watershed. While many studies have been conducted at varying intensities and locations, there are large gaps in the amount of quantitative data available for the basin as a whole. Monitoring sites were chosen in both basins with recent timber harvest and in basins that will be harvested in the foreseeable future. One site on Mill Creek was chosen as an index reach.

The whole watershed will continue to be evaluated on an overall basis by winter overflights, to find specific sediment-generating areas.

Selection of monitoring sites throughout the Garcia River Watershed was based on:

- Mass Wasting and Surface Erosion Modules (Chapter 3), the synthesis of the Watershed Assessment modules (Chapter 4), the Limiting Factors Analysis (Mangelsdorf, 1997) and the sediment production and delivery analysis (Hagans, 1997);

- Data previously collected throughout the Garcia River basin, looking for both the gaps in the data, and places where future monitoring can build on past monitoring efforts. Appendix C : Inventory History in the Garcia River is a record of past data collection efforts compiled from available literature including the Limiting Factors Analysis (Mangelsdorf, 1997), the Garcia River Watershed Enhancement Plan (Monschke 1992), Watershed and Aquatic Wildlife Assessment (CFL, 1997), Analysis of the Garcia River Cross-Sections (Jackson, 1996), the Garcia River Gravel Management Plan (P. Williams & Assoc., 1996) and the Sustained Yield Plan for Coastal Mnemonic (L-P, 1997);

- Current monitoring in progress and opportunities to create a cooperative monitoring strategy. The underlying objective of this plan is to coordinate with existing industry, environmental groups and public agencies, to build on data collection efforts that are already underway throughout the basin and to fill in gaps where data is needed; and

- The history of individual streams within sub-basins with present, potential or historical favorable fish habitat and/or presence of fish.

The final products in this section are;

- • Map 5-1: Monitoring locations.
- • Map 5-2: Map of land ownership within the Garcia River basin;
- • Table 5-2: Selected sites, parties recommended for monitoring and parameters to be measured at each site.

### i. Planning Unit 113.70010: Pardaloe Creek, Mill Creek and Redwood Creek

The headwaters of the Garcia, Pardaloe planning watershed is largely owned by eight ranching families. The Maillard Ranch conducts timber operations on Redwood Creek, and is the source of the Maillard Redwoods State Reserve on Mill Creek. This is a watershed which has a significantly different land use pattern than downstream, industrially-owned watersheds, and also has records of good anadromous fisheries following the blasting of falls in Larmour PW in 1964. By the late '60's, however, Pardaloe Creek's old-growth had been removed with significant disruption, and the stream was considered, for more than 80% of its course, 'damaged' (Monschke and Caldon, 1992).

**<u>Pardaloe Creek</u>**
Potential Limiting Factors:

- Elevated summer temperatures related to insufficient shade/riparian cover and reduced channel depth/low summer flows.
- Minimal pool depth, related to aggradation and limited stream complexity.
- Minimal over wintering habitat, related to sedimentation and limited stream complexity.

Since the 1964 removal by Fish and Game of a waterfall on the mainstem of the Garcia River, Pardaloe Creek has had a history of some of the highest densities of steelhead redds anywhere in the Garcia Basin (Mangelsdorf, 1997). According to the Watershed Enhancement Plan (Monschke and Caldon, 1992), "given its high potential for fish, Pardaloe Creek is an ideal stream to continue monitoring for recovery from past land use impacts". Due to the need to stay within the available monitoring plan budget and the focus on timber harvest activities, FSW is not recommending that a full set of monitoring protocols be employed on Pardaloe Creek at this time. However, it is noted that if more funds become available, establishing a monitoring program or conducting a fish survey on Pardaloe Creek would be a first priority. Because of its inland position up in the headwaters of the watershed, Pardaloe Creek has some of the highest temperatures in the entire Garcia basin (Mendocino County Water Agency, 1997). Temperature data should continue to be collected by the Mendocino County Water Agency in Lower Pardaloe above Mill Creek and in Upper Pardaloe at the bridge on Fish Rock Road.

**<u>Mill Creek</u>**
Potential Limiting Factors:

- No limiting factors identified.

At the April 17, 1997 Limiting Factors meeting of the Garcia Watershed Advisory Group, the agency group discussed the possibility of de-listing the Mill Creek sub-basin from the 303(d) Impaired Waters list. Fish and Game stream surveys, Salmon Trollers Association data and local observations imply that Mill Creek and Redwood Creek have good habitat cover, complexity and riparian conditions which indicates a functioning system

(Mangelsdorf, 1997). It was suggested that instream monitoring be conducted on Mill Creek to confirm the conditions in the basin and to consider it as a potential reference stream for the Garcia Watershed. Data collection may be coordinated between agencies and ranch landowners in the sub-basin. FSW recommends that monitoring protocols be employed in Mill Creek to assess parameters of temperature, substrate composition, gravel permeability, longitudinal profiles, V*, canopy, STCs, LWD, recruitment trees and fishery surveys. Temperature data should continue to be collected by the Mendocino County Water Agency in lower Mill Creek above Pardaloe and in upper Mill Creek at the Maillard Preserve on Fish Rock Road.

### ii. Planning Unit 113.70011: Grant's Camp Creek, Larmour Creek and the Garcia River

Data collected throughout this entire sub-basin is both scant and outdated. Fish and Game stream surveys date back to 1967 on Grant's Camp Creek and no real data is recorded for Larmour Creek. Although this sub-basin represents a gap in data for the entire Garcia River basin, it is not a high priority for this monitoring program because of the relatively low percentage of lands in timber operations. The land use within the basin is divided between Coastal Forestlands and two non-industrial owners who operate cattle ranches with periodic non-industrial timber management plans.

**<u>Grant's Camp Creek</u>**

Potential Limiting Factors:

- No limiting factors identified.

Grant's Camp Creek, due to its low gradient and historical presence of good salmonid habitat, has the potential to provide either suitable salmonid spawning grounds or overwintering habitat, although clearly more data is needed to confirm this (Mangelsdorf, 1997). It is recommended that an evaluative study be conducted on Grant's Camp Creek to measure temperature, substrate composition, gravel permeability, longitudinal profiles, V*, canopy, LWD, recruitment trees, STCs and fishery. After a first year study, the project coordinator can evaluate the value of this stream as anadromous fish habitat and decide whether long-term monitoring is an affordable priority.

**<u>Larmour Creek</u>**

Potential Limiting Factors:

- No limiting factors identified.

Larmour Creek, because of its steeper gradient (7-8% on up) likely provides little anadromous fish habitat. The upper reaches of the stream however should be monitored for sediment delivery (STCs) and temperature to determine the contribution of these two factors to the mainstem Garcia River.

**Garcia River**

The Mendocino Water Agency has been monitoring temperatures on the mainstem of the Garcia River, at a site approximately 3.6 miles downstream from the confluence of Pardaloe Creek with the mainstem Garcia. Hollow Tree Road comes very close to the mainstem at this location. FSW recommends that the Water Agency continue to monitor for temperature in this location.

### iii. Planning Unit 113.70012: Stansbury Creek, Whitlow Creek and the Garcia River

This sub-basin is high on the priority list for establishing an instream monitoring plan. Both Whitlow Creek and Stansbury Creek have a long history of timber harvesting, with extensive operations underway in the Whitlow drainage previous to 1952. The land use within the basin today is divided between Coastal Forestlands (CFL) and two non-industrial owners who operate cattle ranches with periodic harvests under non-industrial timber management plans. In the last ten years, THPs have been filed for approximately 50% of the sub-basin. In spite of the long-term timber extraction within the sub-basin, virtually no data has been collected on stream condition or presence of fish. This sub-basin represents a gap in understanding the processes at work in the Garcia Basin and offers an opportunity to directly test the Forest Practice Rules capability of protecting beneficial uses, in this case fish habitat. Monitoring could become a shared responsibility between the landowners and resource agencies.

**Whitlow Creek**

Potential Limiting Factors:

- Number and depth of pools, particularly due to fine sediment from roads and limited instream complexity.
- Pool cover due to limited instream complexity.

If constraints require choosing only one tributary in this sub-basin, FSW recommends monitoring in Whitlow Creek over Stansbury, for the following reasons: 1) it has a more favorable gradient for fish (3-4%), 2) THP review comments in 1996 note that "the stream was heavily impacted by recent sediment," 3) CFL is installing a sediment catchment basin upslope, to prevent sediment from reaching the creek and 4) the Division of Mines and Geology have recommended that all permanent culverts be pulled so as to reduce the amount of road-related fine sediment that ends up in the stream (Mangelsdorf, 1997). A long-term instream monitoring plan should be established by the RCD on Whitlow Creek for parameters of temperature, substrate composition, gravel permeability, longitudinal profiles, V*, canopy measures, LWD, recruitment trees, STCs and fisheries.

CFL could act as cooperators with the fishery evaluation of Whitlow Creek.

**Stansbury Creek**

The Limiting Factors Analysis describes Stansbury Creek as a fairly steep stream with 6-8% gradient in lower reaches, steepening even more in the upper reaches. Comments from the GWAG committee suggested that the stream might support good summer rearing habitat, given the adequate canopy cover and bedrock channel (Mangelsdorf 1997). Because of the relatively little data available for Stansbury Creek and the active logging in this sub-basin, FSW recommends the RCD begin an instream monitoring program employing protocols for temperature, substrate composition, gravel permeability, longitudinal profiles, V*, canopy measures, LWD, recruitment trees, STCs and fisheries.

**Garcia River**

Since 1995, FrOG has been collecting water temperature on the mainstem of the Garcia River, just upstream from Blue Waterhole Creek. They will continue this data collection as part of the cooperative monitoring process.

### iv. Planning Unit 113.70013: Blue Waterhole Creek

**Blue Waterhole Creek**

Potential Limiting Factors:

- Water temperature for summer rearing, due to poor shade canopy.
- Pool depth, due to fine sediment.

The Blue Waterhole subwatershed has a long history of disturbance and is currently noted for its scattered active slide areas, debris slide slopes and disrupted ground (Mangelsdorf, 1997). A 1967 stream survey by Fish and Game estimated steelhead density of 100 fish per 100 feet, while more recently, revegetation crews observed many steelhead, including large, adult fish (Mangelsdorf, 1997). For these reasons and because of the high density of timber harvest plans filed in this area in the last ten years, this is an excellent sub-basin to monitor.

The basin is owned by both Coastal Forestlands and a family ranch. There have been a number of studies completed on Blue Waterhole Creek, including the NCRWQCB and CDF study, Testing Indices of Cold Water Fish Habitat (Knopp, 1993), MCRCD cross sections established in 1995 to evaluate the restoration work of New Growth Forestry projects, FrOG temperature data and a 1967 Fish and Game stream survey.

FSW recommends that cooperative monitoring be a priority for Blue Waterhole Creek. Cross-sections already established by the MCRCD should be periodically revisited and temperature data collected at four stations by FrOG, should continue to be collected. An instream monitoring program should be also be conducted by the RCD with fixed plots to evaluate temperature, substrate composition, gravel permeability, longitudinal profiles, V*, canopy, LWD, recruitment trees, and STCs. Blue Waterhole Creek is also a good selection for a fish count and spawning survey on an annual or biennial basis.

### v. Planning Unit 113.70014: Inman Creek

**Inman Creek**

Potential Limiting Factors:

- Water temperatures for summer rearing, due to poor canopy cover.
- Number and depth of pools, due to sedimentation and lack of woody debris.
- Instream cover due to lack of woody debris.

Inman Creek, with a gentle gradient in the lower reaches (0-3%), good potential coho habitat and high densities of observed steelhead, is an excellent stream to monitor over time. Approximately 80% of the sub-basin has been included in timber harvest plans during the last ten years, making it a good choice of streams to monitor the effects of timber harvest activities on downstream water quality.

The basin is owned primarily by Coastal Forestlands with smaller parcels owned by both Louisiana-Pacific and a private rancher. Inman Creek is currently being monitored by Coastal Forestlands at three locations, as part of their Watershed and Aquatic Wildlife Assessment plan (CFL 1997). FSW recommends that CFL continue to collect data under their existing channel assessment and riparian habitat monitoring plan at already established sites. Additionally, we recommend that the RCD employ the full set of instream protocols recommended by this plan for parameters of temperature, substrate composition, gravel permeability, longitudinal profiles, V*, canopy, LWD, recruitment trees, STCs and fisheries. Temperature should be monitored at the confluence of Inman Creek with the mainstem of the Garcia.

Possibilities for cooperative monitoring between CFL and the RCD should be explored on this creek, both for temperature and fisheries.

### vi. Planning Unit 113.70020: Signal Creek

**Signal Creek**

Potential Limiting Factors:

- Pool depth and size, due to a lack of woody debris.
- Excessive flow velocities.

Fish counts and spawning surveys on Signal Creek conducted by Fish and Game (1987) and the Salmon Trollers Association (1995-1997) indicate that both live fish (steelhead and a few coho) and spawning redds are found regularly in Signal Creek. Substrate composition, as estimated by Fish and Game habitat typing is favorable for spawning and limiting factors to fishery success are related more to lack of canopy (18% F&G, 1995), woody debris and pools (Mangelsdorf, 1997). Approximately 80% of the sub-basin has been included in timber harvest plans during the last ten years, making this sub-basin an excellent choice of locations to monitor the effects of recent timber harvest activities on downstream anadromous fish habitat. Application of the WM showed Signal Creek PW to have the highest road-related estimated erosion (Chapter 3).

The Signal Creek sub-basin is owned primarily by Coastal Forestlands. Three locations on Signal Creek are currently being monitored by CFL as part of their Watershed and Aquatic Wildlife Assessment plan (CFL 1997). FSW recommends that CFL continue to collect data under their existing channel assessment and riparian habitat monitoring plan at already established sites. Additionally, it is recommended that the RCD establish a set of monitoring protocols on Signal Creek to establish fixed plots and employ the full set of instream protocols recommended by this plan for parameters of temperature, substrate composition, gravel permeability, longitudinal profiles, V*, canopy, LWD, recruitment trees, STCs and fisheries. Temperature should be monitored at the mouth of Signal Creek.

Possibilities for cooperative monitoring between CFL and the RCD should be explored on this creek for both temperature and fisheries.

### vii. Planning Unit 113.70021: Caspar Creek, Graphite Creek and the Garcia River

Ownership of this sub-basin is divided between Louisiana-Pacific (31%) and Coastal Forestlands (69%). L-P rates both of these subwatersheds with a High erosion hazard rating (L-P, 1997), and approximately 60% of the entire sub-basin has been included in timber harvest plans by CFL during the last ten years (CDF, 1997). Very little data has been collected on either Graphite Creek or Caspar Creek. CFL has established a permanent sample site in this sub-basin on the mainstem of the Garcia River. This subwatershed ranked second highest in erosion rates, according to the WM (Chapter 3).

**Graphite Creek and Caspar Creek**

Potential Limiting Factors:

- Channel depth at the mouth, limiting upstream migration particularly during summer when juveniles might be seeking escape from elevated mainstem temperatures.

Although fish surveys conducted by both L-P and the Salmon Trollers Assoc. found no live fish in either Graphite Creek nor Caspar Creek drainage, it was noted at the April 17, 1997 Limiting Factors meeting, that Graphite Creek could be a good coho spawning stream. The presence of a seasonal sediment barrier at the mouth of both Graphite Creek and Caspar Creek is thought to prevent upstream migration of fish escaping high summer temperatures in the mainstem Garcia. FSW recommends that the RCD evaluate seasonal blocking of summer upstream migration and options for possible removal or mitigation of these barriers should be studied. FSW is also recommending that an instream monitoring study reach be established on Graphite Creek employing protocols for temperature, substrate composition, gravel permeability, longitudinal profiles, V*, canopy, LWD, recruitment trees and STCs. A cooperative fish survey would serve to evaluate spawning and fish utilization, if it occurs.

**Garcia River**

Potential Limiting Factors:

- Elevated water temperatures for summer rearing, due to stream width.
-

The mainstem of the Garcia River within this planning unit is currently being monitored at one site by Coastal Forestlands as part of their Watershed and Aquatic Wildlife Assessment plan (CFL 1997). FSW recommends that CFL continues monitoring at this established monitoring site, according to their stream channel/riparian function and aquatic habitat protocols.

### viii. Planning Unit 113.70022: Beebe Creek and the Garcia River

Land ownership within this sub-basin is shared by Louisiana-Pacific (9.3%), the US Air Force (ridgetop) and Coastal Forestlands (majority). Some instream data is available for Beebe Creek from short (100 ft.) stream surveys and a population distribution study (Fish and Game, 1989). Because of its relative steepness (12%) and a potential bedrock barrier found just above the Garcia Haul Road (Mangelsdorf, 1997), Beebe Creek is not designated as high priority for instream monitoring. This barrier should be investigated before a monitoring program can be recommended.

Because this watershed consistently scored highest in erosion rates, with sources equally split between mass wasting and surface erosion (Chapter 3), this stream should be considered a good site for conjunctive hillslope monitoring. The stream, therefore, should be monitored for sediment delivery (STCs) and temperature to determine the contribution of these two factors to the mainstem Garcia River. This could be accomplished by the RCD at the same time that the barrier is evaluated.

**Garcia River**
Potential Limiting Factors:

- Elevated water temperatures for summer rearing, due to stream width.

The mainstem Garcia River is currently being monitored by CFL at two sites in this sub-basin, as part of their Watershed and Aquatic Wildlife Assessment plan (1997). FrOG collected temperature data near the Hot Springs camp in 1994, with late summer temperatures exceeding the upper limit of the preferred coho range approximately 90% of the time (Mangelsdorf, 1997). FrOG has decided that due to the influence of the nearby hot springs, they will discontinue temperature monitoring at this site.

It has been recommended by Maahs (1997) that stretches of the mainstem in this subwatershed be surveyed for fish and spawning redds to evaluate whether steelhead and/or coho are using the mainstem of the Garcia for spawning and rearing.

FSW recommends that CFL continues monitoring at their established monitoring sites, according to their stream channel/riparian function and aquatic habitat protocols, while incorporating as much of this IMP as possible. This site would also be useful for a fish survey, either by the RCD, as part of a larger mainstem survey, or by CFL under the cooperative monitoring program.

### ix. Planning Unit 113.70023: South Fork, Fleming Creek and the Garcia River

Louisiana-Pacific owns approximately 92% of this sub-basin, with the remaining 8% holdings in three ranches atop the ridge separating the Garcia River watershed from the Gualala River watershed. Very little timber harvesting has occurred in this sub-basin over the past ten years (CDF 1997). This is an important sub-basin to begin monitoring in because data collected now before the next timber extraction phase will serve as a baseline by which to assess future impacts of timber harvest and the capability of the Forest Practice Rules to protect fish habitat in the basin.

**South Fork Garcia**
Potential Limiting Factors:

- Pool depth, due to sedimentation and limited instream capacity.
- Cover, due to limited instream complexity.
- Low flow barrier to juveniles seeking refuge from elevated mainstem temperatures.

Many instream studies have been conducted on the South Fork Garcia, including Fish and Game surveys (1987-1989, and 1991-92), Salmon Trollers Association spawning surveys (1989-91 and 1996-97), and a Louisiana-Pacific stream survey (1995). FrOG monitored temperature at the mouth of the South Fork in 1995. Fish and Game stream survey data (1987-92) imply that the South Fork is in a state of recovery with 1992 numbers indicating low sediment levels (<2% sand), high spawning habitat (80%), and a high percent canopy cover (90%). In contrast, the sediment budget prepared by Hagans (1997) showed the South Fork to be inundated with sediment which is moving slowly downstream within the confines of the San Andreas fault zone. The Garcia River Watershed Advisory Committee noted that steelhead frequently pool on the mainstem Garcia at the mouth of the South Fork, unable to get in due to sediment barriers. It was also 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 (Mangelsdorf, 1997).

FSW recommends that a full set of instream monitoring protocols be employed by the RCD on the South Fork Garcia, to assess temperature, substrate composition, gravel permeability, longitudinal profiles, V*, canopy, LWD, recruitment trees and STCs. Temperature monitoring should be conducted by FrOG and/or the RCD. Fish and spawning surveys should be done by the RCD or a cooperator. Cross-sections and thalweg profiles could be used to help better understand the role of sediment and the rate at which it is moving through the system. The RCD should investigate the sediment barrier at the mouth of the South Fork. Ideally, the new owners of the L-P property will be willing and able to participate in cooperative monitoring with the RCD.

**Fleming Creek**
Potential Limiting Factors:

- Pool depth, due to sedimentation.
- Potential culvert barrier to migration.

Fish and Game conducted stream surveys on Fleming Creek in 1987-89 and 1991-92 including a McNeil sample at the mouth of Fleming Creek. According to data compilation from the Limiting Factors Analysis, Fleming Creek is composed of predominantly gravel and rubble, the canopy closure is good, summer water temperatures appear adequate but the proportion of pools to riffles seems to have declined over time (Mangelsdorf 1997). Fish and Game fish surveys from 1987-89 and from 1991-92 noted steelhead densities of

0.55 fish/$m^2$ and coho seen in 1988 at a density of .5 fish/$m^2$. FSW recommends that the RCD establish a monitoring program on Fleming Creek, to collect data on temperature, substrate composition, gravel permeability, longitudinal profiles, V*, canopy, LWD, recruitment trees and STCs. A culvert noted as a potential barrier to fish passage should also be investigated (Mangelsdorf, 1997). The IMP recommends that cooperators be responsible for fish surveys in Fleming Creek.

**Garcia River**

**Potential Limiting Factors:**

- Pool depth, due to limited instream complexity

Available data for the mainstem of the Garcia River is limited to a 1967 Fish and Game survey and 1995 temperature data collected by FrOG just above the confluence with the South Fork. FSW recommends that FrOG continue to monitor temperature in this location.

### x. Planning Unit 113.70024: Mill Creek, Rolling Brook, Lee Creek, Button Gulch, and the Garcia River

Ownership of the Rolling Brook sub-basin is divided between Louisiana-Pacific (57.3%, Coastal Forestlands (small portion along Hutton Gulch) and small, individual landowners. Mill Creek, Rolling Brook Creek, Lee Creek and Hutton Gulch are all fairly steep tributaries flowing from the northeast into the mainstem Garcia. All of these streams could be candidates for monitoring, particularly for steelhead habitat and summer rearing and overwintering habitat for coho (Mangelsdorf, 1997). Studies conducted in this sub-basin have been on Rolling Brook Creek (L-P habitat survey, 1995 and FrOG temp data 1995-97), Hutton Gulch (F&G 1977 stream survey and FrOG temperature data, 1995) Lee Creek (FrOG temperature at mouth, F&G 1989 stream survey) and Mill Creek (FrOG temperature at mouth). Overall, there is a relative lack of quantitative instream data throughout the sub-basin, which represents a gap in data for the larger Garcia River watershed. The data collected now will also serve as a baseline for future evaluations of stream conditions when the Rolling Brook planning unit comes into a harvest rotation by L-P, or the land's new owner, in the future.

**Rolling Brook**

Potential Limiting Factors:

- Number and depth of pools, due to sedimentation.
- Quality of spawning gravels, due to sedimentation.

Rolling Brook is a good stream to monitor in this PW, because it has a higher measured density of fish than the other tributaries, a lower gradient channel, a history of dense steelhead in the lowest one mile stream reach and previous studies conducted by L-P. FSW recommends that the RCD establish a monitoring program on Rolling Brook to monitor for temperature, substrate composition, gravel permeability, longitudinal profiles, V*, canopy, LWD, recruitment trees, STCs and fisheries. Fishery data can be the responsibility of the cooperator.

Collection of water temperature data should be continued by FrOG in Rolling Brook, on lower Mill Creek, in Lee Creek and in Hutton Gulch.

**Garcia River**

It has been noted that dissolved oxygen levels in the mainstem below Rolling Brook may be a limiting factor to juvenile rearing during the hot summer months. Both temperature, stage height and dissolved oxygen data are being collected by the Mendocino County Water Agency at two sites, above and below the Eureka Hill Bridge. This work should continue and a rating curve to relate stage height to flow should be developed. This site has also been selected by the Mendocino Watershed Services and Adopt-a-Watershed Program for a turbidity study to be conducted in conjunction with the Anderson Valley High School in the neighboring Navarro River drainage. Temperature data will also continue to be collected by FrOG in Louie's Hole, just upstream from Lee Creek and at the Eureka Hill bridge.

We also recommend a fishery survey in this section of the mainstem, to check for mainstem utilization. We have assigned this task to the RCD.

### xi. Planning Unit 113.70025: North Fork Garcia, John Olsen Gulch, Olsen Gulch and the Garcia River

Alder Creek is a tributary to the North Fork Garcia, and Olsen Gulch and John Olsen Creek flow directly into the mainstem Garcia downstream from the North Fork confluence. Almost the entire sub-basin is owned by CFL, and THPs have been filed for approximately 90% of the sub-basin over the past ten years (CDF, 1997). Georgia-Pacific also owns property in this sub-basin. Although all of the tributaries in this sub-basin warrant monitoring, the highest priority is to continue monitoring on the North Fork and in the mainstem of the Garcia River.

**North Fork Garcia**

Potential Limiting Factors:

- Lack of woody debris
- Spawning bed scour
- Subsurface flows.

The history of extensive timber harvest combined with reports of high sediment levels, lack of woody debris and high levels of hillslope erosion from failing roads, landings and skid trails (Mangelsdorf, 1997) make the North Fork Garcia a high priority for long-term monitoring and an excellent sub-basin to test the Forest Practice Rules capability of protecting instream beneficial uses.

FSW recommends that CFL continue to collect data under their existing channel assessment and riparian habitat monitoring plan at already established sites. Additionally, it is recommended that the RCD employ the full set of instream protocols recommended by this IMP for parameters of temperature, substrate composition, gravel permeability, longitudinal profiles, V*, canopy, LWD, recruitment trees, and STCs. Possibilities for cooperative monitoring of fisheries, temperature, and instream characteristics should be explored on the North Fork.

**Garcia River**

The mainstem of the Garcia River flows through the North Fork sub-basin at a 1% gradient, in a fairly wide, open and unconfined channel. Summer water temperatures have been reported high for rearing of coho salmon, however both steelhead and coho spawning has been noted during the later months of the year (Mangelsdorf, 1997). Dissolved oxygen levels in the deeper pools may also be limiting fish habitat (GWAG, 1997). Cross-section analysis by Jackson (1997) documents that "overall channel width has remained constant at all of the cross-sections, with an overall trend of decline in both water surface elevation and thalweg elevation, relative to 1991" (Mangelsdorf, 1997).

In 1997, the Mendocino County Water Agency began monitoring for dissolved oxygen, turbidity, flow and conductivity at Connor Hole, and temperature at both Connor Hole and the Buckridge Bar. FrOG also measures for temperature at Connor Hole. FSW recommends that these data be collected annually as part of the cooperative monitoring program. Cross-sections should be repeated at more long-term periodic intervals to monitor the change in channel morphology and movement of sediment through the mainstem over time. It has also been recommended (Maahs, 1997) that stretches of the mainstem be surveyed for fish and spawning redds to evaluate whether steelhead and/or coho are using the mainstem of the Garcia for spawning and rearing. This is a good reach in which to do fish counts and spawning surveys.

### xii. Planning Unit 113.70026: Alien Gulch, Hathaway Creek, the Garcia River and the Estuary

The mainstem of the Garcia River and the Estuary have been studied intensively in the past due to the controversy surrounding extraction of aggregate materials in the lower 7 miles of river. This sub-basin has a number of small landowners and a multiple of land uses. FSW does not recommend that a full monitoring program be established in this sub-basin. Repeating cross sections at periodic intervals on the mainstem may be valuable to further understand the dynamics of this stretch of river. Temperature should continue to be monitored by the Mendocino County Water Agency on Hathaway Creek at Windy Hollow Road and at Minor Hole and Oz Hole by FrOG. Turbidity studies conducted by the Adopt-a-Watershed Program in conjunction with the Navarro High School should be continued at the Highway 1 bridge.

### *D. Cooperative Monitoring Plan for the Garcia River*

The underlying objective of the instream monitoring plan is to coordinate with existing monitoring already being done by industry, environmental groups and the agencies, to fill in the gaps in where data is needed and to build on data collection efforts that are already underway throughout the basin. This results in a cost-effective, comprehensive approach to watershed monitoring of stream and fishery conditions.

Cooperative data sharing with groups and agencies working in the watershed should be facilitated by allowing the RCD to become a data clearinghouse. These data are important to the public, to agencies and to landowners. They are relevant for timber harvest planning, coordinated resource management planning and enforcement of EPA and NCRWQCB goals. A coordinated effort, with the RCD managing protocols, certifying trainers and housing data will allow both information exchange and data analysis. The RCD should look to the Forest Science Project at HSU, an industry-academic cooperative project, for assistance in developing the clearinghouse and locating key personnel.

FSW recommends the RCD, the industry and private landowners cooperate for access to their lands, for training, for monitoring, for information and for the long-term. The long-term is key—this is a two year program, spread over 74,000 acres, monitoring a host of variables, many of which change slowly (Table 5-3). There are 12 streams on which we suggest the full suites of stream reach protocols, and another 16 streams on which we recommend that individual agencies or landowners continue their implementation of individual protocols. Sites are shown on Map 5-1; protocols with their respective streams and cooperators are listed on Table 5-2.

In some cases, people are presently collecting data in a manner similar to our recommendations. While similar, much of it is not directly comparable or interchangeable with the IMP protocols. As an overall watershed survey, the RCD must use uniform protocols in its inventory, implemented by people with the same level of training, and with uniform repetition to give the data similar statistical characteristics.

Some protocols in use are already easily comparable. Hobo XT data, for instance, will continue to be comparable, provided the instream data collection point is the same as in the IMP. Data collected by other equipment or techniques can be calibrated with the IMP protocols, to extend the record into the past and into present continuation of that alternate method.

FSW believes that fisheries monitoring is an element most easily shared by cooperators, representing an important aspect of both watershed condition evaluation and hypothesis testing. The RCD should work with the Salmon Trollers and other cooperators who have conducted these surveys in the past, for the continuation of those protocols into the future, and to train all cooperators on a strategies for spawner/redd surveys and summer fish counts. In particular, the winter surveys need to happen quickly, so a host of cooperators would be most effective. Our budget accounts for eight intensive coho spawning surveys during the two year period. Cooperators can extend this capability significantly.

In addition, individual cooperators should use the implementation of stream reach monitoring as a training and benchmarking opportunity. While the crew inventories the designated plot, landowners should learn the techniques and flagging code, document the location of the stream reach and its plots on the ground and in their mapping system. Landowners can also anticipate remeasuring this plot in one or two years, installing new full or partial plots, and implementing individual protocols of the IMP on other portions of their holdings. In those cases where landowners already have a data collection history, it would be best if they implemented *both* the old and new methods of measurement for at least two years.

We do *not* recommend simply handing out the protocols and encouraging all landowners to conduct their own implementation. This is *not* a cookbook; Washington State certifies individuals as implementors of individual modules. In the Garcia, it is important to have a coordinator with experience and capable of training many people in the individual protocols, and acting, in effect, as the watershed IMP certifier.

Map 5-1 shows the recommended stream reach and individual protocol monitoring sites throughout the Garcia watershed. Each dot represents a beginning location from which stream reach selection would begin. Map 5-2 is a map of land ownership throughout the basin, followed by Table 5-2, which lists the selected sites for monitoring, parameters to be assessed at each site and recommendations for cooperators to implement this monitoring plan.

Missing page 5-31, Map 5-1.

Map 5-2. Map of Land Ownership in the Garcia River Watershed

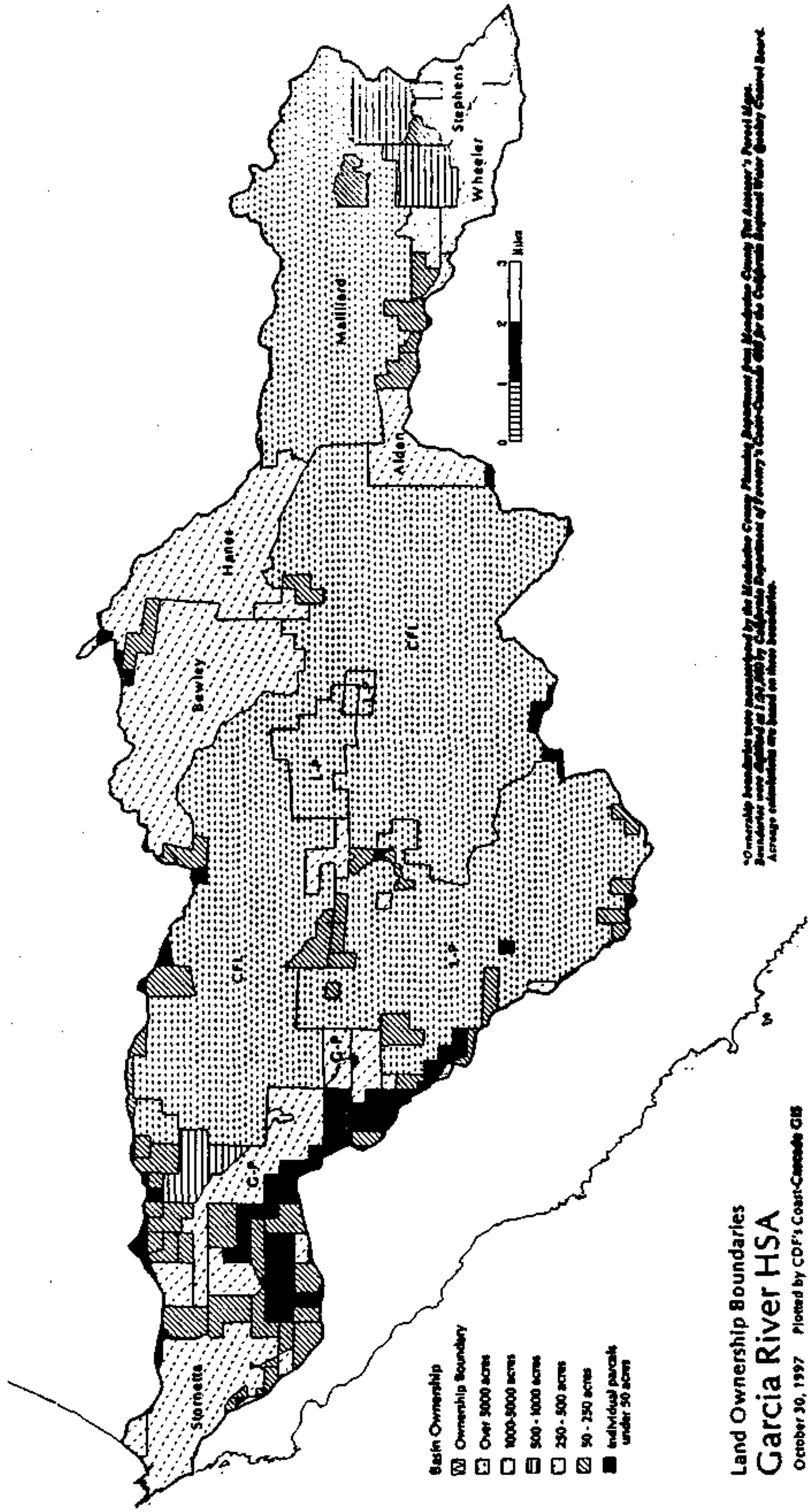


*Table 5-2. Cooperative Monitoring Plan for the Garcia River 1/4*

| Planning unit # Sub-basin | Selected monitoring sites | Monitoring Site Number | Sub-basin landowners | Cooperative monitoring | site map | temperature | substrate composition | permeability of gravels | longitudinal profiles | V* |
|---|---|---|---|---|---|---|---|---|---|---|
| 7010<br>Pardaloe and Mill Creeks | Pardaloe Creek | 1 | 8 ranchland owners | MCWA, RCD, CDFG | | MCWA (2 sites) | | | | |
| | Mill Creek | 2 | | MCWA, RCD | RCD | MCWA (2 sites) | RCD | RCD | RCD | RCD |
| 70011<br>Grant's Camp, Larmour Creek and the Garcia River | Grant's Camp Creek | 3 | CFL, private ranchers | Ranchers, CFL, RCD | RCD | RCD | RCD | RCD | RCD | RCD |
| | Larmour Creek | 4 | | RCD | | RCD | | | | |
| | mainstem Garcia | 5 | | | | MCWA | | | | |
| 70012<br>Stansbury Creek, Whitlow Creek and the Garcia River | Whitlow Creek | 6 | CFL, private ranchers | RCD | RCD | RCD | RCD | RCD | RCD | RCD |
| | Stansbury Creek | 7 | | RCD | RCD | RCD | RCD | RCD | RCD | RCD |
| | mainstem Garcia | 8 | | FrOG | | FrOG | | | | |
| 70013<br>Blue Waterhole | Blue Waterhole Creek | 9 | CFL, private rancher | CFL, FrOG & RCD | RCD | FrOG (4 Sta.) | RCD | RCD | RCD | RCD |
| 70014<br>Inman Creek | Inman Creek | 10 | CFL | CFL, RCD | RCD | CFL, RCD | CFL, RCD | RCD | RCD | RCD |
| 70020<br>Signal Creek | Signal Creek | 11 | CFL | CFL, RCD | RCD | CFL, RCD | CFL, RCD | RCD | RCD | RCD |
| 70021<br>Caspar Creek, Graphite Creek and the Garcia River | mainstem Garcia | 12 | CFL and L-P | CFL | | CFL | CFL | | | |
| | Caspar Creek | 13 | | RCD | | | | | | |
| | Graphite Creek | 14 | | RCD | RCD | RCD | RCD | RCD | RCD | RCD |

***Table 5-2. Cooperative Monitoring Plan for the Garcia River 2/4***

| *Selected monitoring sites* | Monitoring Site Number | canopy measures | LWD | recruitment trees | STC's | aerial surveys | cross sections | channel morphology | turbidity | flow | dissolved oxygen | spawning survey | fish counts | barrier evaluation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Pardaloe Creek* | *1* | | | | | *RCD* | | | | | | *RCD* | *RCD* | |
| *Mill Creek* | *2* | *RCD* | *RCD* | *RCD* | *RCD* | *RCD* | | | | | | *RCD* | *RCD* | |
| *Grant's Camp Creek* | *3* | *RCD* | *RCD* | *RCD* | *RCD* | *RCD* | | | | | | *RCD* | *RCD* | |
| *Larmour Creek* | *4* | | | | *RCD* | *RCD* | | | | | | | | |
| *mainstem Garcia* | *5* | | | | | *RCD* | | | | | | | | |
| *Whitlow Creek* | *6* | *RCD* | *RCD* | *RCD* | *RCD* | *RCD* | | | | | | *co-op* | *co-op* | |
| *Stansbury Creek* | *7* | *RCD* | *RCD* | *RCD* | *RCD* | *RCD* | | | | | | *RCD* | *RCD* | |
| *mainstem Garcia* | *8* | | | | | *RCD* | | | | | | | | |
| *Blue Waterhole Creek* | *9* | *RCD* | *RCD* | *RCD* | *RCD* | *RCD* | *RCD* | | | | | *RCD* | *RCD* | |
| *Inman Creek* | *10* | *CFL, RCD* | *CFL, RCD* | *RCD* | *RCD* | *RCD* | | *CFL* | | | | *coop* | *co-op* | |
| *Signal Creek* | *11* | *CFL, RCD* | *CFL, RCD* | *RCD* | *RCD* | *RCD* | | *CFL* | | | | *co-op* | *co-op* | |
| *mainstem Garcia* | *12* | *CFL* | *CFL* | | | *RCD* | | *CFL* | | | | | | |
| *Caspar Creek* | *13* | | | | | *RCD* | | | | | | | | *RCD* |
| *Graphite Creek* | *14* | *RCD* | *RCD* | *RCD* | *RCD* | *RCD* | | | | | | *co-op* | *co-op* | *RCD* |

***Table 5-2. Cooperative Monitoring Plan for the Garcia River 3/4***

| *Planning unit # Sub-basin* | *Selected monitoring sites* | *Monitoring Site Number* | *Sub-basin landowners* | *Cooperative monitoring* | *site map* | *temperature* | *substrate composition* | *permeability of gravels* | *longitudinal profiles* | *V** |
|---|---|---|---|---|---|---|---|---|---|---|
| *70022 Beebe Creek and the Garcia River* | *Beebe Creek* | *15* | *CFL, L-P and US Air Force* | *RCD* | | *RCD* | | | | |
| | *mainstem Garcia* | *16* | | *CFL* | | *CFL* | *CFL* | | | |
| *70023 South Fork, Fleming Creek and the Garcia River* | *South Fork* | *17* | *L-P, 3 ranchers* | *L-P, RCD* | *RCD* | *RCD* | *RCD* | *RCD* | *RCD* | *RCD* |
| | *Fleming Creek* | *18* | | | *RCD* | *RCD* | *RCD* | *RCD* | *RCD* | *RCD* |
| | *mainstem Garcia* | *19* | | *FrOG* | | *FrOG* | | | | |
| *70024 Rolling Brook* | *Mill Creek* | *20* | | *FrOG* | | *FrOG* | | | | |
| | *Rolling Brook* | *21* | *L-P, CFL and private owners* | *RCD, FrOG* | *RCD* | *RCD, FrOG* | *RCD* | *RCD* | *RCD* | *RCD* |
| | *Lee Creek* | *22* | | *FrOG* | | *FrOG* | | | | |
| | *Hutton Gulch* | *23* | | *FrOG* | | *FrOG* | | | | |
| | *mainstem Garcia* | *24* | | *MCWA, MWS* | | *MCWA, FrOG* | | | | |
| *70025 North Fork* | *North Fork* | *25* | *CFL, G-P, and private landowners* | *CFL, FrOG, RCD* | *RCD* | *RCD* | *CFL, RCD* | *RCD* | *RCD* | *RCD* |
| | *mainstem Garcia* | *26* | | *RCD, FrOG* | | *MCWA* | | | | |
| *70026 Hathaway Creek* | *lower 7 miles of mainstem Garcia* | *27* | *private landowners* | *RCD, FrOG, MCWA, MWS* | | *MCWA, FrOG* | | | | |
| | *Hathaway Creek* | *28* | | | | *FrOG* | | | | |

***Table 5-2. Cooperative Monitoring Plan for the Garcia River 4/4***

| *Selected monitoring sites* | Monitoring Site Number | canopy measures | LWD | recruitment trees | STC's | aerial surveys | cross sections | channel morphology | turbidity | flow | dissolved oxygen | spawning survey | fish counts | barrier evaluation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Beebe Creek* | *15* | | | | *RCD* | *RCD* | | | | | | | | *RCD* |
| *mainstem Garcia* | *16* | *CFL* | *CFL* | | | *RCD* | | *CFL* | | | | *RCD* | *RCD* | |
| *South Fork* | *17* | *RCD* | *RCD* | *RCD* | *RCD* | *RCD* | | | | | | *co-op* | *co-op* | *RCD* |
| *Fleming Creek* | *18* | *RCD* | *RCD* | *RCD* | *RCD* | *RCD* | | | | | | *co-op* | *co-op* | *RCD* |
| *mainstem Garcia* | *19* | | | | | *RCD* | | | | | | | | |
| *Mill Creek* | *20* | | | | | *RCD* | | | | | | | | |
| *Rolling Brook* | *21* | *RCD* | *RCD* | *RCD* | *RCD* | *RCD* | | | | | | *co-op* | *co-op* | |
| *Lee Creek* | *22* | | | | | *RCD* | | | | | | | | |
| *Hutton Gulch* | *23* | | | | | *RCD* | | | | | | | | |
| *mainstem Garcia* | *24* | | | | | *RCD* | *MCWA, FrOG* | | *MWS* | *MCWA* | *MCWA* | *RCD* | *RCD* | |
| *North Fork* | *25* | *CFL, RCD* | *CFL, RCD* | *RCD* | *RCD* | *RCD* | | *CFL* | | | | *co-op* | *co-op* | *RCD* |
| *mainstem Garcia* | *26* | | | | | *RCD* | *MCWA* | | *MCWA* | *MCWA* | *MCWA* | *RCD* | *RCD* | |
| *lower 7 miles of mainstem Garcia* | *27* | | | | | *RCD* | *FrOG* | | *MWS* | | | | | |
| *Hathaway Creek* | *28* | | | | | *RCD* | | | | | | | | |

*RCD – Mendocino County Resource Conservation District*
*MCWA - Mendocino County Water Agency*
*G-P - Georgia-Pacific*
*MWS – Mendocino Watershed Services*
*CFL - Coastal Forestlands, Ltd.*
*FrOG - Friends of the Garcia River*
*L-P – Louisiana-Pacific*

## E. Reference Catalogue

The number of agencies which have engaged in the monitoring set of protocols included in this document ranges from extremely numerous to relatively few. Some methods are 'standard methods,' for which we reference the American Public Health Association Manual (1997). While this manual is the standard for *lab analysis,* it does not give field methods, or 'tailgate protocols.' These are generally developed by the implementing agency. We recommend working with the NCRWQCB for turbidity, dissolved oxygen protocols. They implement these protocols on a daily level, and have standards acceptable to the basin plan.

McNeil samples have been done by fisheries personnel for years. We recommend the gravimetric protocol, and reference Mr. Randy Klein of Arcata and Redwood National Park, as well as the TFW program. We believe that CFL has done samples within this protocol to date.

Permeability samples have been done by Mr. Scott McBain of Arcata, as well as the USDA Forest Service Six Rivers Forest. McBain and Trush are working with Simpson Timber Co. on increasing their use, and L-P is considering them for the Garcia, as well (Pious 1997).

Cross-sections have been used extensively in stream assessment and engineering applications. Jackson's (1997) report documents their use in the Garcia, as does Williams' (1996). They are also noted for many locations throughout California, including Dry Creek and the Russian River, and are a standard method in Dunne and Leopold (1978) and Rosgen (1996a). Both texts have multiple examples.

Longitudinal profiles are being used by the SF Estuary Institute for the development of 'Riparian Stations', and have been implemented on Coyote Creek, the Napa River and Wildcat Creek in the Bay Area. McBain and Trush use them within the Simpson holdings. Dunne and Leopold (1978) and Rosgen (1996a) put them forward as standard methodologies with examples.

V* has been used by Lisle and Hilton (1992) and Knopp (1993) in North Coast streams. In Trinity County, V* was used to assess the recovery of Grass Valley Creek. V* derivatives have been used within the WFPB protocols, and by FSW in the Sierras and Cascades, for UC's Blodgett Forest and Collins Pine Co. The Greenwood Watershed Association has also used a V* approach in coastal Mendocino County, under the tutelage of FSW.

The densiometer for measuring canopy is a standard forestry measure, around for more than 40 years. It has been used by timber companies throughout the US, and is included in the CDFG <u>California Salmonid Habitat Restoration Manual</u> (Flosi and Reynolds 1994).

The Solar Pathfinder approach was formalized for assessment of solar power potential, and has been used by architects throughout the US. It is used, as well, by the USDA Forest Service Six Rivers Forest, CDF, UC Berkeley Blodgett Forest, and as a standard tool for SFEI's Riparian Stations.

LWD measurements are standardized in the State of Washington under TFW and the WFPB. They are also used at UC's Blodgett Forest, and on Collins Pine Co. lands, for their SYP. Recruitment tree measurements are taken directly from the WFPB protocol, but it is not certain how commonly they are used. Blodgett Forest and CDF do conduct riparian recruitment tree assessments with similar tools, but their protocols are different, though similar. All use standard forestry assessment tools, and some form of plot-based measurements.

Sediment Transport Corridors have been evaluated systematically at Blodgett Forest, Greenwood Creek and Collins Pine Co. holdings. They have proven reliable for identifying restoration priorities and typical causal mechanisms. The causal mechanism approach of WFPB has been widely used in Washington state, and is similar in many respects.

Forensic methods for assessing sedimentation using overflights have been used in estuarine and lake sedimentation situations. Monschke (1998) has stated that helicopter overflights have been useful in this terrain. Rosgen (1996b) suggested that this is the easiest, most straightforward way to find watershed problems.

Fishery surveys have been done in this watershed for many years. We have found records of spawning surveys, redd counts, carcass counts, summer juvenile counts and electrofishing. The Salmon Trollers Association and the Department of Fish and Game are the best sources for training and protocol development for fishery surveys for this IMP.

### *F. Time Frame and Schedule of Monitoring Activities*

The protocols recommended have intrinsic timelines determined by what they measure. Some characteristics of watersheds change quickly, others slowly. The time scale shown relative to parameters and indices in Table 5-3 indicates the rate of change, and therefore the necessity of revisits and remeasures of the protocols presented in this section. Table 5-4 proposes a schedule for the RCD and cooperators for the next two years. Table 5-4 also states management needs for the RCD to implement this IMP, including hiring a coordinator, purchasing equipment, identifying sites, and interacting with cooperators.

The ultimate time frame for watershed monitoring relies on the amount of effort directed at this project by the MCRCD and its cooperators. While any given watershed can receive monitoring now, it may take years for a full suite of protocols to be instituted throughout the watershed.

It is FSW's experience that revisits to plots are best done sooner, rather than later, to take advantage of experienced personnel, to re-find points, to refresh flagging, to update maps (roads change quickly in timber harvest areas), and to not lose the plots. Some revisits are intrinsic in this sampling methodology; temperatures must be downloaded every two months, for instance. The tendency to let remeasures 'slide' until their location is lost or forgotten, though, will always be an active danger to this kind of long-term, watershed wide study in a changing landscape.

This is a two year study, however. In those two years, it would be a wasted effort to focus only on a very small number of streams while waiting for canopy and channel changes. Thus we recommend establishing twelve full plots, at a rate of six per year, with the hope of revisits by cooperators or a continuing RCD program over the next pair of years.

An alternative method would be to only install six plots and remeasure them the following year. FSW is concerned that indices may change very little in a year, and that extrapolation of these data into a trend would be misleading. These are long-term monitoring sites.

While morphology should be measured every other year or less often (but not less than twice a decade!), fishery values can vary strongly from year to year. We have budgeted for four sites per year to be walked three times during the winter season. The more this can be stretched, either by the RCD or cooperators, the better the overall quality of this study will be. The quality of the fishery is, ultimately, the true test of adaptive management.

We have not stated which streams should be monitored in which year. This will be highly dependent on access issues, cooperators' infusions of effort, and the implementation approach used by the coordinator.

*Table 5-3 Time Scale of Watershed Parameter Change: Remeasuring Schedule*

| **class of parameter** | **index** | | **time scale** | | | | |
|---|---|---|---|---|---|---|---|
| | | point-in-time | seasonal | annual | multi-year | decades | centuries |
| water quality | turbidity | x | | | | | |
| | dissolved oxygen | x | x | | | | |
| | temperature | x | x | x | x | | |
| | | | | | | | |
| gravel quality | percent fines <1mm | | x | x | x | | |
| | permeability | | x | x | x | | |
| | | | | | | | |
| channel assessment | cross sections | | | x | x | x | x |
| | longitudinal profiles | | | | x | x | x |
| | LWD survey | | | x | x | x | x |
| | V* | | x | x | x | x | |
| | | | | | | | |
| riparian function | canopy measures | | | | x | x | x |
| | recruitment trees | | | | x | x | x |
| | | | | | | | |
| causal mechanisms | sediment transport corridors | | x | x | x | | |
| | turbidity | x | | | | | |
| | | | | | | | |
| fish productivity | summer fish surveys | | x | x | x | x | x |
| | spawner & redd counts | | x | x | x | x | x |

*Table 5-4. Schedule of Monitoring Activities*

| RCD Tasks | | 1998 | | | | 1999 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | winter | spring | summer | fall | winter | spring | summer | fall |
| Project Management | hire coordinator | X | X | | | | | | |
| | contact co-op's, share profs, pool co-op data | X | X | | | | | | |
| | purchase equipment | | X | | | | | | |
| | select monitoring sites, gain access | | X | X | | X | X | | |
| | manage, analyze data | X | X | | | X | X | | |
| Stream Reach Sites | site map | | | 24 plots on six reaches | | | | 24 plots on six reaches | |
| | substrate composition | | | 3 points * 24 plots on six reaches | | | | 3 points * 24 plots on six reaches | |
| | permeability of gravels | | | 3 points * 24 plots on six reaches | | | | 3 points * 24 plots on six reaches | |
| | longitudinal profiles | | | 6 profiles on six reaches | | | | 6 profiles on six reaches | |
| | V* | | | 2 pools * 24 plots on six reaches | | | | 2 pools * 24 plots on six reaches | |
| | canopy measures | | | 3 points * 24 plots on six reaches | | | | 3 points * 24 plots on six reaches | |
| | LWD | | | 24 plots on six reaches | | | | 24 plots on six reaches | |
| | recruitment trees | | | 24 plots on six reaches | | | | 24 plots on six reaches | |
| | STC's | | | six entire reaches | | | | six entire reaches | |
| on plots, trib's and mainstem | spawning surveys | | | | | 8 reaches over 2 years + co-op's | | | |
| | fish counts | | | 6-10 reaches by co-op's or rcd | | | | 16 reaches by co-op's or rcd | |
| sites plus existing network | temperature | | 22 launches + co-op's | | | | 22 launches + co-op's | | |
| whole watershed | aerial survey | asap | | | | co-op opportunity | | | |
| specific pools | dissolved oxygen | | | co-op or rcd | | | | co-op or rcd | |
| trib. sites | barrier evaluation | | | six, or with plots | | | | remainder | |

### G. *Quality Assurance/Quality Control*

**Recommended project criteria** and necessary qualifications for people implementing these protocols are generally as stated in the TFW (Shuett-Hames et al. 1994) and WFPB (1995) documents. Crew trainers should be masters' level or its equivalent, with several years of field experience. Crew members should be tested on the protocols both in the office and in the field. If there is more than one crew, crews should redo each others' work on a regular basis to test for bias, and crew trainers should check on protocol implementation weekly. The tendency to drift is kept to a minimum if crew trainers are on site as team leaders; if crews are mixed regularly, to find irregularities; if crew members are not specialists, so the protocols do not drift under an individual's bias; and if field protocols are at hand, in the field to be checked at all times.

Cooperators should be considered as crew for their respective sector of the IMP. If they are conducting any kind of test or survey which occurs around the watershed and is part of the common database, they must train in a similar manner to other crews, and be checked regularly. Poor data collection can undermine the quality of the pooled data set.

**Recommendations for statistical considerations** related to data design, data processing and data analysis are to follow a multiple cluster plot design in a stratified systematic survey, as discussed in Chapter 5. Significant repetition of point samples, long continuous samples, large sets of points in pools, frequent measurement intervals along longitudinal profiles and cross-sections are all ways of ensuring statistical strength. Some samples, such as fishery data and McNeils defy statistics, because they are sampling highly variable situations with high-cost, intensive methods that prohibit multiple repetitions. Finding strongly correlated proxies for cumbersome methods, such as permeability for McNeils, encourages multiple sample points and significantly strengthens the statistic, even though it decreases apparent precision. This tradeoff for accuracy rather than precision is important, and is a paramount consideration.

The question of thermometer accuracy will be a problem with these data sets. We recommend launching the Hobo XTs after a check that they are working at room temperature, averaging two through a stream reach, and reading them with a +\-one degree Centigrade error. This addresses questions of both accuracy of the device and zonation of streams. If Hobos are found to read significantly differently, either the stream or the instruments are showing more than expected variation.

### *H. Estimated costs of implementing the IMP.*

Table 5-5 gives our estimated costs for implementing an instream monitoring program in the Garcia watershed. Within a budget of $118,250, we believe the RCD can implement an effective start to adaptive management, with the help of cooperators. The cooperative monitoring provides continued cost support for many parameters already being measured, and new efforts a gathering fisheries data and supporting the RCD's IMP team in access, site location and site monitoring.

The budget is for a two year period. As this report is presented in late January of 1998, it may be too late to implement fish surveys this year. Trush (1998) has offered that it is probably too late for coho, but in time for steelhead, if we were to implement in late winter and spring of 1998. Money for two years of fishery surveys may be concentrated in the winter of 1999, or spread out to winter of 2000 if it is not used immediately. Cooperators are, of course, encouraged to continue and expand present activities to coincide with the IMP's stream monitoring recommendations.

This budget does not consider costs of maintaining the LTMP beyond the two year period. If the program is to continue, many portions can be extended by trained and calibrated representatives from the cooperators. Other points, particularly those in ranchland and watersheds shared among non-industrial owners, should be maintained by the RCD.

The RCD must also continue to maintain the database into the future, ideally at the RCD's office, to allow public access and consistency in record keeping. Protocols should also be maintained by RCD staff, to maintain the knowledge of what is in the database, and the capability of gathering new information.

Finally, data analysis is not included in this budget. The nature of the LTMP implies that, apart from meeting requirements of the TMDL process or Basin Plan, and apart from testing the assumptions made in this document and timber companies' evaluations, data analysis will occur with information gathered at the five to twenty year level. The RCD must seek further funding or long-term cooperators to maintain the database for its useful life and ultimate utility.

*Table 5-5. Budget: Garcia River Watershed Instream Monitoring* 1/2

| **Garcia River Instream Monitoring Plan<br>Two Year Estimated Budget** | | | | | |
|---|---|---|---|---|---|
| **task** | **no. persons** | **time** | **rate** | **annual cost** | **two year cost** |
| **Administration** | | | | | |
| project coordination, data management | 1 | 15 hrs/wk | $18/hr | $14,040 | $28,080 |
| office supplies and copies | | | | $400 | $800 |
| phone | | | $30/month | $360 | $720 |
| travel | | | $.32/mile | $1,000 | $2,000 |
| overhead to RCD for entire project | | | 15% | $10,454 | $20,907 |
| staff benefits | | | 30% | $4,212 | $8,424 |
| **Subtotal - Administration** | | | | $30,466 | $60,931 |
| **Field Work** | | | | | |
| fixed plot IMP - site map, substrate composition, gravel permeability, Longitudinal profiles, V*, canopy, LWD, recruitment trees and STC's | 2 | Average of 4 days/stream reach, 6 streams/yr. | 1 @ $18/hr.<br>1 @ $15/hr. | $6,336 | $12,672 |
| temperature | 1 | 6-8 hobos/day; 3 x yr. | $18/hr | $1,296 | $2,592 |
| fish counts and spawning surveys | 2 | 4 streams/yr., 2 days/stream, 3x during coho season | 1 @ $18/hr.<br>1 @ $15/hr. | $6,336 | $12,672 |
| STC's only | 2 | 3 days/yr. | 1 @ $18/hr.<br>1 @ $15/hr. | $792 | $1,584 |
| cross-sections | 2 | 1 day/yr. | 1 @ $18/hr.<br>1 @ $15/hr. | $264 | $528 |
| barrier evaluations | 2 | 3 days/yr. | 1 @ $18/hr.<br>1 @$15/hr. | $792 | $1,584 |
| staff benefits | | 30% | | $4,745 | $9,490 |
| **Subtotal - Field Work** | | | | $20,561 | $41,122 |

*Table 5-5. Budget: Garcia River Watershed Instream Monitoring Plan 2/2*

| **Garcia River Instream Monitoring Plan<br>Two Year Estimated Budget** | |
|---|---|
| **Equipment** | |
| DO test kit-Winkler wet titration kit. LaMotte (bm 221788) | $33 |
| Topcon level-AT G7 (bm 100365) | $595 |
| dome head tripod (bm 100174) | $128 |
| Mound city 4.5 m rod (bm 100853) | $105 |
| Keson fiberglass 100 m tape (bm 122733) | $80 |
| Keson fiberglass 30 m tape (bm 122731) | $27 |
| 2 style A form holders (tatums) (bm 102609) | $39 |
| 3 sieves: 6.3 mm, 2.0 mm, 0.83 mm | $143 |
| 22 hobo temps X-T plus housing | $2,617 |
| siphon pump for permeability (200304) | $22 |
| spherical densiometer (102165) | $99 |
| solar pathfinder plus refill horizontal surfaces (Jade equipment) | $120 |
| McNeil sampler | $140 |
| 2 Silva Ranger compasses | $83 |
| diameter logger's tape (121460) | $45 |
| **Subtotal - Equipment** | $4,274 |
| **Other** | |
| aerial photo turbidity flight (includes pilot, plane and all supplies) | $6,000 |
| 5% miscellaneous and contingencies | $5,924 |
| **Subtotal - Other** | $11,924 |
| **Total Budget** | $118,250 |

## *6. Tributary Selection for Conjunctive Hillslope and Instream Monitoring*

Evaluation of data for the watershed has shown several trends. We have postulated where the erosion rates are the greatest, and determined where that erosion is greater or less than expected. We have seen where data exists, and where it is missing. We have postulated what causal mechanisms may be guiding pollution impacts from the hillslopes into the streams. With this information and speculation, we must select appropriate watersheds for conjunctive monitoring. The synthesis table for impacts is Appendix B; the monitoring summary is Appendix C.

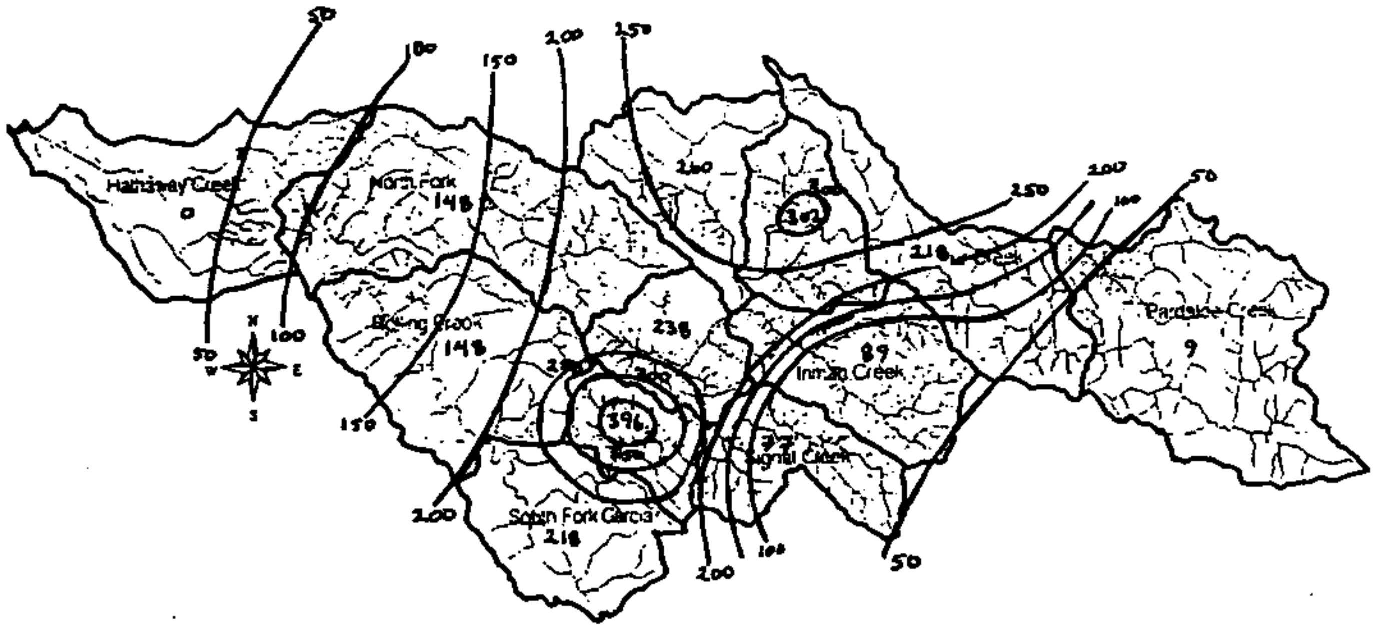
Watershed erosion rates are summarized in Maps 6-1. and 6-2. These maps show lines of equal erosion rates for mass wasting and surface erosion, as developed in Chapter 3. The isolines are based on applying rates to watershed centroids, and determining rate gradients between those points. These maps are presented as analysis tools, because they show the gross pattern of estimated erosion rates in the Garcia watershed.

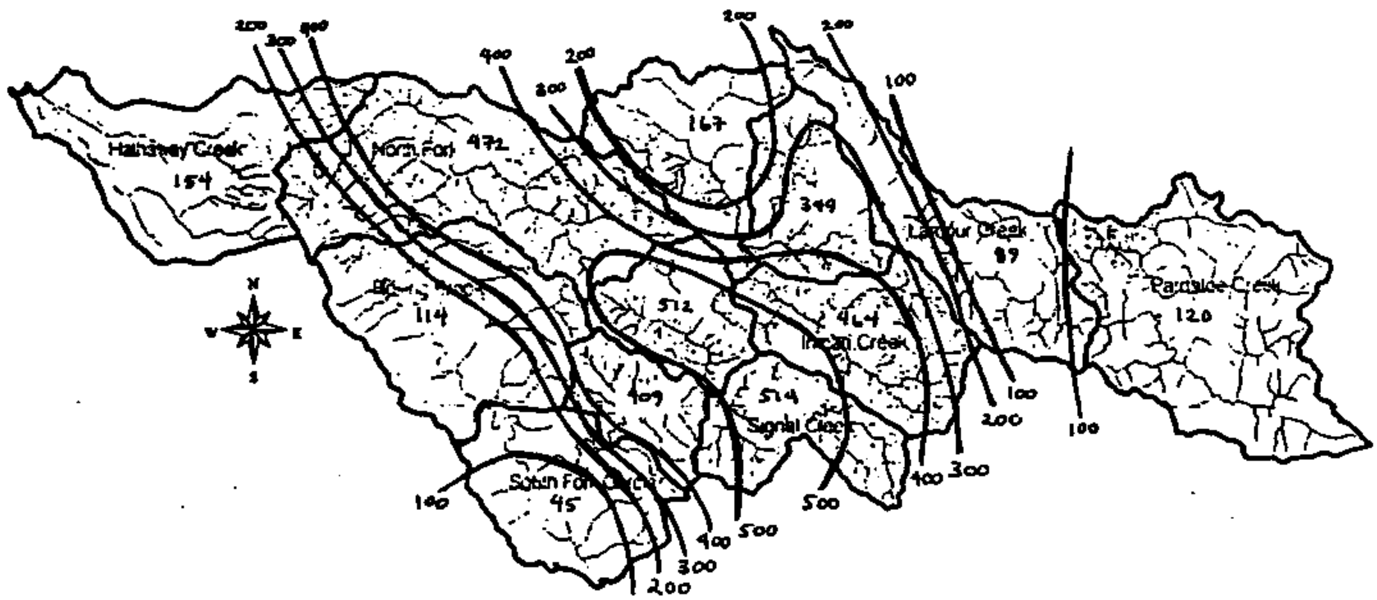
Consideration of erosion rates shows that the Graphite PW, Basin no. 7022 with Beebe Ck., is both an important producer while it is essentially along the model line (Chapter 4). Review of maps show that it is not only the Graphite that has this kind of topography and land management, but areas of Hot Springs PW, basin no. 7021 with Graphite Ck., which has extremely steep slopes and a recent history of intense harvest. Similar conditions also exist in the North Fork watershed, though with less relief, due to a longer watershed, and greater fish productivity for the same reasons. These areas of very high landslide and road erosion deserve an investigation.

Evaluation of estimated erosion with expected erosion also shows some watersheds as unlikely low producers. Either something is making those watersheds more stable--such as good BMP implementation—or our models need work. In particular, Inman Ck., Signal Ck., and possibly Whitlow Ck. would be good candidates for study. These areas also have good historical fisheries.

The synthesis (Appendix B) finds that, among the existing data, there are very few sites which are considered to have 'good' conditions with 'good' fish populations. It is important to monitor these sites because they may be the most robust refugia for genetic stocks, particularly if the ecosystem were to undergo the stress of drought, floods or management impacts. These sites are also important to monitor because they may be the only sites sensitive enough to respond to environmental impacts. The only stream with low present sediment effects, high complexity, good canopy and fair fish populations-though declined from original levels-was the South Fork Garcia. Some site data conflicts with this interpretation, making its assessment even more important.

Map 6-1. Isomap of Estimated Mass Wasting Rates in t/mi$^2$/y, Garcia River Watershed




Map 6-2. Isomap of Estimated Surface Erosion Rates in t/mi$^2$/y, Garcia River Watershed

An area with low erosion, relatively stable sediment in stream channels and good fisheries is the South Fork PW. Relative to other watersheds, it is in very good condition. The area has been unlogged for the past decade, so it is reasonable to assume that the low impact of land management has allowed the watershed to 'heal.' The South Fork is a good candidate, therefore, because it may be harvested in the near future and it has some of the best fish habitat in the watershed.

It is also important to have sites dominated by road erosion. While Signal Ck., Inman Ck. and North Fork all have similar erosion rates and road / mass wasting balances, the North Fork is a significantly different type of watershed. It is larger, it has greater relief, and it does not appear as dominated by fault- or rock-contact- trending geology. Along with to its fishery history, this appears to make North Fork a good watershed to pair with Inman, Signal or Whitlow Creeks.

Other streams that should be considered are:

- Pardaloe Creek, which has good fisheries, high sedimentation, poor pools and habitat structure in a watershed with relatively little relief. It is not clear where the sediment is coming from, nor why the fish population is doing relatively well.

- Tributaries of the North Fork, particularly Olsen Gulch. Olsen Gulch, however, may have so limited fisheries at this time, and such hazardous conditions due to sedimentation (Maahs 1997), that North Fork will be a more practical stream for assessment.

- Mainstem Garcia. Surveys of summer condition, particularly for temperature and oxygen. While the mainstem channel is quite changeable, it is monitored through a set of cross-sections. V*, LWD, and canopy measures are not particularly suited to the mainstem. Cross-sections should, however, be augmented by longitudinal profiles, to see cumulative effects of timber, gravel extraction and range activities on the mainstem.

- Redwood Creek, Pardaloe watershed. This creek is the closest this watershed has to baseline conditions. While a joint hillslope-instream monitoring program would be hard to implement in anticipation of a harvest, it would be frustrated with this sampling problem, it is important to understand native conditions in these ecosystems and river basins.

Choosing among these as targets for joint monitoring efforts requires the input of timber interests, the Department of Forestry and the RCD. It is clear that joint monitoring for hillslope processes requires both land that has, recently, been harvested, and land that will, soon, be harvested.

The mainstem Garcia, while important, does not fit the correct scale. The scale of the river does not match many of the protocols recommended within the IMP, apart from fishery surveys. The mainstem should be reviewed for bottleneck conditions that would restrict the validity of the habitat hypothesis, and needs to be monitored for significant point source or STC sediment inputs.

CDF's LTMP should look for recently harvested and soon to be harvested areas with known habitat and clearly good or bad conditions, such as Whitlow, North Fork, South Fork and Graphite Creeks. Control streams should be considered. Evaluating these individual streams would begin to answer questions about hillslope-stream connections for sediment and other timber-related impacts, but in no way evaluate sediment source identification or fisheries reduction in the larger watershed.

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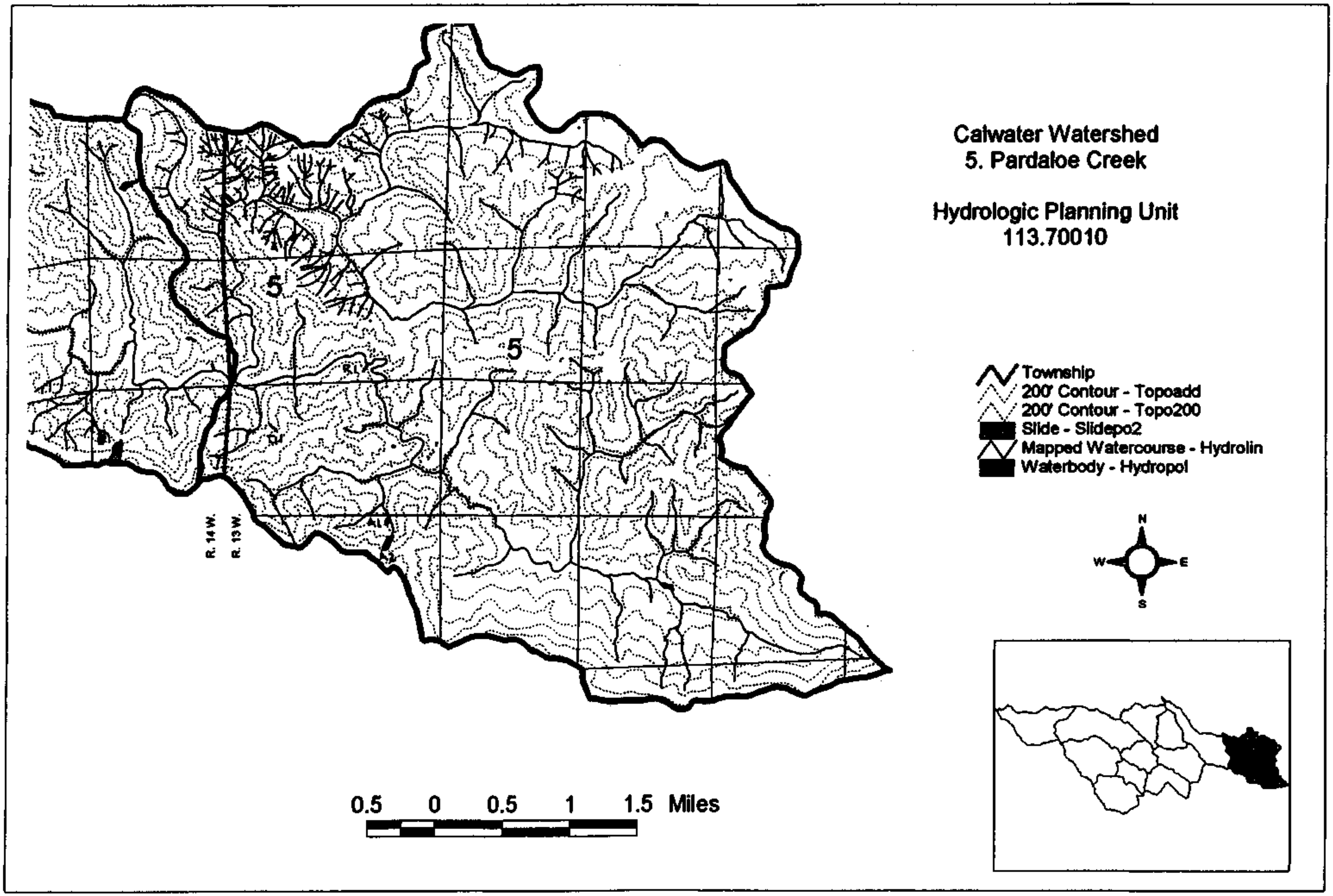
# *APPENDIX A.*

## *LOCATION AND VOLUMES OF MASS WASTING SITES*

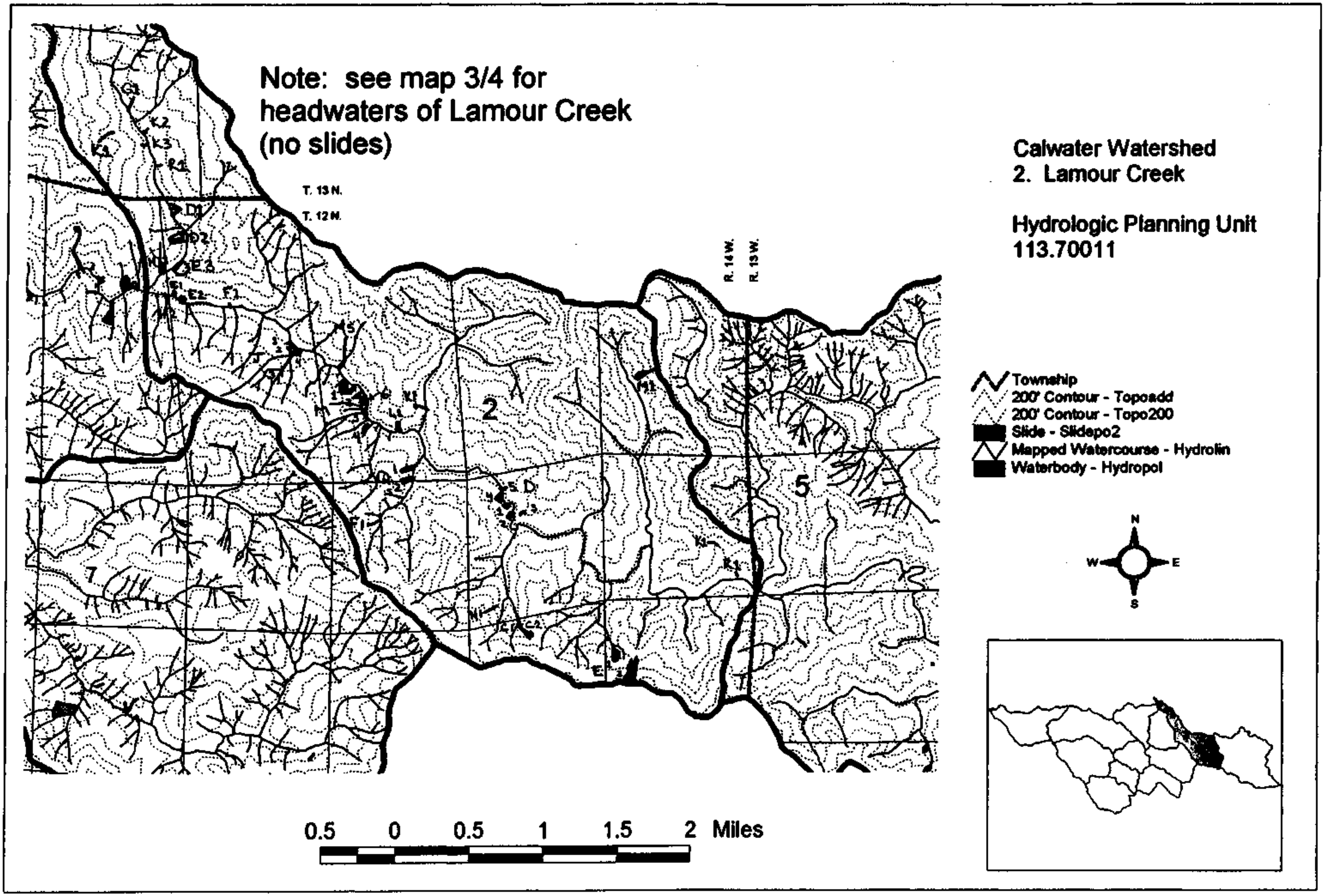
# Garcia Watershed - Basins



# GARCIA RIVER WATERSHED ASSESSMENT
# APPENDIX A - MASS WASTING INVENTORY DATA
## Calwater Watershed 5 - Pardaloe Creek

| Photo Year | Township | Range | Section | Init Loc | Feature # | Sub Water | Process | Confidence | Delivery | Stream Or | Land use | Slope Sha | 1965 Size | 1978 Size | 1996 Size |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 78 | T12N | R13W | 7 | R | 1 | 5 | SR | D | Y | 4 | R | c | | L | |
| 78 | T12N | R13W | 19 | A | 2 | 5 | SR | D | Y | 1 | N | P | | L | |
| 78 | T12N | R13W | 19 | A | 1 | 5 | SR | D | Y | 1 | N | P | | M | |

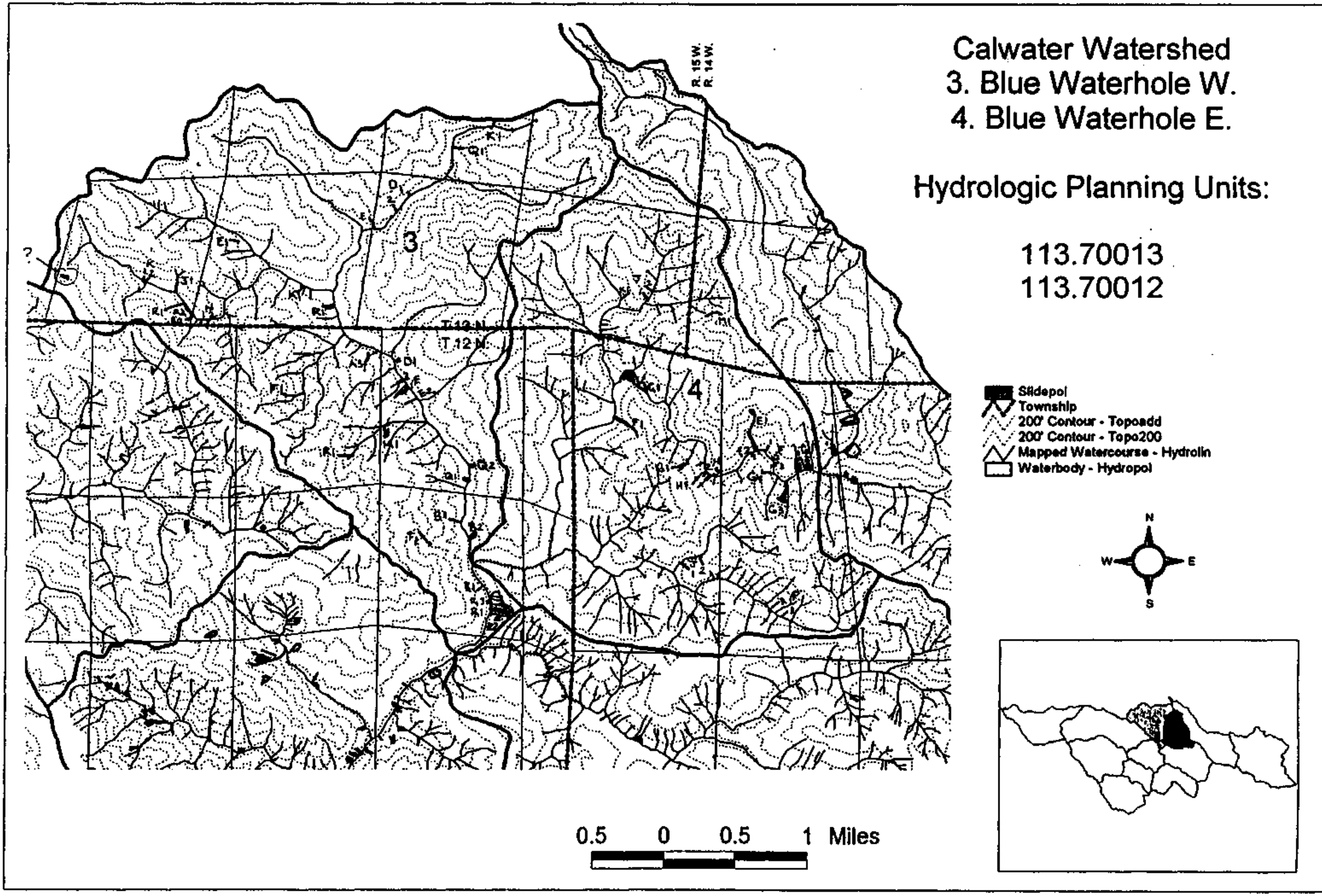
# Garcia Watershed - Basins



# GARCIA RIVER WATERSHED ASSESSMENT
# APPENDIX A - MASS WASTING INVENTORY DATA
# Calwater Watershed 2 - Larmour Cr.

| Photo Year | Township | Range | Section | Init Loc | Feature # | Sub Water | Process | Confidence | Delivery | Stream Or | Land use | Slope Sha | 1965 Size | 1978 Size | 1996 Size |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 65 | T13N | R14W | 31 | K | 1 | 2 | DF | P | Y | 2 | R | C | S | | |
| 65 | T12N | R14W | 3 | M | 1 | 2 | LPD | D | Y | 4 | H/IG | C | XL | XL | L |
| 65 | T12N | R14W | 3 | M | 2 | 2 | SR | D | Y | 4 | H/IG | P | XL | L | |
| 65 | T12N | R14W | 3 | M | 3 | 2 | SR | D | Y | 4 | N/IG | C | XL | M | |
| 65 | T12N | R14W | 3 | M | 4 | 2 | SR | P | N | | R | C | M | S | |
| 65 | T12N | R14W | 3 | Q | 1 | 2 | SR | D | Y | 2 | H | C | XL | XL | |
| 65 | T12N | R14W | 3 | Q | 2 | 2 | SR | D | Y | 2 | H | P | XL | L | |
| 65 | T12N | R14W | 4 | E | 2 | 2 | SR | D | Y | 4 | N | D | M | M | M |
| 65 | T12N | R14W | 4 | J | 1 | 2 | SR | D | Y | 4 | H | C | S | | |
| 65 | T12N | R14W | 4 | J | 2 | 2 | SR | D | Y | 4 | H | C | S | | |
| 65 | T12N | R14W | 5 | H | 1 | 2 | SR | D | Y | 2 | N/IG | C | L | | L |
| 65 | T12N | R14W | 5 | H | 2 | 2 | SR | Q | Y | 4 | H | P | M | L | |
| 78 | T12N | R14W | 3 | M | 5 | 2 | DF | Q | Y | 4 | R | C | | L | |
| 78 | T12N | R14W | 4 | J | 3 | 2 | DF | P | Y | 4 | R | P | | L | |
| 78 | T12N | R14W | 3 | K | 1 | 2 | LPD | P | N | | H | P | | L | |
| 78 | T12N | R14W | 4 | D | 1 | 2 | LPD | D | Y | 3 | N | D | | XL | XL |
| 78 | T12N | R14W | 1 | M | 1 | 2 | SR | P | N | | N | D | | L | |
| 78 | T12N | R14W | 11 | D | 2 | 2 | SR | D | Y | 4 | N | C | | L | L |
| 78 | T12N | R14W | 12 | K | 1 | 2 | SR | D | Y | 1 | N | P | | L | |
| 78 | T12N | R14W | 13 | E | 1 | 2 | SR | D | Y | 1 | N | C | | L | |
| 78 | T12N | R14W | 14 | c | 2 | 2 | SR | P | Y | 1 | R | C | | L | L |
| 78 | T12N | R14W | 4 | D | 2 | 2 | SR | P | Y | 3 | R | P | | L | |
| 78 | T12N | R14W | 4 | E | 1 | 2 | SR | D | Y | 4 | N | P | | M | M |
| 78 | T12N | R14W | 11 | D | | 2 | SR | D | Y | 4 | N | C | | M | |
| 78 | T12N | R14W | 11 | D | | 2 | SR | D | Y | 4 | N | C | | M | |
| 78 | T12N | R14W | 11 | D | | 2 | SR | D | Y | 4 | N | C | | M | L |
| 78 | T12N | R14W | 11 | N | | 2 | SR | P | N | | R | C | | M | |
| 78 | T12N | R14W | 14 | C | | 2 | SR | P | Y | 1 | N | C | | S | |
| 78 | T12N | R14W | 12 | R | | 2 | SR | D | Y | 4 | R | P | | S | |
| 78 | T13N | R14W | 31 | R | | 2 | SR | D | Y | 3 | N | P | | S | |
| 78 | T12K | R14W | 13 | E | | 2 | SR | D | N | | R | P | | XL | |
| 96 | T12N | R14W | 3 | M | | 2 | LPD | P | Y | 4 | H | c | | | L |
| 96 | T12N | R14W | 4 | B | | 2 | LPD | D | Y | 2 | R | c | | | L |
| 96 | T12N | R14W | 3 | L | | 2 | SR | D | Y | 4 | N | D | | | L |
| 96 | T12N | R14W | 10 | F | | 2 | SR | P | N | | R | C | | | M |
| 96 | T13N | R14W | 31 | K | | 2 | SR | D | Y | 2 | R | D | | | M |
| 96 | T12N | R14W | 2 | Q | | 2 | SR | D | Y | 4 | R | P | | | S |
| 96 | T12N | R14W | 3 | M | | 2 | SR | D | N | | R | P | | | S |
| 96 | T12N | R14W | 4 | F | | 2 | SR | D | Y | 4 | N | P | | | S |
| 96 | T12N | R14W | 11 | D | | 2 | SR | D | Y | 4 | R | C | | | S |
| 96 | T13N | R14W | 31 | G | | 2 | SR | D | Y | 2 | N | P | | | S |
| 96 | T13N | R14W | 31 | K | 2 | 2 | SR | D | Y | 2 | N | P | | | S |
| 96 | T12N | R14W | 4 | J | 4 | 2 | SR | D | Y | 4 | N | C | | | XL |

# Garcia Watershed - Basins



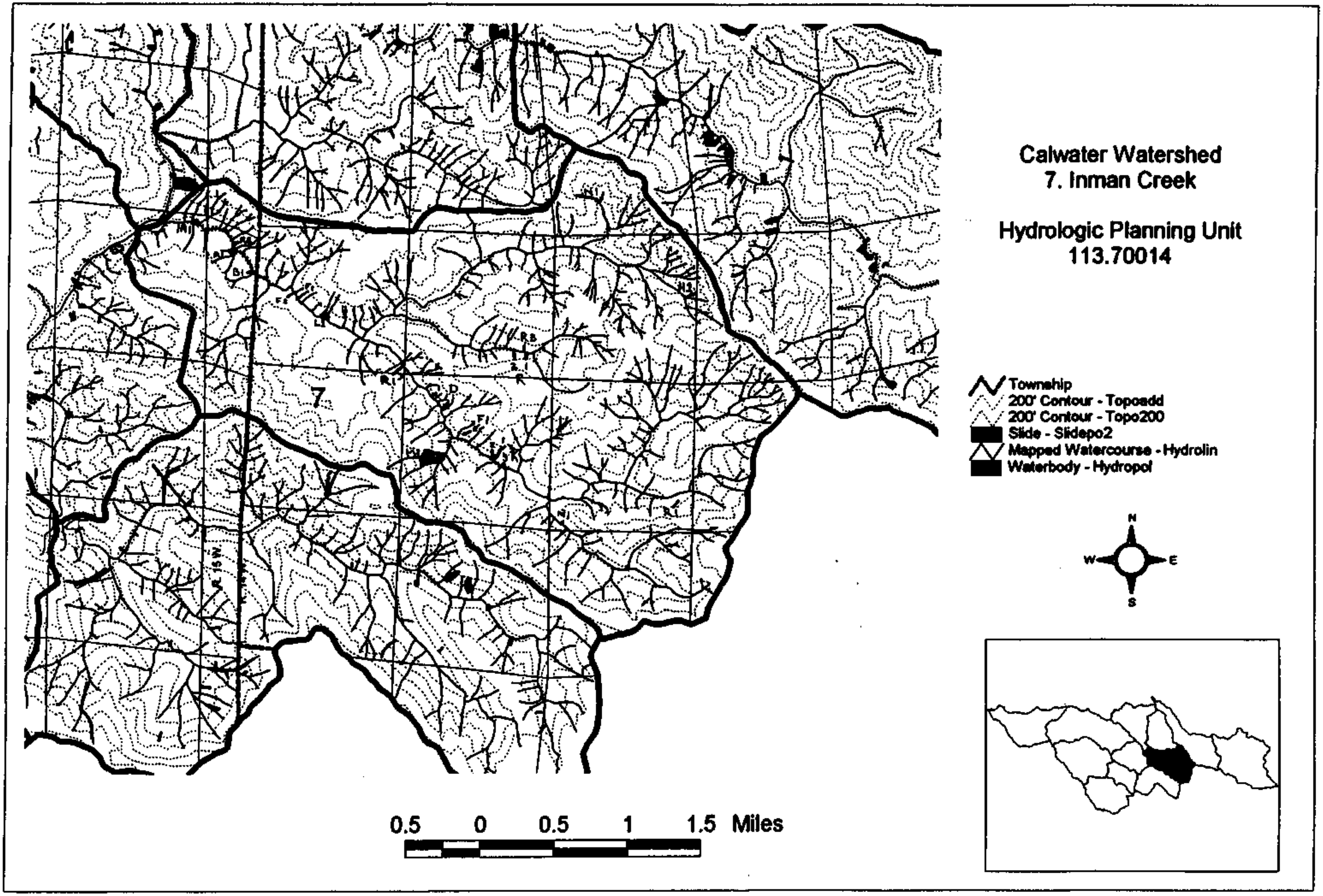
# GARCIA RIVER WATERSHED ASSESSMENT
# APPENDIX A - MASS WASTING INVENTORY DATA
# Calwater Watershed 4 - Blue Waterhole E.

| Photo Year | Township | Range | Section | Init Loc | Feature # | Sub Water | Process | Confidence | Delivery | Stream Or | Land use | Slope Sha | 1965 Size | 1978 Size | 1996 Size |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 65 | T12N | R14W | 5 | E | 1 | 4 | DF | D | Y | 4 | H? | C | L | | |
| 65 | T12N | R14W | 6 | F | 1 | 4 | DF | P | Y | 4 | R | C | L | | |
| 65 | T12N | R14W | 5 | E | 2 | 4 | SR | D | Y | 4 | R | P/C | M | | |
| 65 | T12N | R14W | 5 | P | 1 | 4 | SR | D | Y | 4 | R | C | M | | |
| 65 | T12N | R14W | 6 | H | 1 | 4 | SR | D | Y | 4 | R | C | S | | |
| 65 | T12N | R14W | 6 | H | 2 | 4 | SR | D | Y | 4 | R | C | M | M | |
| 65 | T12N | R14W | 6 | J | 1 | 4 | SR | D | Y | 2 | R | D | L | | |
| 65 | T12N | R14W | 6 | J | 2 | 4 | SR | D | Y | 2 | R | D | M | | |
| 65 | T13N | R15W | 36 | J | 1 | 4 | SR | D | Y | 2 | H | P | L | | |
| 65 | T13N | R15W | 36 | K | 1 | 4 | SR | Q | Y | 2 | R | C | M | | |
| 78 | T12N | R14W | 5 | G | 3 | 4 | DF | P | Y | 4 | R | P | | M | |
| 78 | T12N | R14W | 6 | a | 1 | 4 | DF | P | Y | 2 | R | C | | L | |
| 78 | T12N | R14W | 5 | G | 1 | 4 | LPD | D | Y | 4 | N | P | | XL | XL |
| 78 | T12N | R14W | 5 | 0 | 2 | 4 | LPD | D | Y | 4 | N | P | | XL | XL |
| 78 | T12N | R14W | 6 | c | 1 | 4 | LPD | P | Y | 4 | H | C | | XL | XL |
| 78 | T12N | R14W | 6 | H | 3 | 4 | SR | P | N | | H | P | | M | |
| 78 | T12N | R14W | 5 | 0 | 4 | 4 | SR | D | Y | 4 | R | C | | XL | |
| 96 | T12N | R14W | 5 | F | 2 | 4 | SR | D | Y | 4 | R | C | | | S |
| 96 | T12N | R14W | 5 | P | 2 | 4 | SR | D | Y | 2 | R | D | | | L |
| 96 | T13N | R14W | 31 | M | 1 | 4 | SR | D | Y | 1 | N | P | | | L |
| 96 | T12N | R14W | 5 | F | 3 | 4 | SR | D | Y | 4 | R | D | | | M |
| 96 | T12K | R14W | 6 | G | 2 | 4 | SR | D | Y | 4 | N | C | | | M |
| 96 | T13N | R15W | 36 | J | 2 | 4 | SR | P | Y | 2 | R | C | | | M |
| 96 | T12N | R14W | 5 | F | 1 | 4 | SR | D | Y | 4 | R | C | | | M |

# GARCIA RIVER WATERSHED ASSESSMENT
# APPENDIX A - MASS WASTING INVENTORY DATA
## Calwater Watershed 3 - Blue Waterhole W.

| Photo Year | Township | Range | Section | Init Loc | Feature # | Sub Water | Process | Confidence | Delivery | Stream Or | Land use | Slope Sha | 1965 Size | 1978 Size | 1996 Size |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 65 | T13N | R15W | 33 | J | 1 | 3 | DF | D | Y | 2 | R | C | L | | |
| 65 | T13N | R15W | 33 | R | 1 | 3 | DF | P | Y | 2 | H | C | L | | |
| 65 | T12N | R15W | 2 | B | 1 | 3 | LPD | D | Y | 4 | R | P | XL | | |
| 65 | T12N | R15W | 11 | R | 1 | 3 | LPD | D | Y | 4 | H | P | XL | XL | XL |
| 65 | T12N | R15W | 2 | D | 1 | 3 | SR | D | Y | 4 | R | P | M | | |
| 65 | T12N | R15W | 3 | R | 1 | 3 | SR | D | Y | 2 | H | P | M | S | |
| 65 | T12N | R15W | 11 | B | 1 | 3 | SR | P | Y | 4 | R | P | *M* | | |
| 65 | T12N | R15W | 11 | B | 2 | 3 | SR | P | Y | 4 | H/IG | P | XL | L | |
| 65 | T12N | R15W | 11 | K | 1 | 3 | SR | D | N | | R | P | S | | |
| 65 | T13N | R15W | 33 | R | 2 | 3 | SR | D | Y | 2 | R | P | M | M | |
| 65 | T13N | R15W | 34 | E | 1 | 3 | SR | D | N | | H | D | L | | |
| 65 | T13N | R15W | 34 | N | 1 | 3 | SR | D | Y | 2 | R | D | L | L | |
| 65 | T13N | R15W | 34 | N | 2 | 3 | SR | D | Y | 2 | R | D | M | *M* | |
| 65 | T13N | R15W | 34 | R | 1 | 3 | SR | D | Y | 4 | R | C | L | M | M |
| 78 | T12N | R15W | 11 | R | 2 | 3 | DF | Q | Y | 4 | N | P | | M | |
| 78 | T12N | R15W | 2 | E | 2 | 3 | SR | D | Y | 3 | R | C | | L | |
| 78 | T12N | R15W | 3 | A | 1 | 3 | SR | D | N | | R | P | | M | |
| 78 | T12N | R15W | 11 | R | 3 | 3 | SR | D | Y | 4 | R | P | | M | |
| 78 | T12N | R15W | 2 | M | 1 | 3 | SR | D | Y | 2 | H | D | | XL | |
| 96 | T12N | R15W | 3 | F | 1 | 3 | SR | Q | Y | 1 | H | C | | | L |
| 96 | T13N | R15W | 26 | K | 1 | 3 | SR | D | Y | 2 | R | C | | | L |
| 96 | T13N | R15W | 26 | Q | 1 | 3 | SR | D | Y | 2 | | P | | | L |
| 96 | T13N | R15W | 33 | R | 3 | 3 | SR | D | Y | 3 | N | P | | | L |
| 96 | T12N | R15W | 2 | E | 3 | 3 | SR | P | Y | 3 | N | C | | | M |
| 96 | T12N | R15W | 11 | F | 1 | 3 | SR | D | N | | N | P | | | M |
| 96 | T13N | R15W | 34 | K | 1 | 3 | SR | P | Y | 3 | N | C | | | M |
| 96 | T13M | R15W | 35 | D | 1 | 3 | SR | D | Y | 3 | R | P | | | M |
| 96 | T13N | R15W | 35 | D | 2 | 3 | SR | D | Y | 3 | R | P | | | M |
| 96 | T13N | R15W | 35 | E | 1 | 3 | SR | P | Y | 3 | R | D | | | M |
| 96 | T12N | R15W | 2 | Q | 2 | 3 | SR | D | Y | 3 | R | C | | | S |
| 96 | T13N | R15W | 33 | K | 1 | 3 | SR | D | Y | 3 | N | P | | | S |
| 96 | T13N | R15W | 33 | K | 2 | 3 | SR | D | Y | 3 | N | P | | | S |

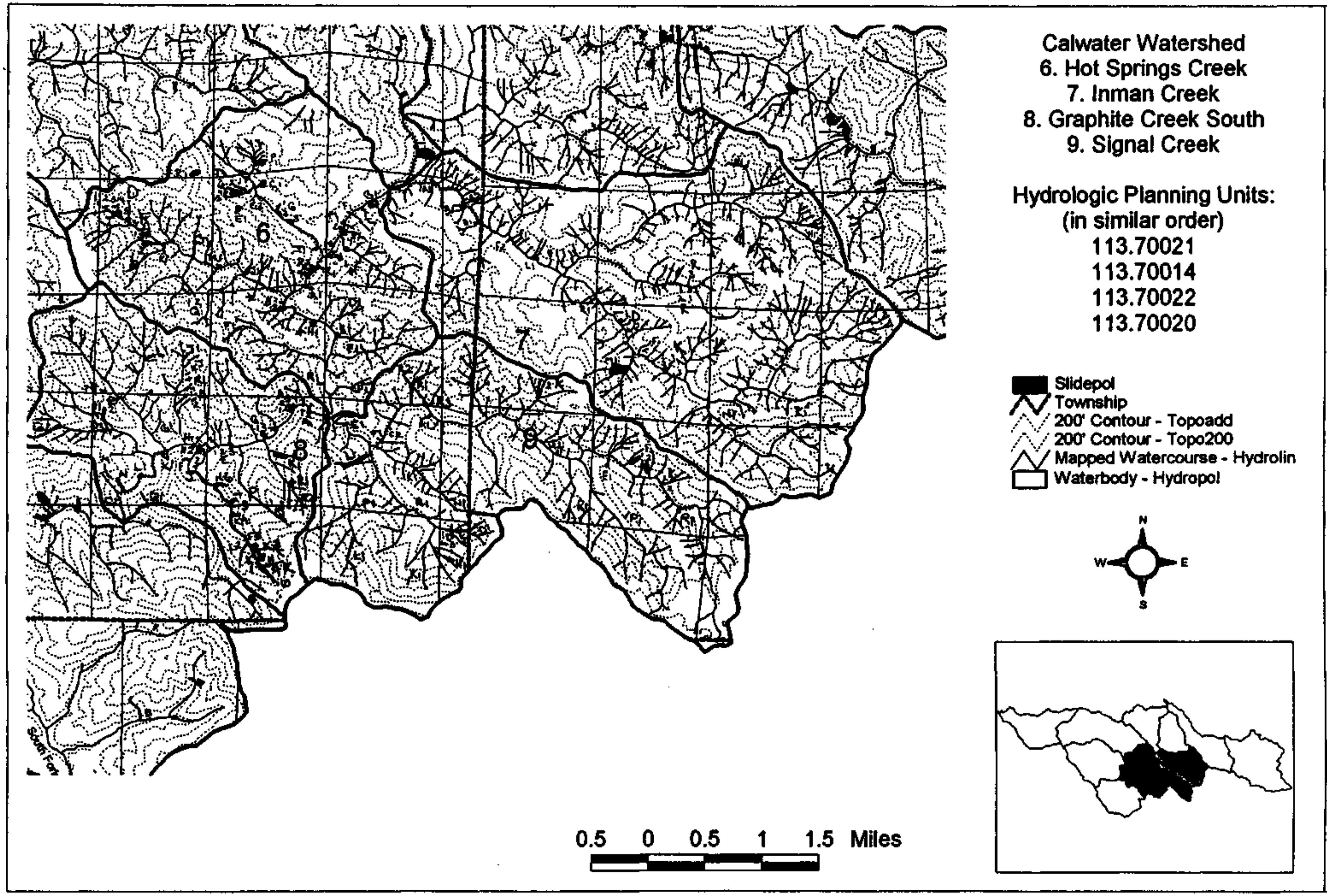
# Garcia Watershed - Basins



# GARCIA RIVER WATERSHED ASSESSMENT
# APPENDIX A - MASS WASTING INVENTORY DATA
# Calwater Watershed 7 - Inman Creek

| Photo Year | Township | Range | Section | Init Loc | Feature # | Sub Water | Process | Confidence | Delivery | Stream Or | Land use | Slope Sha | 1965 Size | 1978 Size | 1996 Size |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 65 | T12N | R14W | 4 | N | 1 | 7 | SR | D | Y | 1 | H | P | L | | |
| 65 | T12N | R14W | 7 | F | 1 | 7 | SR | D | Y | 3 | R | C | S | | |
| 65 | T12N | R14W | 8 | R | 1 | 7 | SR | P | Y | 2 | R | P | M | S | |
| 65 | T12N | R15W | 13 | A | 1 | 7 | SR | D | Y | 3 | R | C | M | | |
| 65 | T12N | R15W | 14 | A | 1 | 7 | SR | D | Y | 4 | R | P | S | M | M |
| 78 | T1ZN | R14W | 8 | R | 2 | 7 | DF | D | Y | 2 | R | P | | M | |
| 78 | T12N | R14W | 9 | H | 1 | 7 | SR | D | Y | 2 | R | D | | M | |
| 78 | T12N | R15W | 13 | A | 2 | 7 | SR | D | Y | 4 | R | P | | M | |
| 78 | T12N | R15W | 13 | B | 1 | 7 | SR | D | Y | 3 | R | P | | M | |
| 78 | T12N | R14W | 16 | R | 1 | 7 | SR | D | Y | 1 | H | P | | S | |
| 78 | T12N | R15W | 14 | A | 2 | 7 | SR | D | Y | 4 | R | C | | S | |
| 96 | T12N | R14W | 17 | M | 1 | 7 | LPD | D | Y | 2 | R | C | | | XL |
| 96 | T12N | R14W | 7 | L | 1 | 7 | SR | D | Y | 4 | R | C | | | L |
| 96 | T12N | R14W | 17 | K | 2 | 7 | SR | D | Y | 4 | R | C | | | L |
| 96 | T12N | R14W | 17 | K | 3 | 7 | SR | D | Y | 4 | R | P | | | L |
| 96 | T12N | R14W | 7 | R | 1 | 7 | SR | D | N | | H | P | | | M |
| 96 | T12N | R14W | 8 | R | 3 | 7 | SR | D | Y | 2 | H | D | | | M |
| 96 | T12N | R14W | 17 | D | 2 | 7 | SR | D | Y | 4 | R | C | | | M |
| 96 | T12N | R14W | 17 | F | 1 | 7 | SR | D | N | | R | P | | | M |
| 96 | T12N | R14W | 17 | K | 1 | 7 | SR | D | Y | 4 | R | C | | | M |
| 96 | T12N | R14W | 7 | F | 2 | 7 | SR | P | Y | 4 | R | C | | | S |
| 96 | T12N | R14W | 16 | N | 1 | 7 | SR | D | Y | 3 | R | P | | | S |
| 96 | T12N | R14W | 17 | D | 1 | 7 | SR | D | Y | 4 | R | D | | | S |

# Garcia Watershed - Basins



# GARCIA RIVER WATERSHED ASSESSMENT
# APPENDIX A - MASS WASTING INVENTORY DATA
# Calwater Watershed 9 - Signal Creek

| Photo Year | Township | Range | Section | Init Loc | Feature # | Sub Water | Process | Confidence | Delivery | Stream Or | Land use | Slope Sha | 1965 Size | 1978 Size | 1996 Size |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 65 | T12N | R15W | 26 | L | 1 | 9 | DF | D | Y | 4 | R | C | L | L | |
| 65 | T12N | R15W | 35 | L | 1 | 9 | DF | P | Y | 2 | R | C | L | | |
| 65 | T12N | R15W | 36 | D | 1 | 9 | DF | D | Y | 2 | R | C | M | L | |
| 65 | T12N | R14W | 19 | R | 1 | 9 | SR | D | N | | R | C | L | | |
| 65 | T12N | R14W | 20 | B | 1 | 9 | SR | P | N | | N | D | L | L | |
| 65 | T12N | R15W | 25 | N | 1 | 9 | SR | D | Y | 1 | R | D | L | | |
| 65 | T12N | R15W | 26 | A | 1 | 9 | SR | D | Y | 3 | R | C | S | | |
| 65 | T12N | R15W | 26 | F | 1 | 9 | SR | P | Y | 3 | R | P | S | | |
| 65 | T12N | R15W | 26 | K | 1 | 9 | SR | D | Y | 2 | R | D | S | | |
| 65 | T12N | R15W | 26 | P | 1 | 9 | SR | P | Y | 2 | R | C | M | | |
| 65 | T12N | R15W | 26 | R | 1 | 9 | SR | D | Y | 3 | R | D | S | | |
| 65 | T12N | R15W | 36 | H | 1 | 9 | SR | D | Y | 1 | R | C | L | | |
| 78 | T12N | R15W | 23 | R | 1 | 9 | DF | Q | Y | 4 | R | C | | L | |
| 78 | T12N | R15W | 35 | K | 1 | 9 | SR | P | Y | 1 | R | C | | M | |
| 78 | T12N | R15W | 36 | D | 2 | 9 | SR | D | K | | R | C | | M | |
| 78 | T12N | R15W | 36 | D | 3 | 9 | SR | D | Y | 2 | R | C | | M | |
| 78 | T12N | R14W | 30 | D | 1 | 9 | SR | D | Y | 1 | R | P | | S | |
| 78 | T12N | R15W | 26 | E | 1 | 9 | SR | D | Y | 4 | R | P | | S | |
| 78 | T12N | R15W | 26 | F | 2 | 9 | SR | D | Y | 4 | R | C | | S | |
| 96 | T12N | R14W | 18 | K | 1 | 9 | DF | Q | N | | H | P | | | S |
| 96 | T12N | R14W | 18 | K | 2 | 9 | DF | Q | N | | H | P | | | S |
| 96 | T12N | R14W | 20 | F | 1 | 9 | SR | D | N | | H | C | | | L |
| 96 | T12N | R14W | 20 | F | 2 | 9 | SR | D | N | | H | D | | | L |
| 96 | T12N | R14W | 19 | H | 1 | 9 | SR | D | Y | 3 | R | P | | | S |
| 96 | T12N | R14W | 20 | P | 1 | 9 | SR | D | N | | H | D | | | S |
| 96 | T12N | R14W | 20 | R | 1 | 9 | SR | D | Y | 3 | R | C | | | S |
| 96 | T12N | R15W | 23 | R | 2 | 9 | SR | D | N | | N | D | | | S |
| 96 | T12N | R15W | 23 | R | 3 | 9 | SR | D | N | | R | D | | | S |
| 96 | T12N | R14W | 29 | A | 1 | 9 | SR | D | N | | R | C | | | S |

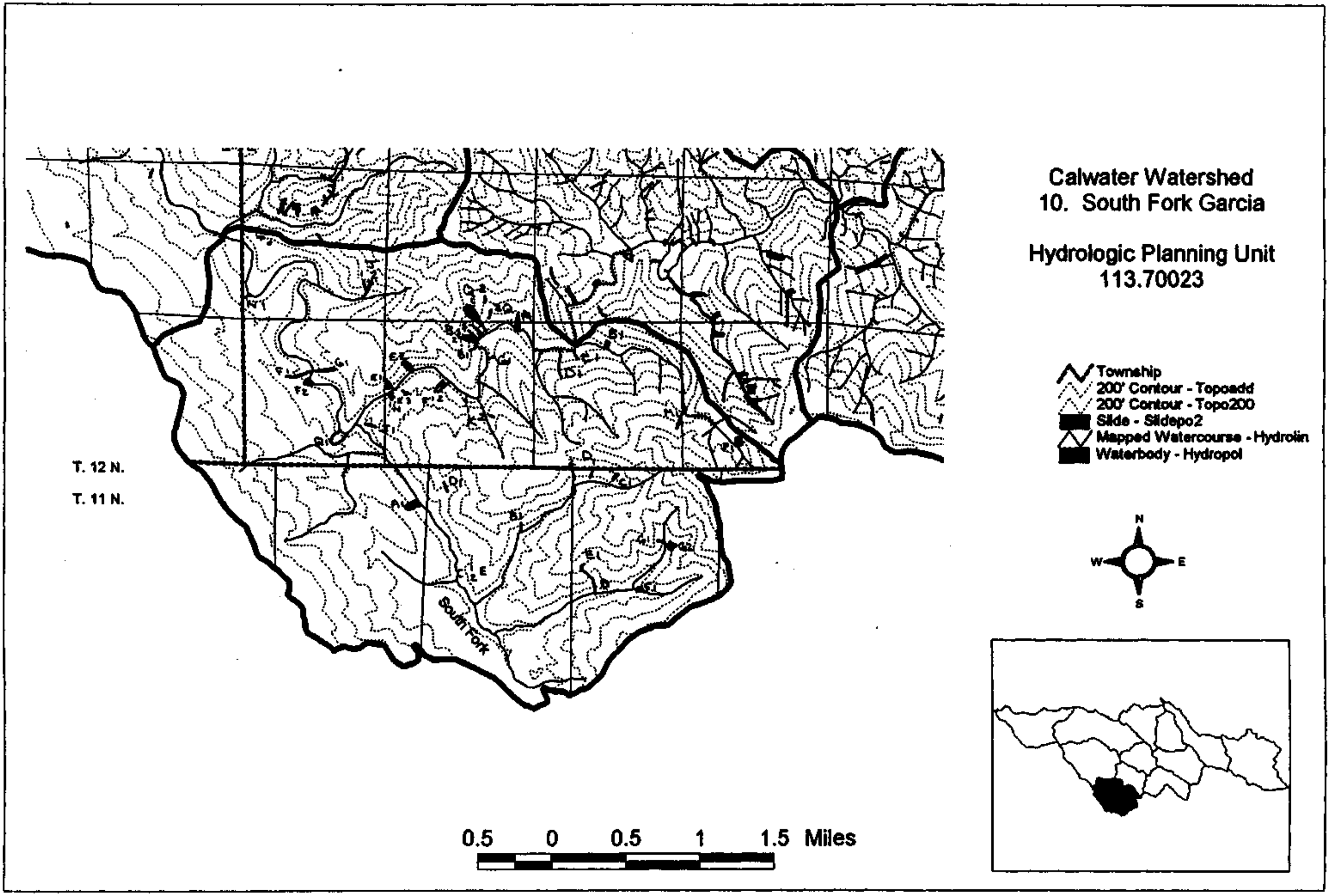
# GARCIA RIVER WATERSHED ASSESSMENT
# APPENDIX A - MASS WASTING INVENTORY DATA
# Calwater Watershed 6 - Hot Springs Creek

| Photo Year | Township | Range | Section | Init Loc | Feature # | Sub Water | Process | Confidence | Delivery | Stream Or | Land use | Slope Sha | 1965 Size | 1978 Size | 1996 Size |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 65 | T12N | R15W | 16 | J | 1 | 6 | DF | P | Y | 2 | R | C | L | L | |
| 65 | T12N | R15W | 16 | L | 1 | 6 | DF | P | Y | 2 | R | C | L | | |
| 65 | T12N | R15W | 14 | M | 5 | 6 | SR | P | Y | 2 | H | P | S | | |
| 65 | T12N | R15W | 14 | M | 2 | 6 | SR | D | Y | 5 | R | P | S | M | |
| 65 | T12N | R15W | 14 | N | 1 | 6 | SR | P | N | | H/R | P | L | | |
| 65 | T12N | R15W | 14 | N | 2 | 6 | SR | D | Y | 5 | R | P | M | | |
| 65 | T12N | R15W | 15 | C | 1 | 6 | SR | D | Y | 3 | R | C | L | M | |
| 65 | T12N | R15W | 15 | C | 2 | 6 | SR | D | Y | 3 | R | C | L | XL | M |
| 65 | T12N | R15W | 15 | D | 1 | 6 | SR | D | Y | 3 | H | P | L | S | |
| 65 | T12N | R15W | 15 | D | 2 | 6 | SR | D | Y | 2 | H/R | D/P | L | L | |
| 65 | T12N | R15W | 15 | D | 3 | 6 | SR | D | Y | 2 | R | P | M | M | |
| 65 | T12N | R15W | 15 | D | 4 | 6 | SR | D | Y | 2 | R | P | M | M | |
| 65 | T12N | R15W | 15 | D | 5 | 6 | SR | D | Y | 1 | R | C | M | S | |
| 65 | T12N | R15W | 15 | J | 1 | 6 | SR | D | N | | R | C | M | | |
| 65 | T12N | R15W | 15 | R | 1 | 6 | SR | D | Y | 5 | R | C | L | L | L |
| 65 | T12N | R15W | 15 | R | 2 | 6 | SR | D | Y | 5 | H | P | S | S | S |
| 65 | T12N | R15W | 15 | R | 3 | 6 | SR | D | Y | 5 | H | P | M | M | M |
| 65 | T12N | R15W | 15 | R | 4 | 6 | SR | D | Y | 5 | H | P | M | M | M |
| 65 | T12N | R15W | 16 | D | 5 | 6 | SR | P | Y | 2 | H/IG | P | M | L | |
| 65 | T12N | R15W | 16 | K | 1 | 6 | SR | P | Y | 3 | H | C | M | | |
| 65 | T12N | R15W | 22 | B | 1 | 6 | SR | D | Y | 5 | R | C | S | | |
| 65 | T12N | R15W | 22 | B | 2 | 6 | SR | D | Y | 5 | R | C | M | | M |
| 65 | T12N | R15W | 22 | F | 1 | 6 | SR | P | Y | 2 | R | C | M | | |
| 65 | T12N | R15W | 22 | H | 1 | 6 | SR | D | Y | 5 | R | P | L | | |
| 65 | T12N | R15W | 23 | E | 1 | 6 | SR | D | Y | 5 | R | C | L | | XL |
| 78 | T12N | R15W | 14 | M | 3 | 6 | DF | D | Y | 5 | R | D | | M | |
| 78 | T12N | R15W | 14 | G | 1 | 6 | LPD | P | Y | 5 | R | C | | L | L |
| 78 | T12N | R15W | 16 | F | 1 | 6 | LPD | P | Y | 1 | H | C | | M | M |
| 78 | T12N | R15W | 10 | P | 1 | 6 | SR | D | Y | 2 | R | C | | L | L |
| 78 | T12N | R15W | 15 | G | 1 | 6 | SR | D | Y | 3 | H | P | | L | |
| 78 | T12N | R15W | 22 | A | 1 | 6 | SR | D | Y | 5 | H | P | | L | |
| 78 | T12N | R15W | 14 | F | 1 | 6 | SR | D | Y | 5 | R | D | | M | |
| 78 | T12N | R15W | 14 | M | 1 | 6 | SR | D | Y | 5 | R | D | | M | |
| 78 | T12N | R15W | 14 | M | 1 | 6 | SR | D | Y | 5 | R | D | | M | |
| 78 | T12N | R15W | 15 | M | 1 | 6 | SR | D | Y | 3 | H | P | | M | M |
| 78 | T12N | R15W | 16 | D | 2 | 6 | SR | D | Y | 1 | H | P | | M | |
| 78 | T12N | R15W | 16 | D | 6 | 6 | SR | D | Y | 1 | H | P | | M | M |
| 78 | T12N | R15W | 16 | L | 2 | 6 | SR | D | Y | 2 | H | P | | M | |
| 78 | T12N | R15W | 15 | G | 2 | 6 | SR | D | Y | 3 | R | P | | S | |
| 78 | T12N | R15W | 16 | D | 1 | 6 | SR | P | Y | 1 | H | P | | S | |
| 78 | T12N | R15W | 16 | D | 3 | 6 | SR | D | Y | 1 | H | P | | S | |
| 78 | T12N | R15W | 16 | D | 4 | 6 | SR | D | Y | 1 | H | P | | S | |
| 78 | T12N | R15W | 16 | D | 7 | 6 | SR | D | Y | 1 | H | P | | S | |
| 78 | T12N | R15W | 23 | P | 1 | 6 | SR | P | N | | R | C | | S | |
| 96 | T12N | R15W | 15 | D | 6 | 6 | SR | P | Y | 1 | N | D | | | L |
| 96 | T12N | R15W | 16 | F | 2 | 6 | SR | D | Y | 1 | H | P | | | L |
| 96 | T12N | R15W | 23 | D | 1 | 6 | SR | P | N | | R | C | | | L |
| 96 | T12N | R15W | 15 | E | 1 | 6 | SR | P | N | | V | P | | | M |
| 96 | T12N | R15W | 15 | 0 | 3 | 6 | SR | D | Y | 2 | N | C | | | M |
| 96 | T12N | R15W | 22 | R | 1 | 6 | SR | P | Y | 5 | N | P | | | S |
| 96 | T12N | R15W | 23 | F | 1 | 6 | SR | P | Y | 2 | R | C | | | S |
| 96 | T12N | R15W | 9 | R | 1 | 6 | SR | P | N | | N | C | | | XL |

# GARCIA RIVER WATERSHED ASSESSMENT
# APPENDIX A - MASS WASTING INVENTORY DATA
# Calwater Watershed 8 - Graphite Creek South

| Photo Year | Township | Range | Section | Init Loc | Feature # | Sub Water | Process | Confidence | Delivery | Stream Or | Land use | Slope Sha | 1965 Size | 1978 Size | 1996 Size |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 65 | T12N | R15W | 27 | 0 | 1 | 8 | DF | D | Y | 5 | R | D | M | M | M |
| 65 | T12N | R15W | 28 | M | 1 | 8 | DF | D | Y | 5 | R | P | S | | |
| 65 | T12N | R15W | 28 | N | 1 | 8 | DF | D | N | | R | P | M | M | |
| 65 | T12N | R15W | 29 | G | 1 | 8 | DF | D | Y | 2 | R | C | L | | |
| 65 | T12N | R15W | 34 | K | 1 | 8 | DF | P | Y | 5 | R | C | XL | | |
| 65 | T12N | R15W | 34 | L | 2 | 8 | DF | Q | Y | 2 | R | C | M | | |
| 65 | T1ZN | R15W | 21 | L | 1 | 8 | SR | D | Y | 2 | R | C | L | | |
| 65 | T12N | R15W | 21 | J | 1 | 8 | SR | D | Y | 2 | R | C | S | | |
| 65 | T12N | R15W | 27 | A | 1 | 8 | SR | D | Y | 5 | R | C | XL | XL | |
| 65 | T12N | R15W | 27 | A | 2 | 8 | SR | D | Y | 5 | R | C | L | M | |
| 65 | T12N | R15W | 27 | B | 1 | 8 | SR | D | Y | 5 | R | C | M | M | |
| 65 | T12N | R15W | 27 | B | 2 | 8 | SR | D | Y | 5 | R | C | M | S | |
| 65 | T12N | R15W | 27 | B | 3 | 8 | SR | D | Y | 5 | R | C | M | M | |
| 65 | T12N | R15W | 27 | B | 4 | 8 | SR | D | Y | 5 | R | C | S | | |
| 65 | T12N | R15W | 27 | N | 6 | 8 | SR | D | Y | 5 | R | C/P | L | L | |
| 65 | T12N | R15W | 27 | P | 5 | 8 | SR | D | Y | 2 | R | P | L | L | |
| 65 | T12N | R15W | 27 | R | 1 | 8 | SR | D | Y | 1 | H | P | L | M | |
| 65 | T12N | R15W | 28 | A | 1 | 8 | SR | P | Y | 2 | R | D | S | | |
| 65 | T12N | R15W | 28 | G | 1 | 8 | SR | D | Y | 2 | R | C | L | | |
| 65 | T12N | R15W | 28 | J | 1 | 8 | SR | D | Y | 5 | H | P | M | | |
| 65 | T12N | R15W | 34 | c | 4 | 8 | SR | D | Y | 2 | R | P | M | S | |
| 65 | T12N | R15W | 34 | K | 3 | 8 | SR | D | Y | 2 | R | D | M | | |
| 65 | T12N | R15W | 28 | J | 2 | 8 | SR | D | Y | 5 | R | P | S | | |
| 78 | T12N | R15W | 27 | K | 1 | 8 | DF | D | N | | R | C | | L | M |
| 78 | T12N | R15W | 27 | Q | 2 | 8 | DF | D | Y | 1 | R | P | | L | |
| 78 | T12N | R15W | 28 | D | 1 | 8 | DF | P | Y | 2 | H | P | | XL | |
| 78 | T12N | R15W | 28 | D | 2 | 8 | DF | D | Y | 2 | H | P | | XL | |
| 78 | T12N | R15W | 34 | F | 8 | 8 | DF | D | Y | 2 | R | C | | L | M |
| 78 | T12N | R15W | 34 | K | 10 | 8 | DF | P | Y | 2 | R | C | | L | |
| 78 | T12N | R15W | 28 | H | 2 | 8 | SR | D | N | | R | P | | L | |
| 78 | T12N | R15W | 27 | B | 2 | 8 | SR | D | Y | 5 | R | P | | M | M |
| 78 | T12N | R15W | 27 | G | 2 | 8 | SR | D | Y | 5 | H | D | | M | |
| 78 | T12N | R15W | 27 | P | 7 | 8 | SR | D | Y | 2 | H | P | | M | L |
| 78 | T12N | R15W | 27 | Q | 1 | 8 | SR | D | Y | 2 | R | P | | M | |
| 78 | T12N | R15W | 27 | R | 1 | 8 | SR | D | Y | 1 | R | P | | M | |
| 78 | T12N | R15W | 28 | Q | 1 | 8 | SR | D | N | | R | C | | M | |
| 78 | T12N | R15W | 34 | 0 | 1 | 8 | SR | D | N | | R | C | | M | |
| 78 | T12N | R15W | 28 | H | 1 | 8 | SR | D | Y | 5 | H | C | | S | |
| 78 | T12N | R15W | 33 | C | 2 | 8 | SR | D | N | | H | P | | S | |
| 78 | T12N | R15W | 34 | K | 9 | 8 | SR | P | Y | 2 | R | C | | S | |
| 96 | T12N | R15W | 28 | H | 3 | 8 | SR | D | Y | 5 | R | D | | | L |
| 96 | T12N | R15W | 21 | R | 1 | 8 | SR | P | N | | R | C | | | M |
| 96 | T12N | R15W | 28 | D | 3 | 8 | SR | P | Y | 2 | R | C | | | M |
| 96 | T12N | R15W | 28 | L | 1 | 8 | SR | D | Y | 5 | R | C | | | M |
| 96 | T12N | R15W | 21 | 7 | 2 | 8 | SR | P | N | | R | C | | | S |
| 96 | T12N | R15W | 21 | N | 1 | 8 | SR | D | N | | R | C | | | S |
| 96 | T12N | R15W | 27 | B | 3 | 8 | SR | D | Y | 5 | N | C | | | S |
| 96 | T12N | R15W | 28 | A | 2 | 8 | SR | D | N | | H | C | | | S |
| 96 | T12N | R15W | 28 | K | 1 | 8 | SR | Q | Y | 5 | N | P | | | XL |
| 96 | T12N | R15W | 34 | K | 11 | 8 | SR | D | N | | R | P | | | XL |

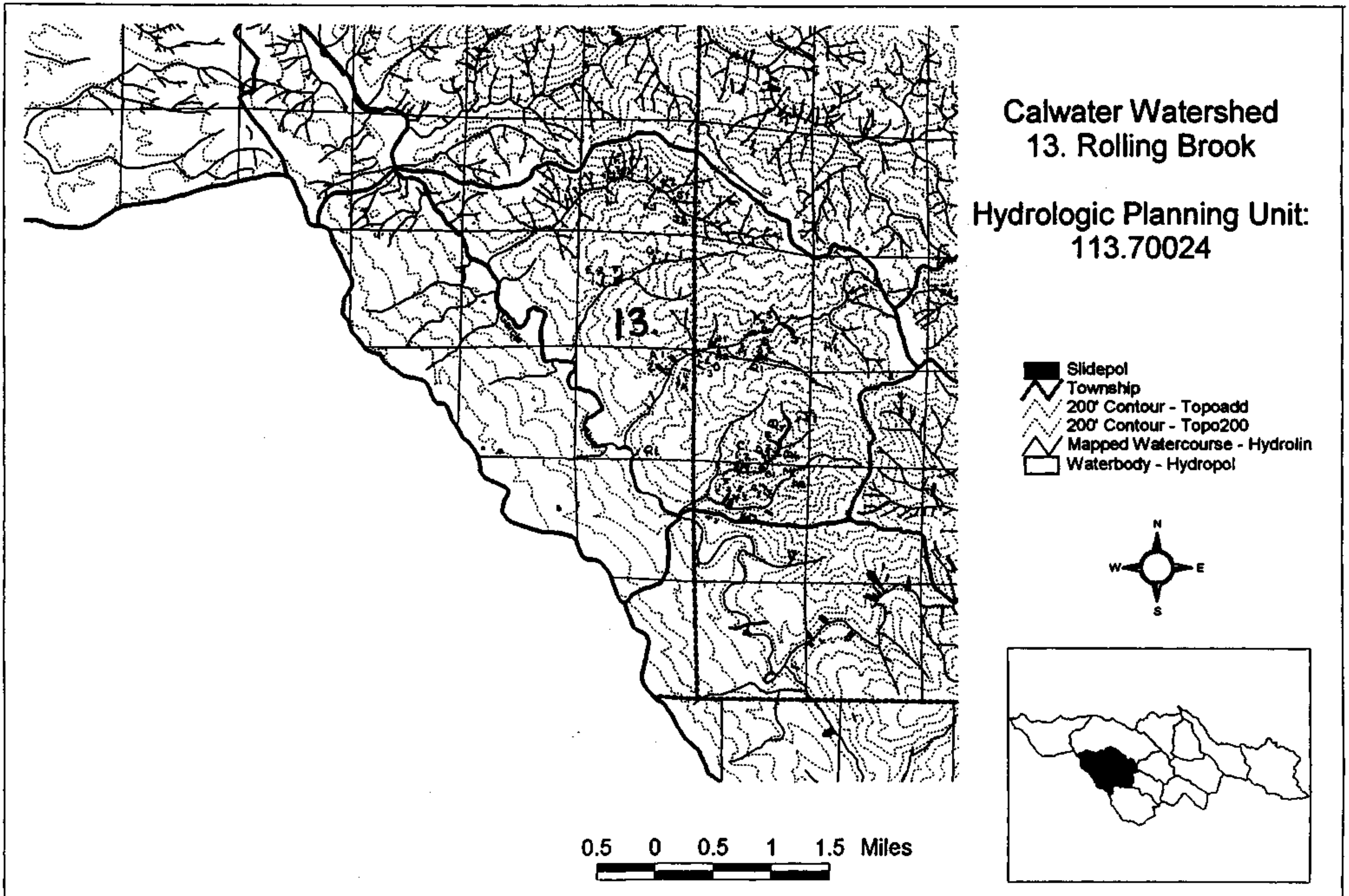
# Garcia Watershed - Basins



# GARCIA RIVER WATERSHED ASSESSMENT
# APPENDIX A - MASS WASTING INVENTORY DATA
# Calwater Watershed 10 - South Fork Garcia Creek

| Photo Yea | Township | Range | Section | Init Loc | Feature # | Sub Water | Process | Confidence | Delivery | Stream Or | Land use | Slope Sha | 1965 Size | 1978 Size | 1996 Size |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 65 | T11N | R15W | 3 | E | 1 | 10 | DF | D | Y | 3 | H | C | XL | | |
| 65 | T12N | R15W | 32 | K | 1 | 10 | DF | D | Y | 5 | R | C | M | | |
| 65 | T12N | R15W | 33 | D | 1 | 10 | DF | P | Y | 5 | R | C | M | | |
| 65 | T12N | R15W | 34 | M | 1 | 10 | DF | D | Y | 2 | R | C | M | | |
| 65 | T12N | R15W | 31 | Q | 1 | 10 | LPD | D | Y | 5 | H | P | XL | | |
| 65 | T11N | R15W | 3 | C | 1 | 10 | SR | P | N | | R | P | S | S | |
| 65 | T11N | R15W | 4 | B | 1 | 10 | SR | D | Y | 3 | R/H | P | M | | |
| 65 | T11N | R15W | 3 | J | 1 | 10 | SR | D | Y | 3 | R/IG | P | M | | |
| 65 | TUN | R15W | 5 | A | 1 | 10 | SR | D | Y | 3 | H/R | P | M | | |
| 65 | T12N | R15W | 29 | Q | 1 | 10 | SR | D | Y | 5 | R | C | L | | |
| 65 | T12N | R15W | 31 | F | 1 | 10 | SR | D | Y | 5 | R | C | M | | |
| 65 | T12N | R15W | 31 | J | 1 | 10 | SR | D | N | 5 | R | D | S | | |
| 65 | T12N | R15W | 32 | A | 1 | 10 | SR | D | N | | H | C | M | M | |
| 65 | T12N | R15W | 32 | B | 1 | 10 | SR | D | Y | 5 | H | C | S | | |
| 65 | T12N | R15W | 32 | B | 2 | 10 | SR | D | Y | 5 | R | C | M | S | |
| 65 | T12N | R15W | 32 | B | 3 | 10 | SR | D | Y | 5 | H | C | S | S | |
| 65 | T12N | R15W | 32 | B | 4 | 10 | SR | D | Y | 5 | H | C | S | | |
| 65 | T12N | R15W | 32 | B | 5 | 10 | SR | D | Y | 5 | H | C | S | S | |
| 65 | T12N | R15W | 32 | B | 1 | 10 | SR | Q | Y | 5 | H? | P | M | | |
| 65 | T12N | R15W | 32 | B | 2 | 10 | SR | D | Y | 5 | H | C | M | | |
| 65 | T12N | R15W | 32 | F | 1 | 10 | SR | D | Y | 5 | R | C | M | L | |
| 65 | T12N | R15W | 32 | F | 2 | 10 | SR | D | Y | 5 | R? | C | L | | |
| 65 | T12N | R15W | 32 | N | 1 | 10 | SR | D | Y | 5 | R | P | L | | |
| 65 | T12N | R15W | 32 | N | 2 | 10 | SR | D | Y | 5 | R | P | M | | |
| 65 | T12N | R15W | 32 | N | 3 | 10 | SR | D | N | | R | D | M | | |
| 65 | T12N | R15W | 33 | C | 1 | 10 | SR | D | Y | 5 | H | C | S | | |
| 78 | T12N | R15W | 31 | F | 1 | 10 | LPD | D | Y | 5 | R | C | | XL | |
| 78 | T11N | R15W | 3 | D | 2 | 10 | SR | D | N | | H | P | | M | |
| 78 | T11N | R15W | 4 | B | 1 | 10 | SR | D | Y | 3 | R | C | | M | |
| 78 | T12N | R15W | 30 | J | 2 | 10 | SR | d | Y | 1 | R | C | | M | |
| 78 | T12N | R15W | 31 | G | 1 | 10 | SR | P | N | | R | C | | M | |
| 78 | T12N | R15W | 33 | B | 1 | 10 | SR | D | Y | 2 | H | P | | M | M |
| 78 | T11N | R15W | 3 | D | 1 | 10 | SR | P | N | | R | P | | S | |
| 78 | T11N | R15W | 3 | G | 1 | 10 | SR | D | Y | 2 | H | P | | S | |
| 78 | T12N | R15W | 32 | K | 1 | 10 | SR | P | N | | R | P | | S | |
| 78 | T11N | R15W | 4 | B | 2 | 10 | SR | D | Y | 3 | R | C | | S | |
| 78 | T12N | R15W | 30 | J | 1 | 10 | SR | d | Y | 1 | R | C | | S | |
| 96 | T12N | R15W | 30 | N | 1 | 10 | DF | D | Y | 5 | N | C | | | L |
| 96 | T12N | R15W | 34 | P | 1 | 10 | SR | P | N | | R | P | | | L |
| 96 | T11N | R15W | 3 | F | 1 | 10 | SR | D | Y | 1 | R | P | | | M |
| 96 | T11N | R15W | 3 | G | 2 | 10 | SR | D | Y | 1 | N | D | | | M |
| 96 | T12N | R15W | 32 | G | 1 | 10 | SR | D | Y | 5 | N | P | | | M |
| 96 | T11N | R15W | 4 | D | 1 | 10 | SR | D | Y | 2 | R | P | | | S |
| 96 | T12N | R15W | 29 | Q | 2 | 10 | SR | D | Y | 1 | N | P | | | S |
| 96 | T12N | R15W | 29 | Q | 3 | 10 | SR | D | Y | 2 | H | P | | | S |

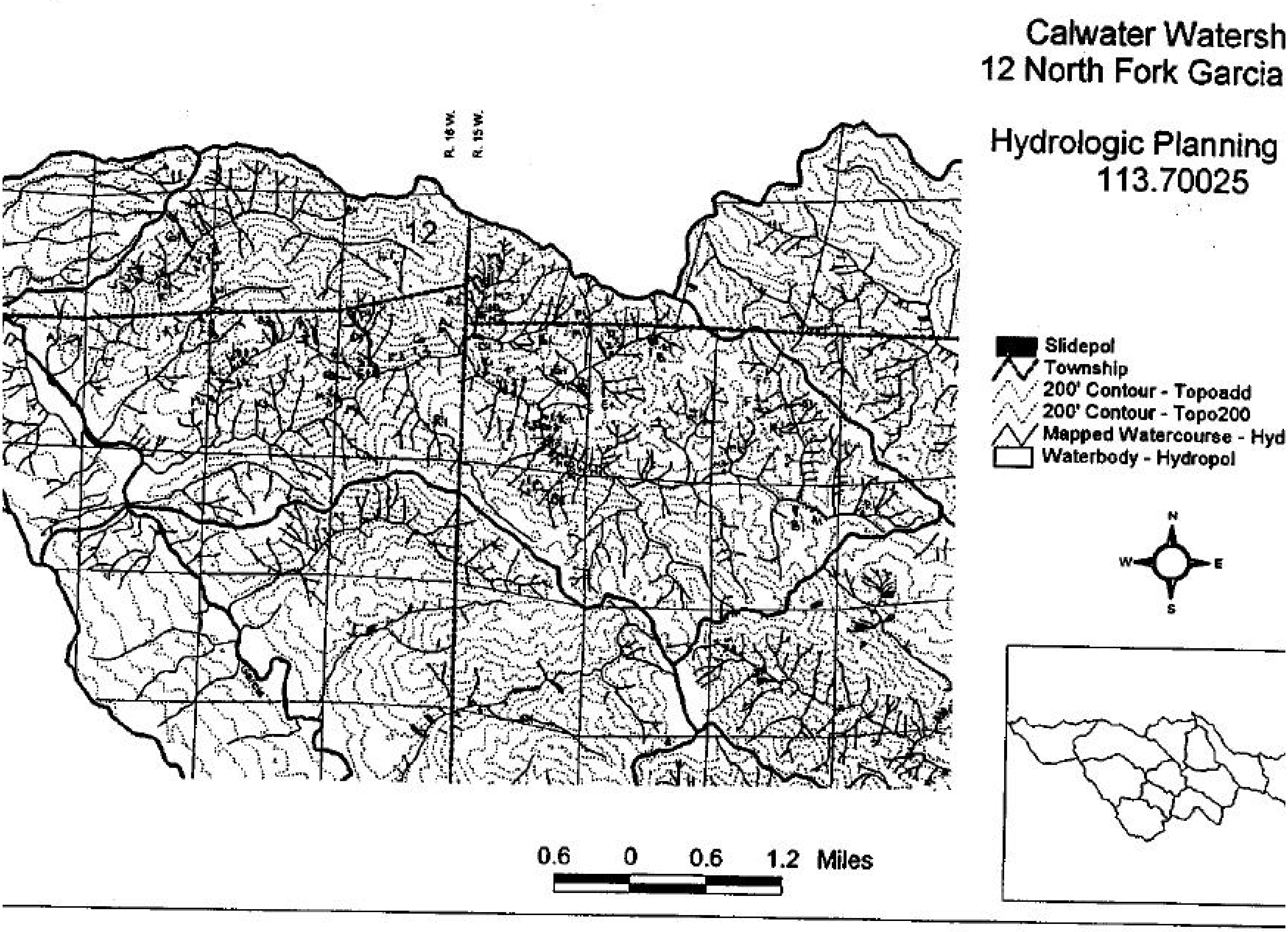
# Garcia Watershed - Basins



# GARCIA RIVER WATERSHED ASSESSMENT
# APPENDIX A - MASS WASTING INVENTORY DATA
## Calwater Watershed 13 - Rolling Brook

| Photo Year | Township | Range | Section | Init Loc | Feature # | Sub Water | Process | Confidence | Delivery | Stream Or | Land use | Slope Sha | 1965 Size | 1978 Size | 1996 Size |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 65 | T12N | R15W | 19 | Q | 1 | 13 | DF | P | Y | 2 | R | C | XL | | |
| 65 | T12N | R15W | 18 | J | 1 | 13 | SR | D | Y | 3 | R | C | M | M | |
| 65 | T12N | R15W | 19 | Q | 2 | 13 | SR | D | Y | 2 | R | D | M | | |
| 65 | T12N | R15W | 19 | Q | 3 | 13 | SR | D | Y | 2 | R | D | S | | |
| 65 | T12N | R15W | 19 | Q | 4 | 13 | SR | D | Y | 2 | R | D | M | | |
| 65 | T12N | R16W | 24 | A | 4 | 13 | SR | D | N | | R | D | S | | |
| 65 | T12N | R15W | 30 | A | 1 | 13 | SR | D | Y | 2 | R | C | S | | |
| 65 | T12N | R15W | 30 | A | 2 | 13 | SR | D | Y | 2 | R | D | M | | |
| 65 | T12N | R15W | 30 | B | 1 | 13 | SR | D | Y | 2 | R | D | M | | |
| 65 | T12N | R15W | 30 | C | 1 | 13 | SR | D | Y | 2 | R | P | L | XL | |
| 78 | T12N | R16W | 12 | F | 3 | 13 | DF | D | Y | 3 | R | C | | L | |
| 78 | T12N | R15W | 18 | K | 1 | 13 | SR | D | Y | 3 | N | C | | L | L |
| 78 | T12N | R15W | 18 | Q | 1 | 13 | SR | D | Y | 2 | R | P | | L | |
| 78 | T12N | R15W | 30 | C | 2 | 13 | SR | D | Y | 2 | R | P | | L | M |
| 78 | T12N | R15W | 30 | F | 3 | 13 | SR | D | Y | 3 | R | P | | L | S |
| 78 | T12N | R15W | 30 | K | 1 | 13 | SR | D | N | | R | P | | L | S |
| 78 | T12N | R16W | 12 | K | 1 | 13 | SR | D | Y | 2 | R | P | | L | |
| 78 | T12N | R16W | 12 | L | 1 | 13 | SR | D | Y | 2 | R | D | | L | |
| 78 | T12N | R16W | 13 | F | 1 | 13 | SR | D | Y | 2 | R | C | | L | M |
| 78 | T12N | R16W | 24 | A | 1 | 13 | SR | D | Y | 3 | N | C | | L | M |
| 78 | T12N | R15W | 18 | K | 3 | 13 | SR | D | Y | 3 | N | C | | M | |
| 78 | T12N | R15W | 18 | K | 2 | 13 | SR | D | Y | 4 | N | C | | M | M |
| 78 | T12N | R15W | 18 | P | 1 | 13 | SR | D | Y | 3 | R | P | | M | |
| 78 | T12N | R15W | 19 | Q | 5 | 13 | SR | D | Y | 2 | H | C | | M | |
| 78 | T12N | R15W | 19 | Q | 6 | 13 | SR | D | Y | 2 | R | C | | M | |
| 78 | T12N | R15W | 30 | F | 1 | 13 | SR | D | N | | R | D | | M | |
| 78 | T12N | R15W | 30 | F | 2 | 13 | SR | D | Y | 3 | R | P | | M | L |
| 78 | T12N | R16W | 12 | F | 1 | 13 | SR | D | Y | 3 | N | D | | M | M |
| 78 | T12N | R16W | 12 | F | 2 | 13 | SR | D | Y | 3 | H | P | | M | XL |
| 78 | T12N | R16W | 13 | E | 1 | 13 | SR | P | N | | R | P | | M | |
| 78 | T12N | R16W | 13 | E | 2 | 13 | SR | D | Y | 2 | N | P | | S | |
| 78 | T12N | R15W | 18 | N | 1 | 13 | SR | P | Y | 3 | N | P | | S | |
| 78 | T12N | R15W | 18 | N | 2 | 13 | SR | D | Y | 3 | N | P | | S | |
| 78 | T12N | R15W | 18 | Q | 2 | 13 | SR | D | Y | 2 | R | P | | S | |
| 78 | T12N | R15W | 19 | D | 1 | 13 | SR | D | Y | 3 | R | P | | S | |
| 78 | T12N | R15W | 19 | D | 2 | 13 | SR | D | Y | 3 | R | P | | S | |
| 78 | T12N | R15W | 19 | J | 1 | 13 | SR | D | N | | R | C | | S | |
| 78 | T12N | R16W | 24 | A | 3 | 13 | SR | D | Y | 3 | R | C | | S | |
| 78 | T12N | R16W | 24 | A | 2 | 13 | SR | D | Y | 3 | N | C | | XL | |
| 96 | T12N | R15W | 18 | Q | 3 | 13 | LPD | P | Y | 2 | H | P | | | XL |
| 96 | T12N | R15W | 19 | D | 3 | 13 | SR | D | N | | R | C | | | S |
| 96 | T12N | R15W | 17 | C | 1 | 13 | SR | P | N | | R | C | | | M |
| 96 | T12N | R15W | 17 | M | 1 | 13 | SR | P | N | | N | C | | | M |
| 96 | T12M | R15W | 30 | F | 4 | 13 | SR | D | N | | R | C | | | M |
| 96 | T12N | R15W | 30 | G | 1 | 13 | SR | D | Y | 2 | R | C | | | M |
| 96 | T12N | R15W | 30 | G | 2 | 13 | SR | D | Y | 2 | N | P | | | M |
| 96 | T12N | R16W | 12 | F | 4 | 13 | SR | D | Y | 3 | H | C | | | M |
| 96 | T12N | R16W | 13 | G | 1 | 13 | SR | D | Y | 2 | N | C | | | M |
| 96 | T12N | R16W | 12 | J | 1 | 13 | SR | D | Y | 3 | N | C | | | S |
| 96 | T12N | R16W | 12 | J | 2 | 13 | SR | P | Y | 2 | N | D | | | S |
| 96 | T12N | R16W | 12 | K | 2 | 13 | SR | D | Y | 3 | H | D | | | S |
| 96 | T12N | R16W | 24 | 0 | 1 | 13 | SR | P | N | | R | P | | | S |

# Garcia Watershed - Basins



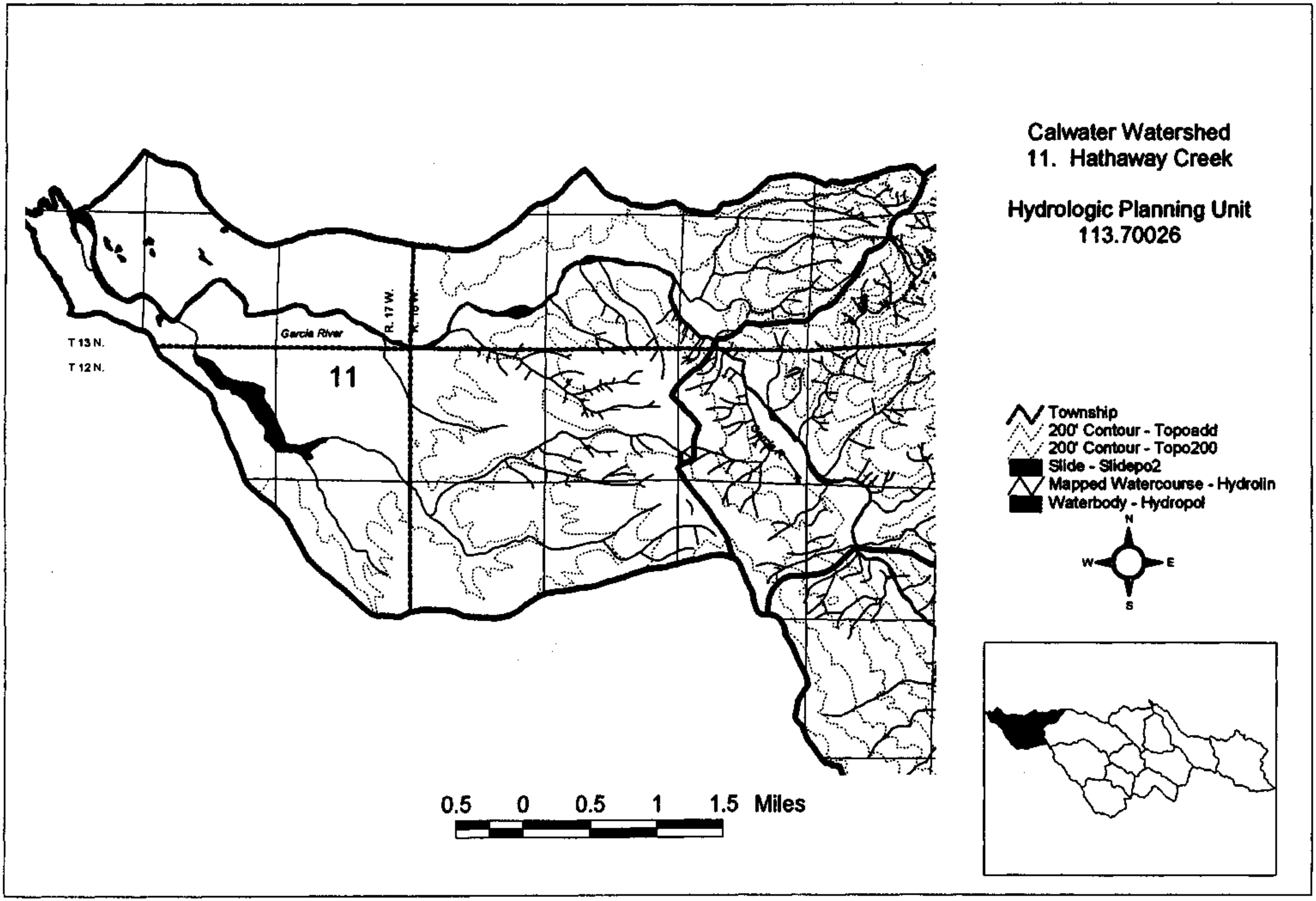
# GARCIA RIVER WATERSHED ASSESSMENT
# APPENDIX A - MASS WASTING INVENTORY DATA
# Calwater Watershed 12 - North Fork Garcia River

| Photo Year | Township | Range | Section | Init Loc | Feature # | Sub Water | Process | Confidence | Delivery | Stream Or | Land use | Slope Sha | 1965 Size | 1978 Size | 996 Size |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 65 | T12N | R15W | 6 | R | 2 | 12 | DF | D | Y | 4 | H | P | L | | S |
| 65 | T12N | R15W | 4 | F | 1 | 12 | SR | D | Y | 2 | H | P | M | | |
| 65 | T12N | R15W | 4 | F | 2 | 12 | SR | D | Y | 1 | H | P | M | | |
| 65 | T12N | R15W | 4 | K | 1 | 12 | SR | D | Y | 2 | R | P | M | | |
| 65 | T12N | R15W | 4 | K | 2 | 12 | SR | D | Y | 2 | R | P | M | | |
| 65 | T12N | R15W | 4 | N | 1 | 12 | SR | D | Y | 2 | H | C | L | | |
| 65 | T12N | R15W | 5 | B | 1 | 12 | SR | D | Y | 2 | R | C | XL | XL | |
| 65 | T12N | R15W | 6 | Q | 1 | 12 | SR | D | Y | 4 | H/R/IG | D | S | S | |
| 65 | T12N | R15W | 6 | Q | 2 | 12 | SR | P | Y | 4 | R/IG | C | M | | |
| 65 | T12N | R15W | 6 | R | 1 | 12 | SR | D | Y | 4 | R/IG | P | M | | |
| 65 | T12N | R15W | 9 | A | 1 | 12 | SR | D | Y | 3 | H | P/C | M | | |
| 65 | T12N | R15W | 10 | D | 1 | 12 | SR | D | Y | 2 | H | P/C | L | | |
| 78 | T12N | R15W | 5 | D | 1 | 12 | DF | P | Y | 1 | R | C | | S | M |
| 78 | T12N | R15W | 5 | E | 1 | 12 | DF | P | Y | 2 | N | C | | M | |
| 78 | T12N | R15W | 6 | L | 2 | 12 | DF | D | Y | 4 | R | C | | L | |
| 78 | T12N | R16W | 2 | M | 1 | 12 | DF | D | Y | 2 | N | P | | L | |
| 78 | T12N | R16W | 1 | F | 2 | 12 | LPD | D | Y | 4 | N | P | | M | L |
| 78 | T12N | R15W | 6 | F | 2 | 12 | SR | D | Y | 4 | H | P | | S | S |
| 78 | T12N | R15W | 6 | F | 3 | 12 | SR | D | Y | 4 | H | C | | L | |
| 78 | T12N | R15W | 6 | F | 4 | 12 | SR | D | Y | 4 | H | C | | L | S |
| 78 | T12N | R15W | 6 | H | 1 | 12 | SR | D | Y | 2 | R | C | | L | |
| 78 | T12N | R15W | 6 | K | 1 | 12 | SR | D | Y | 4 | R | C | | L | M |
| 78 | T12N | R15W | 6 | K | 2 | 12 | SR | D | Y | 4 | R | P | | L | L |
| 78 | T12N | R16W | 1 | E | 1 | 12 | SR | D | Y | 2 | R | C | | L | |
| 78 | T12N | R16W | 1 | F | 1 | 12 | SR | D | Y | 4 | N | P | | L | |
| 78 | T12N | R16W | 2 | L | 2 | 12 | SR | D | Y | 2 | R | D | | L | |
| 78 | T12N | R16W | 2 | L | 3 | 12 | SR | D | Y | 2 | H | D | | L | L |
| 78 | T12N | R16W | 3 | A | 2 | 12 | SR | D | Y | 1 | R | P | | L | |
| 78 | T12N | R16W | 4 | A | 1 | 12 | SR | D | N | | N | P | | L | |
| 78 | T12N | R16W | 4 | A | 2 | 12 | SR | D | N | | N | P | | L | |
| 78 | T13N | R16 | 31 | N | 2 | 12 | SR | D | Y | 2 | H | D | | L | |
| 78 | T13N | R16W | 34 | J | 1 | 12 | SR | D | N | | R | P | | L | |
| 78 | T13N | R16W | 34 | J | 2 | 12 | SR | D | N | | R | D | | L | |
| 78 | T13N | R16W | 34 | J | 4 | 12 | SR | D | N | | H | P | | L | |
| 78 | T13N | R16W | 34 | L | 2 | 12 | SR | D | Y | 4 | H | P | | L | L |
| 78 | T12N | R15W | 4 | G | 1 | 12 | SR | P | Y | 2 | R | C | | M | |
| 78 | T12N | R15W | 5 | D | 3 | 12 | SR | D | Y | 2 | R | P | | M | |
| 78 | T12N | R15W | 5 | J | 1 | 12 | SR | D | Y | 2 | H | C | | M | |
| 78 | T12N | R15W | 6 | A | 1 | 12 | SR | D | Y | 2 | R | P | | M | |
| 78 | T12N | R15W | 6 | B | 1 | 12 | SR | D | N | | R | P | | M | |
| 78 | T12N | R15W | 6 | D | 1 | 12 | SR | D | Y | 2 | N | P | | M | L |
| 78 | T12N | R15W | 6 | E | 1 | 12 | SR | D | Y | 4 | H | P | | M | |
| 78 | T12N | R15W | 6 | F | 1 | 12 | SR | D | Y | 4 | H | P | | M | M |
| 78 | T12N | R15W | 6 | L | 1 | 12 | SR | P | N | 4 | R | D | | M | |
| 78 | T12N | R15W | 6 | R | 3 | 12 | SR | P | Y | 4 | H | C | | M | S |
| 78 | T12N | R15W | 6 | R | 4 | 12 | SR | P | Y | 4 | H | C | | M | |
| 78 | T12N | R15W | 7 | C | 1 | 12 | SR | D | Y | 1 | R | C | | M | |
| 78 | T12N | R16W | 1 | A | 1 | 12 | SR | D | Y | 3 | N | P | | M | |
| 78 | T12N | R16W | 2 | K | 1 | 12 | SR | D | Y | 2 | N | C | | M | |
| 78 | T12N | R16W | 3 | A | 1 | 12 | SR | D | Y | 1 | R | P | | M | |
| 78 | T13N | R15W | 31 | M | 2 | 12 | SR | D | Y | 2 | H | C | | M | |
| 78 | T13N | R15W | 32 | P | 1 | 12 | SR | D | Y | 2 | R | P | | M | |
| 78 | T13N | R16W | 34 | K | 1 | 12 | SR | D | Y | 3 | H | P | | M | |
| 78 | T12N | R16W | 3 | A | 3 | 12 | SR | D | N | | R | P | | S | |
| 78 | T13N | R16W | 34 | K | 2 | 12 | SR | D | Y | 3 | H | P | | S | M |
| 78 | T12N | R15W | 4 | F | 3 | 12 | SR | D | N | | H | C | | S | |
| 78 | T12N | R15W | 5 | D | 2 | 12 | SR | D | Y | 2 | H | P | | S | M |
| 78 | T12N | R15W | 6 | E | 2 | 12 | SR | D | Y | 4 | N | P | | S | |
| 78 | T12N | R15W | 7 | C | 2 | 12 | SR | D | N | | R | P | | S | |
| 78 | T12N | R16W | 1 | M | 1 | 12 | SR | D | Y | 4 | R | D | | S | |
| 78 | T13N | R15 | 31 | N | 1 | 12 | SR | D | Y | 2 | N | P | | S | |
| 78 | T13N | R15W | 31 | M | 1 | 12 | SR | P | Y | 2 | R | C | | S | |
| 78 | T13N | R16W | 35 | N | 1 | 12 | SR | D | Y | 1 | H | P | | S | S |
| 78 | T12N | R16W | 2 | L | 1 | 12 | SR | D | Y | 2 | H | D | | XL | |
| 78 | T13N | R16W | 34 | J | 3 | 12 | SR | D | N | | R | D | | XL | |
| 8 | T13N | R16W | 34 | L | 1 | 12 | SR | D | Y | 3 | H | C | | XL | |
| 78 | T13N | R16W | 34 | L | 3 | 12 | SR | D | Y | 5 | H | P | | XL | |

# GARCIA RIVER WATERSHED ASSESSMENT
# APPENDIX A - MASS WASTING INVENTORY DATA
## Calwater Watershed 12 - North Fork Garcia River

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 96 | T12N | R16W | 1 | A | 2 | 12 | DF | D | Y | 4 | N | P | | | L |
| 96 | T12N | R16W | 1 | D | 1 | 12 | DF | D | Y | 4 | R | C | | | L |
| 96 | T13N | R16W | 34 | G | 1 | 12 | DF | D | Y | 2 | R | C | | | |
| 96 | T12N | R15W | 6 | K | 3 | 12 | LPD | P | N | | N | P | | | L |
| 96 | T12N | R15W | 5 | B | 2 | 12 | SR | D | Y | 2 | R | C | | | L |
| 96 | T12N | R15W | 9 | B | 1 | 12 | SR | D | Y | 3 | N | C | | | L |
| 96 | T12N | R16W | 1 | D | 2 | 12 | SR | D | Y | 1 | R | P | | | L |
| 96 | T12N | R16W | 1 | E | 2 | 12 | SR | D | | | R | D | | | L |
| 96 | T12N | R16W | 2 | A | 1 | 12 | SR | D | Y | 1 | R | C | | | L |
| 96 | T12N | R16W | 2 | A | 2 | 12 | SR | D | N | | R | D | | | L |
| 96 | T12N | R16W | 2 | B | 2 | 12 | SR | D | Y | 2 | R | C | | | L |
| 96 | T12N | R16W | 2 | L | 4 | 12 | SR | D | Y | 2 | H | D | | | L |
| 96 | T12N | R15W | 6 | Q | 3 | 12 | SR | D | Y | 1 | R | P | | | M |
| 96 | T12N | R15W | 7 | B | 1 | 12 | SR | D | Y | 2 | N | P | | | M |
| 96 | T12N | R16W | 1 | F | 2 | 12 | SR | D | Y | 2 | H | P | | | M |
| 96 | T12N | R16W | 1 | G | 1 | 12 | SR | D | Y | 4 | N | P | | | M |
| 96 | T12N | R16W | 2 | L | 5 | 12 | SR | D | Y | 2 | H | D | | | M |
| 96 | T13N | R15W | 31 | M | 3 | 12 | SR | Q | Y | 2 | R | D | | | M |
| 96 | T12N | R16W | 1 | M | 3 | 12 | SR | D | Y | 4 | R | C | | | M |
| 96 | T12N | R15W | 4 | N | 2 | 12 | SR | D | Y | 3 | N | C | | | S |
| 96 | T12N | R16W | 1 | G | 2 | 12 | SR | D | Y | 4 | N | P | | | S |
| 96 | T12N | R16W | 1 | M | 2 | 12 | SR | D | Y | 4 | R | C | | | S |
| 96 | T13N | R15W | 31 | M | 4 | 12 | SR | Q | Y | 2 | R | D | | | S |
| 96 | T13N | R16W | 36 | L | 1 | 12 | SR | D | N | | R | D | | | S |
| 96 | T12N | R15W | 5 | N | 1 | 12 | SR | D | Y | 3 | R | P | | | |
| 96 | T13N | R16W | 34 | H | 1 | 12 | SR | D | Y | 2 | R | C | | | |
| 96 | T13N | R16W | 34 | H | 2 | 12 | SR | D | Y | 2 | R | D | | | |

# Garcia Watershed - Basins



# *Appendix B*

# *MATRIX OF RESOURCE CONDITION AND SENSITIVITY*

| Location | | | | | Reported Conditions, cont. | | | | | Synthesis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | watershed | | tributaries | shade, canopy | complexity | fine sediment | habitat | comments | fish | Is the land sensitive to use here? | Are the fish sensitive to land use here? | model results |
| SWRCB no. | CFL name | CDF name | | ave = average beneficial value | "+ = better, ++ = far better, etc | | | | | relative ratings | relative ratings | rel. relief . landslides |
| 1 | 5 | 4 | 1,5,7 | 1,5 | 1,5 | 1,5 | 1,2,5, 6 | 1, 2, 5, 9 | 1,2,5,6 | synthesis | synthesis | synthesis |
| 70010 | pardaloe | pardaloe | mainstem | | | | | | | | | underestimate |
| 70010 | | | mill | | | hi | limited | ok pools | poor, good steelhead, lampreys | yes | yes | |
| 70010 | | | redwood | | ok | | limited | | | | | |
| 70010 | | | monahan | | | | | | | | | |
| 70010 | | | pardaloe | poor | low | hi | poor | poor pools | good | yes | yes | |
| 70011 | 1armour | larmour | mainstem | | | hi | | site of falls blasting | good | | | ok |
| 70011 | | | larmour | poor | | | limited | falls, no other data | | ? | no | |
| 70011 | | | grants' camp | | ok | | limited | small pools | | | | |
| 70011 | | | east end | | | | | | | | | |
| 70012 | blue waterhole e | no name 4 | mainstem | | ok | | | | | | | ok |
| 70012 | | | stansbury | | poor | | limited | debris jam | poor / none | | no | |
| 70012 | | | whitlow | poor, ave+ | poor | hi | | | coho runs into '70s | yes | | |
| 70013 | blue waterhole w | no name 3 | | | | | | | | | | ok |
| 70013 | | | blue waterhole | ave+ | ok | hi | good | boulder cover, low slope | good | yes | yes | |

| Location | | | | | Reported Conditions, cont. | | | | | Synthesis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | watershed | | tributaries | shade, canopy | complexity | fine sediment | habitat | comments | fish | Is the land sensitive to use here? | Are the fish sensitive to land use here? | model results |
| SWRCB no. | CFL name | CDF name | | ave = average beneficial value | "+ = better, ++ = far better, etc | | | | | relative ratings | relative ratings | rel. relief . landslides |
| 1 | 5 | 4 | 1,5,7 | 1,5 | 1,5 | 1,5 | 1,2,5, 6 | 1,2,5,9 | 1,2,5,6 | synthesis | synthesis | synthesis |
| 70014 | inman | inman | | | | | | | | | | underestimate |
| 70014 | | | inman | poor, ave+, ave- | ave- | hi, ave+, deep | limited | embeddedness 40-80%, 5-10 ft of stored sed in alluv. reaches, slow recovery | good, few '95, more '96 | yes | | |
| 70020 | signal | signal | | | | | | | | | | |
| 70020 | | | signal | poor, ave++ | ave++ | ave- | limited | recovery mode, fire in '94 | good, fair | | | |
| 70021 | hot springs ck, graphite ck. n | no name 6 | mainstem | ave-- | poor, ave- | hi, ave+ | | algae, minor downcutting | fair, fewer than expected | | | |
| 70021 | | | graphite | ave+ | | | limited | barrier, steep | none | | | |
| 70021 | | | Caspar | ave+ | | | limited | steep | none | | | |
| 70022 | graphite ck s | no name 8 | mainstem | poor, ave-- | ave- | ave+ | limited | no pools, limited recovery | steelhead likely | | | ok |
| 70022 | | | beebe | poor, ave+ | ok | | limited | | fair | | | |

| | Location | | | | Watershed | | | | | Erosion | | | | | Reported Conditions | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | watershed | | tributaries | land use | mainstem | size | relief | relative relief | landslides | landslides | road erosion | road erosion | annual rainfall | erodibility | erodibility 2 | (high) temp | DO |
| | SWRCB no. | CFL name | CDF name | | | | acres | feet | relief per acre | | 0-100 low, | 100-300 med, | 300+ high | | | | | |
| sources: | 1 | 5 | 4 | 1,5,7 | 4 | 1,4 | 8 | 7 | | 3 | t/mi2/y | 3 | t/mi2/y | 8 | 8 | 6 | 1,2 | 1,2 |
| | 70023 | south fork | south fork | mainstem | timber | lower | 5595 | 2090 | 0.37 | m | 218 | 1 | 45 | 55 | l-h | m-h-x | 75 | |
| | 70023 | | | south fork | | | | | | | | | | | | | 63 | |
| | 70023 | | | fleming | | | | | | | | | | | | | | |
| | 70024 | rolling brook | rolling brook | mainstem | timber | lower | 7999 | 2224 | 0.28 | m | 148 | m | 114 | 55 | m-h | m-h | 63 | |
| | 70024 | | | rolling brook | | | | | | | | | | | | | 65, >64 | |
| | 70024 | | | hutton gulch | | | | | | | | | | | | | 61 | |
| | 70024 | | | mill ck | | | | | | | | | | | | | 61 | |
| | 70024 | | | lee | | | | | | | | | | | | | 59 | |

| Location | | | | | Reported Conditions, cont. | | | | | Synthesis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | watershed | | tributaries | shade, canopy | complexity | fine sediment | habitat | comments | fish | Is the land sensitive to use here? | Are the fish sensitive to land use here? | model results |
| SWRCB no. | CFL name | CDF name | | ave = average beneficial value | "+ = better, ++ = far better, etc | | | | | relative ratings | relative ratings | rel. relief . landslides |
| 1 | 5 | 4 | 1,5,7 | 1,5 | 1,5 | 1,5 | 1,2,5, 6 | 1, 2, 5, 9 | 1,2,5,6 | synthesis | synthesis | synthesis |
| 70023 | south fork | south fork | mainstem | | 1 | hi | | | | | | overestimate |
| 70023 | | | south fork | good | good | low, hi | declined | underground flows, decline in habitat quality, sediment in storage in S Fk, San Andreas Fault | fair | yes | yes | |
| 70023 | | | fleming | good | good | low | limited | | | | | |
| 70024 | rolling brook | rolling brook | mainstem | | | | | | | | | underestimate ? |
| 70024 | | | rolling brook | | fair | | limited | | fair, coho present | yes | yes | |
| 70024 | | | hutton gulch | no openings | poor | hi | | | | yes | | |
| 70024 | | | mill ck | | hi | | | | good | ? | ? | |
| 70024 | | | lee | | | | limited | | fair | | | |

| | Location | | | | Watershed Characteristics | | | | | Erosion | | | | Reported Conditions | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | watershed | | tributaries | land use | mainstem | size | relief | relative relief | landslides | landslides | road erosion | road erosion | annual rainfall | erodibility | erodibility 2 | (high) temp | DO |
| | SWRCB no. | CFL name | CDF name | | | | acres | feet | relief per acre | | 0-100 low, | 100-300 med, | 300+ high | | | | | |
| sources: | 1 | 5 | 4 | 1,5,7 | 4 | 1,4 | 8 | 7 | | 3 | t/mi2/y | 3 | t/mi2/y | 8 | 8 | 6 | 1.2 | 1,2 |
| | 70025 | north fork | north fork | mainstem | timber | lower | 10373 | 2265 | 0.22 | m | 148 | h | 472 | 50 | l-h | m-h | 70 | low? |
| | 70025 | | | olsen ck | | | | | | | | | | | | | good | |
| | 70025 | | | John olsen ck | | | | | | | | | | | | | good | |
| | 70025 | | | alder ck | | | | | | | | | | | | | | |
| | 70025 | | | north fork | | | | | | | | | | | | | good | |
| | 70026 | Hathaway ck. | hathaway ck. | mainstem | agri-timber | estuary | 7847 | 1700 | 0.22 | 1 | 0 | m | 154 | 45 | 1-m | | 72 | low |
| | 70026 | | | bentonite | | | | | | | | | | | | | | |
| | 70026 | | | allen gulch | | | | | | | | | | | | | | |
| | 70026 | | | hathaway | | | | | | | | | | | | | 56 | |

| Location | | | | | Reported Conditions, cont. | | | | | Synthesis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | watershed | | tributaries | shade, canopy | complexity | fine sediment | habitat | comments | fish | Is the land sensitive to use here? | Are the fish sensitive to land use here? | model results |
| SWRCB no. | CFL name | CDF name | | ave = average beneficial value | "+ = better, ++ = far better, etc | | | | | relative ratings | relative ratings | rel. relief . landslides |
| 1 | 5 | 4 | 1,5,7 | 1.5 | 1,5 | 1,5 | 1,2,5, 6 | 1,2,5,9 | 1,2,5,6 | synthesis | synthesis | synthesis |
| 7002 5 | north fork | north fork | mainste m | | | | | | poor | | | underestimate |
| 7002 5 | | | olsen ck | ave++ | low, ave+ | hi, ave- | limited | severely affected by harvest, well along the road to recovery, sediment 20+ ft | none, many | yes | no | |
| 7002 5 | | | john olsen ck | good, ave++ | med, ave+ | hi, ave- | | | many | | | |
| 7002 5 | | | alder ck | ave++ | ave+ | hi, ave- | limited | | good | | | |
| 7002 5 | | | north fork | ave++ | poor, ave+ | hi, ave- | poor | severe reduction, good pop below falls | good | yes | yes | |
| 7002 6 | hathaway ck. | hathaway ck. | mainste m | | low | hi | | | | | | underestimate |
| 7002 6 | | | bentonit e | good | poor | hi | poor | believed used | fair | yes | yes | |
| 7002 6 | | | allen gulch | | | hi | | | fair / none | | | |
| 7002 6 | | | hathawa y | good | | hi | good | once plentiful | poor | yes | yes | |

Key

1. Manglesdorf, A.  1997. Garcia River Watershed Assessment. Limiting Factors. DRAFT. NCRWQCB (sic)
2. Monschke, J. and Caldon, D.  1992. Garcia River Watershed Enhancement Plan. MCRCD.
3. O'Conner, M.  1997. Level 1 Erosion Assessment of the Garcia River Watershed. FSW, MCRC (in this study)
4. NRCS / CDF 1997. Soil Resource Assessment and Soil Survey of Mendocino County. Prepared for this study, with Soil Descriptions from *Eastern 1/2 of County.
5. Coastal Forestlands, Ltd.  1997. Sustained Yield Plan. DRAFT
6. Louisiana Pacific.  1997. Sustained Yield Plan.
7. USGS. 1977, 1991. Topographic maps. 1:24,000.
8. CDF. 1997. Coast Cascade Region GIS Data.

# ***APPENDIX C***

## ***INVENTORY HISTORY IN THE GARCIA RIVER WATERSHED***

| SWRCB no., Subwatershe d | monitoring reach | flow | channel gradient | cross-sections | longitudinal profiles | bankful width | bankful depth |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| **70010 Pardaloe** | **Pardaloe Creek** | Late summer flows measured (WEP). Flow estimated by % area above Eureka Br. at bankful discharge. (LFA) | from topos | MCRCD did x-secs at restoration sites | | | |
| | **Box Canyon Ck.** | | | | | | |
| | **Monahan Ck.** | | | | | | |
| | **Newton Ck.** | | | | | | |
| | **Unnamed** | | | | | | |
| | **Mill Creek** | | from topos | | | | |
| | **North Mill** | | from topos | | | | |
| | **Sled Creek** | | from topos | | | | |
| | **Redwood Creek** | | from topos | | | | |
| | **Cabin Creek** | | from topos | | | | |
| | | | | | | | |
| **70011 Larmour** | **mainstem Garcia from Mill to Larmour Creek** | 1948 F&G est. of flow. Flow estimated by % area above Eureka Br. at bankful discharge. (LFA) | from topos | | | | |
| | **Larmour** | | from topos, GWAG observations | | | | |
| | **Grant's Camp** | F&G 1967 stream survey estimate. | F&G 1967 steam survey description. | | | F&G 1967 stream survey estimate. | |
| | **East End** | | | | | | |

| SWRCB no., Subwatershed | monitoring reach | valley width | confinement | turbidity | substrate composition | sediment |
|---|---|---|---|---|---|---|
| | | | | | | |
| **70010 Pardaloe** | **Pardaloe Creek** | | | | WEP 1992, habitat typing iden. 2 dom. substrate size classes and % exposed sub. F&G 1994 stream survey of 102 meters, estimated. % sub. composition | |
| | **Box Canyon Ck.** | | | | | |
| | **Monahan Ck.** | | | | | |
| | **Newton Ck.** | | | | | |
| | **Unnamed** | | | | | |
| | **Mill Creek** | | | | F&G 1994 stream survey, 126 meter reach. | |
| | **North Mill** | | | | | |
| | **Sled Creek** | | | | | |
| | **Redwood Creek** | | | | 1994 consultant for Mailliard particle size dist. (McNeil) | |
| | **Cabin Creek** | | | | | |
| | | | | | | |
| **70011 Larmour** | **mainstem Garcia from Mill to Larmour Creek** | | from 1952 & 1988 aerial photos | | no data | aerial photos of 1952 showed lots of sediment |
| | **Larmour** | from topos | | | | |
| | **Grant's Camp** | | F&G 1967 stream survey estimate. | | F&G 1967 stream survey. | |
| | **East End** | | | | | |

| SWRCB no., Subwatershed | monitoring reach | embeddedness | pebble counts | woody debris | pools | temperature |
|---|---|---|---|---|---|---|
| | | | | | | |
| **70010 Pardaloe** | **Pardaloe Creek** | WEP 1992 Hab. typing | | | | WEP hab. typing (Flosi & Reynolds) Lower 4.1 miles. F&G Stream Survey, 1994. No known continuous monitoring of temp. MCWA (1997) |
| | **Box Canyon Ck.** | | | | | |
| | **Monahan Ck.** | | | | | |
| | **Newton Ck.** | | | | | |
| | **Unnamed** | | | | | |
| | **Mill Creek** | | | | | F&G 1994 Stream Survey. Mailliard consultant 1994, hobos. MCWA (1997) |
| | **North Mill** | | | | | |
| | **Sled Creek** | | | | | |
| | **Redwood Creek** | | 1994 consultant for Mailliard particle size dist, (McNeil) | | | F&G 1994 Stream Survey. Mailliard consultant 1994, hobos. |
| | **Cabin Creek** | | | | | |
| | | | | | | |
| **70011 Larmour** | **mainstem Garcia from Mill to Larmour Creek** | | | | | 1948 F&G survey from Zeni Ranch to Garcia Falls; CFL hobo in summer 1995, MCWA 1997. |
| | **Larmour** | | | | | GWAG observations of canopy 1997 |
| | **Grant's Camp** | | | | | F&G 1967 stream survey. |
| | **East End** | | | | | |

| SWRCB no., Subwatershed | monitoring reach | dissolved oxygen | fish | redds/spawning substrate | carcasses | habitat types & distributions |
|---|---|---|---|---|---|---|
| | | | | | | |
| **70010 Pardaloe** | **Pardaloe Creek** | | WEP 1992, Direct Underwater Observation Method, (Hankin and Reeves,) and ocular est., river mile (MA Salmon Trollers survey 1995-96. | WEP observations 1992. Salmon Trollers survey, 1995-96. | | WEP 1992, Hab. typing, tower 4.1 miles. F&G Stream Survey, 1994. |
| | **Box Canyon Ck.** | | | | | WEP 1992, Hab. typing in tower reaches |
| | **Monahan Ck.** | | | | | |
| | **Newton Ck.** | | | | | |
| | **Unnamed** | | | | | |
| | **Mill Creek** | | F&G 1994 Stream Survey, electro-shock fish and amphibians. | Salmon Trollers winters 1995-96, 1996-97. | Salmon Trollers winters 1995-96, 1996-97. | F&G 1994 Stream Survey. |
| | **North Mill** | | | | | |
| | **Sled Creek** | | | | | |
| | **Redwood Creek** | | Mailliard consultant 1994, fish and amphibs. | | | |
| | **Cabin Creek** | | | | | |
| | | | | | | |
| **70011 Larmour** | **mainstem Garcia from Mill to Larmour Creek** | | 1948 F&G survey from Zeni Ranch to Garcia Falls; 1993 field notes from F&G.; 1987 F&G population study (elect) .25 miles from East End Ck. | 1993 field notes from F&G.; | | no data for this reach, 1948 F&G stream survey from Zeni Ranch to Garcia Falls est. good spawning areas. One pool measured CFL 1995. |
| | **Larmour** | | | | | |
| | **Grant's Camp** | | F&G 1967 stream survey noted frogs and newts. | | | |
| | **East End** | | | | | |

| SWRCB no., Subwatershed | monitoring reach | canopy | instream cover | invertebrates/ food supply | barriers |
|---|---|---|---|---|---|
| | | ' | | | |
| **70010 Pardaloe** | **Pardaloe Creek** | | WEP 1992, Hab. typing, lower 4.1 miles. F&G Stream Survey, 1994. | | WEP, Hab. typing (Flosi & Reynolds) Lower 4.1 miles. |
| | **Box Canyon Ck.** | | | | |
| | **Monahan Ck.** | | | | |
| | **Newton Ck.** | | | | |
| | **Unnamed** | | | | |
| | **Mill Creek** | | F&G 1994 Stream Survey. | | |
| | **North Mill** | | | | |
| | **Sled Creek** | | | | |
| | **Redwood Creek** | | | | |
| | **Cabin Creek** | | | | |
| | | | | | |
| **70011 Larmour** | **mainstem Garcia from Mill to Larmour Creek** | | CFL 1995 describes cover in hobo pool | | |
| | **Larmour** | GWAG observations of canopy 1997 | | | GWAG observations of 75 foot falls 1997 |
| | **Grant's Camp** | | F&G 1967 stream survey. | F&G 1967 stream survey. | F&G 1967 stream survey. |
| | **East End** | | | | |

| SWRCB no., Subwatershed | monitoring reach | flow | channel gradient | cross-sections | longitudinal profiles | bankful width | bankful depth |
|---|---|---|---|---|---|---|---|
| | | | | ' | | | |
| **70012 Stansbury Creek, Whitlow Creek, Garcia River** | **mainstem Garcia from Larmour to Blue Waterhole** | Flow estimated by % area above Eureka Br. at bankful discharge.(LFA) | from topos | MCRCD 1995 established x-secs to monitor restoration work of New Growth Forestry. | | F&G1946 stream survey observations. | |
| | **Stansbury** | | from topos | | | | |
| | **Whitlow** | | from topos | GWAG notes creek w/wide, flat channel w/ vertical, unprotected banks. | | | |
| | | | | | | | |
| **70013 Blue Waterhole Creek** | **mainstem Garcia** | | (CFL) With clinometer at 100 ft. intervals along sample reaches and averaged. | | | (CFL) bankful channel width at 3 prominent riffles w/ a surveying tape | (CFL) Average of 10 equally spaced depths across bankful channel at 3 riffles w/ stadia rod. |
| | **Blue Waterhole Creek** | GWAG noted good summer flows 1997. Flow estimated by % area above Eureka Br. at bankful discharge.(LFA) F&G 1987 stream survey estimate. | from topos and CDF GIS | MCRCD x-secs to monitor New Growth Forestry restoration sites. | | F&G 1987 stream survey observations and estimates. | |

| SWRCB no., Subwatershed | monitoring reach | valley width | confinement | turbidity | substrate composition | sediment |
|---|---|---|---|---|---|---|
| | | | | | | |
| **70012 Stansbury Creek, Whitlow Creek, Garcia River** | **mainstem Garcia from Larmour to Blue Waterhole** | | 1952 and 1988 aerial photo measurements. | | F&G 1948 stream survey observations. | 1952 aerial photos. |
| | **Stansbury** | | | | GWAG info of rock gorge. | |
| | **Whitlow** | | | | CFL consultant 1996 noted .5 miles of creek w/ heavy impact by recent sediment. (THP MEN).; GWAG noted 1997, high fines. | |
| | | | | | | |
| **70013 Blue Waterhole Creek** | **mainstem Garcia** | Measured out from bankful at 3 riffles (same spot as bankful and pebble cts.). averaged from 3 sites for overall v.w. for reach. | | | | |
| | **Blue Waterhole Creek** | | F&G 1967 stream survey observations and estimates. | | F&G 1967 stream survey observations. NCRWQCB & CDF study measured RASI, D50 and V*. | |

| SWRCB no., Subwatershed | monitoring reach | embeddedness | pebble counts | woody debris | pools | temperature |
|---|---|---|---|---|---|---|
| | | | | | | |
| **70012 Stansbury Creek, Whitlow Creek, Garcia River** | **mainstem Garcia from Larmour to Blue Waterhole** | | | | | FrOG 1995 w/ hobo. |
| | **Stansbury** | | | | | |
| | **Whitlow** | | | | GWAG notes lack of pools 1997. | |
| | | | | | | |
| **70013 Blue Waterhole Creek** | **mainstem Garcia** | | Wolman pebble cts. in 3 potential spawning riffles. 100 particles. Several indices of substrate size calculated and averaged for reach. | (CFL) Inventories within bankful channel for entire reach, as per Bilby and Ward (1989). | 3 pools/reach residual depth, residual length, and residual width. V-(1/12pi)x(l,w,d) | |
| | **Blue Waterhole Creek** | | | | F&G 1967 stream survey observations and estimates NCRWQCB & CDF study measured pools/1000m, max pool depth. | F&G stream survey 1967 Aug. temp. FrOG 19931 station; 1994, 3; 1995, 4 stations. Summer temps. CFL consultant 1995. |

| SWRCB no., Subwatershed | monitoring reach | dissolved oxygen | fish | redds/spawning substrate | carcasses | habitat types & distributions |
|---|---|---|---|---|---|---|
| | | | | | | |
| **70012 Stansbury Creek, Whitlow Creek, Garcia River** | **mainstem Garcia from Larmour to Blue Waterhole** | | 1948 F&G stream survey noted fish. | | | |
| | **Stansbury** | | Steelhead seen in 1995 (GWAG). | GWAG noted no spawning in 1993-94. | | |
| | **Whitlow** | | CFL consultant THP 1996 noted number of Juvenile fish, no redds. | CFL consultant THP 1996 noted number of juvenile fish, no redds. | | No data, CFL consultant notes lack of LWD, sinuosity and good pool/riffle ratio. THP 1996 |
| | | | | | | |
| **70013 Blue Waterhole Creek** | **mainstem Garcia** | | | | | |
| | **Blue Waterhole Creek** | | F&G stream survey 1967 observed fish and amphibs. | | | F&G 1967 stream survey observations and estimates. NCRWQCB & CDF study measured LWD volume/1000m. GWAG noted boulder cover 1997. |

| SWRCB no., Subwatershed | monitoring reach | canopy | instream cover | invertebrates/ food supply | barriers |
|---|---|---|---|---|---|
| | | | | | |
| **70012 Stansbury Creek, Whitlow Creek, Garcia River** | **mainstem Garcia from Larmour to Blue Waterhole** | | | | |
| | **Stansbury** | GWAG notes good canopy from mouth to upper fork. | | | GWAG note of logjam barrier .5 mite up from mouth. Passage opened 1992 by blasting of Garcia Falls. |
| | **Whitlow** | GWAG notes moderate at best, (max 65%), 1997. | CFL THP 1996 states cover is s simplistic, lacks pool forming elements. | | no known barriers (LFA). |
| | | | | | |
| **70013 Blue Waterhole Creek** | **mainstem Garcia** | (CFL) % closure visually est. above bankful at 100 ft. intervals (decid. & everg.), averaged for reach. | | | |
| | **Blue Waterhole Creek** | GWAG noted 1997 poor cover w/ good volunteer revegetation efforts. | | F&G stream survey 1967 observed abundant food. | GWAG noted barriers, rock barriers, falls and landing site blocks. |

| SWRCB no., Subwatershed | monitoring reach | flow | channel gradient | cross-sections | longitudinal profiles | bankful width | bankful depth |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| **70014 Inman Creek** | **Inman Creek** | Flow estimated by % area above Eureka Br. at bankful discharge (LFA). GWAG 1997 estimated summer flows a 1.5 cfs and winter flows at 26-32 cfs. | from topos; (CFL) 3 sites with clinometer at 100 ft. intervals along sample reaches and averaged. | | | (CFL) bankful channel width at 3 prominent riffles w/ a surveying tape | (CFL) Average of 10 equally spaced depths across bankful channel at 3 riffles w/ stadia rod. |
| | **North Fork Inman** | | from topos | | | | |
| | **Pepperwood Creek** | | from topos | | | | |
| | | | | | | | |
| **70020 Signal Creek** | **Signal Creek** | Flow estimated by % area above Eureka Br. at bankful discharge.(LFA) | (CFL) 3 sites with clinometer at 100 ft. intervals along sample reaches and averaged. From topos (LFA). L-P Channel Network map of source/response reaches. | | | (CFL) bankful channel width at 3 prominent riffles w/ a surveying tape | (CFL) Average of 10 equally spaced depths across bankful channel at 3 riffles w/ stadia rod. |

| SWRCB no., Subwatershed | monitoring reach | valley width | confinement | turbidity | substrate composition | sediment |
|---|---|---|---|---|---|---|
| | | | | | | |
| **70014 Inman Creek** | **Inman Creek** | Measured out from bankful at 3 riffles (same as bankful and pebble cts.). averaged from 3 sites for overall v.w. for reach. | GWAG observations. | | 1994 (CFL) Particle size distribution (4 McNeil samples) at 2 stations at pool/riffle crests. 1995 (CFL) McNeil sample at mouth. CFL THP 1996 observations. GWAG notes, 1997. New Growth Forestry reported substrate conditions 1990. | |
| | **North Fork Inman** | | | | | |
| | **Pepperwood Creek** | | | | | |
| | | | | | | |
| **70020 Signal Creek** | **Signal Creek** | Measured out from bankful at 3 riffles (same as bankful and pebble cts.). averaged from 3 sites for overall v.w. for reach. | L-P's Channel sensitivity map; SYP 1997. GWAG notes. Aerial photo interp., (LFA) | | F&G 1987, 98 meter survey estimated substrate comp. F&G 1995 repeated survey, 108 meters. GWAG 1997 observations. | |

| SWRCB no., Subwatershed | monitoring reach | embeddedness | pebble counts | woody debris | pools | temperature |
|---|---|---|---|---|---|---|
| | | | | | | |
| **70014 Inman Creek** | **Inman Creek** | CFL THP 1996 observations and #s. (checked embed.?) | Wolman pebble cts. in 3 potential spawning riffles. 100 particles. Several indices of substrate size calculated and averaged for reach. | CFL Inventories within bankful channel for entire reach, as per Bilby and Ward (1989). Mendocino Watershed Service, inc. observed lack of woody debris 1995. CFL THP 1996 observations of woody debris. GWAG notes that woody debris is low. | 3 pools/reach residual depth, residual length, and residual width. V=(1/12pi)x(l,w,d); CFL THP 1996 observations of pool abundance. | 1994 & 1995 CFL consultant collected summer temps at mouth. |
| | **North Fork Inman** | | | | | |
| | **Pepperwood Creek** | | | | | |
| | | | | | | |
| **70020 Signal Creek** | **Signal Creek** | | Wolman pebble cts. in 3 potential spawning riffles. 100 particles. Several indices of substrate size calculated and averaged for reach. | (CFL) Inventories within bankful channel for entire reach, as per Bilby and Ward (1989). GWAG 1997 woody debris observations. Mendocino Watershed Services installed woody debris before 1995. | 3 pods/reach residual depth, residual length, and residual width. V=(1/12pi)x(l,w,d) | F&G 1987 stream survey estimated temp. F&G 1995 repeated survey. |

| SWRCB no., Subwatershed | monitoring reach | dissolved oxygen | fish | redds/spawning substrate | carcasses | habitat types & distributions |
|---|---|---|---|---|---|---|
| | | | | | | |
| **70014 Inman Creek** | **Inman Creek** | | F&G 1987 fish pop. survey. CFL 1994 consultant conducted fish pop. survey. L-P 1995 conducted fish pop. survey. Salmon Trollers 1995-96 conducted spawning survey. | Salmon Trollers 1995-96 conducted redd survey. | Salmon Trollers 1995-96 conducted carcass survey. | New Growth Forestry for restoration grant reported habitat conditions 1990. GWAG notes that spawning habitat is okay. |
| | **North Fork Inman** | | | | | CFL THP 1996 observations of adequate habitat for salmonids.. |
| | **Pepperwood Creek** | | | | | WEP 1992, Hab. typing in lower reaches. |
| | | | | | | |
| **70020 Signal Creek** | **Signal Creek** | | F&G 1987, 98 meter survey counted fish. F&G 1995 repeated fish count survey, 108 meters. Salmon Trollers Assoc. spawning survey 1995-96. Repeated survey 1996-97. CFL observations 1992. | Salmon Trollers Assoc. spawning survey counted redds 1995-96. Repeated survey 1996-97. CFL observations 1992. GWAG notes. | Salmon Trollers Assoc. spawning survey counted redds 1995-96. Repeated survey 1996-97. | F&G 1987, 98 meter survey estimated nab. types F&G 1995 repeated survey, 108 meters. GWAG 1997 spawning nab. observations. |

| SWRCB no., Subwatershed | monitoring reach | canopy | instream cover | invertebrates/ food supply | barriers |
|---|---|---|---|---|---|
| | | | | | |
| **70014 Inman Creek** | **Inman Creek** | (CFL)% closure visually est. above bankful at 100 ft. intervals (decid. & everg.), averaged for reach. New Growth Forestry for restoration grant reported canopy conditions 1990. | GWAG notes that woody debris is low. CFL THP 1996 observed amount of cover. | CFL THP 1996 consultant observations. | New Growth Forestry for restoration grant reported barriers 1990. |
| | **North Fork Inman** | | | | New Growth Forestry for restoration grant reported barriers 1990. |
| | **Pepperwood Creek** | | | | New Growth Forestry for restoration grant reported barriers 1990. |
| | | | | | |
| **70020 Signal Creek** | **Signal Creek** | (CFL)% closure visually est. above bankful at 100 ft. intervals (decid. & everg.), averaged for reach. | F&G 1987, 98 meter survey estimated instream objects F&G 1995 repeated survey, 108 meters. GWAG 1997 cover observations. | | GWAG notes on steep bedrock falls. |

| SWRCB no., Subwatershed | monitoring reach | flow | channel gradient | cross-sections | longitudinal profiles | bankful width | bankful depth |
|---|---|---|---|---|---|---|---|
| | | ' | | | ' | | |
| **70021 Casper Ck, Graphite Ck., Garcia River** | **mainstem Garcia** | Flow estimated by % area above Eureka Br. at bankful discharge.(LFA) L-P reports mean annual volume runoff. | CDF GIS; L-P SYP Channel Network Map 1997. (CFL) With clinometer at 100 ft. intervals along sample reaches and averaged. | | | (CFL) bankful channel width at 3 prominent riffles w/ a surveying tape. GWAG notes that channel is very wide. | (CFL) Average of 10 equally spaced depths across bankful channel at 3 riffles w/ stadia rod. |
| | **Casper Creek** | | CDF GIS; L-P SYP Channel Network Map 1997. | | | | |
| | **Graphite Creek** | | CDF GIS; L-P SYP Channel Network Map 1997. 1968 aerial photos show lg. drop-off at mouth. | | | | |
| | | | | | | | |

| SWRCB no., Subwatershed | monitoring reach | valley width | confinement | turbidity | substrate composition | sediment |
|---|---|---|---|---|---|---|
| | | | | | | |
| **70021 Casper Ck, Graphite Ck., Garcia River** | **mainstem Garcia** | Measured out from bankful at 3 riffles (same spot as bankful and pebble cts.). averaged from 3 sites for overall v.w. for reach. | 1852 and 1988 aerial photos. L-P Channel Sensitivity map. | | CFL consultant collected particle size dist. data downstream from Blue Waterhole Creek 1995. L-P SYP 1997 Channel Substrate Predicted Particle Size map. | |
| | **Casper Creek** | | L-P SYP 1997 Channel Sensitivity map from slope and confinement) method unknown. (LFA) | | L-P SYP 1997 Channel Substrate Predicted Particle Size map. | |
| | **Graphite Creek** | | L-P SYP 1997 Channel Sensitivity map from slope and confinement; method unknown. (LFA) | | L-P SYP 1997 Channel Substrate Predicted Particle Size map. GWAG notes. | |
| | | | | | | |

| SWRCB no., Subwatershed | monitoring reach | embeddedness | pebble counts | woody debris | pools | temperature |
|---|---|---|---|---|---|---|
| | | | | | | |
| **70021 Casper Ck, Graphite Ck., Garcia River** | **mainstem Garcia** | | Wolman pebble cts. in 3 potential spawning riffles. 100 particles. Several indices of substrate size calculated and averaged for reach. | (CFL) Inventories within bankful channel for entire reach, as per Bilby and Ward (1989). | 3 pools/reach residual depth, residual length, and residual width. V=(1/12pi)x(l,w,d) | GWAG notes warm temps, tots of algal growth. |
| | **Casper Creek** | | | | | L-P conducted pop. distrib. survey in 1995 & 96, incld. temp. |
| | **Graphite Creek** | | | | | |

| SWRCB no., Subwatershed | monitoring reach | dissolved oxygen | fish | redds/spawning substrate | carcasses | habitat types & distributions |
|---|---|---|---|---|---|---|
| | | | | | | |
| **70021 Casper Ck, Graphite Ck., Garcia River** | **mainstem Garcia** | | F&G 1987 conducted electro. pop. survey. GWAG observations. | GWAG observations. | | |
| | **Casper Creek** | | L-P conducted pop. dist.. survey in 1995 & 96, incld. fish and amphib counts. | | | L-P conducted pop. distrib. survey in 1995 & 96, incld. nab. types. |
| | **Graphite Creek** | | Salmon Trollers conducted survey from Dec 1996-Jan. 1997, 1 mile. Repeated from Feb-April, 1997, 0.3 miles. | Salmon Trollers conducted survey from Dec 1996-Jan. 1997, 1 mile. Repeated from Feb-April, 1997, 0.3 miles. | Salmon Trollers conducted survey from Dec 1996-Jan. 1997, 1 mile. Repeated from Feb-April, 1997, 0.3 miles. | |
| | | | | | | |

| SWRCB no., Subwatershed | monitoring reach | canopy | instream cover | invertebrates/ food supply | barriers |
|---|---|---|---|---|---|
| | | | | | |
| **70021 Casper Ck, Graphite Ck., Garcia River** | **mainstem Garcia** | (CFL) % closure visually est. above bankful at 100 ft. intervals (decid. & everg.), averaged for reach. | | | |
| | **Casper Creek** | | | | |
| | **Graphite Creek** | | GWAG notes. | | 1988 aerial photos note lg. drop-off at mouth. GWAG notes barrier where road crosses stream. |

| SWRCB no., Subwatershed | monitoring reach | flow | channel gradient | cross-sections | longitudinal profiles | bankful width | bankful depth |
|---|---|---|---|---|---|---|---|
| **70022 Beebe Creek, Garcia River** | **mainstem Garcia** | | CDF GIS. L-P SYP Channel Network Map 1997. CFL; with clinometer at 100 ft. intervals along sample reaches and averaged. | | | (CFL) bankful channel width at 3 prominent riffles w/ a surveying tape. GWAG notes mainstem wide with shallow pools. | (CFL) Average of 10 equally spaced depths across bankful channel at 3 riffles w/ stadia rod. |
| | **Beebe Creek** | F&G 1989 stream survey estimated flow over log. | From topos LFA; L-P SYP Channel Network Map 1997. | | | | |
| | | | | | | | |

| SWRCB no., Subwatershed | monitoring reach | valley width | confinement | turbidity | substrate composition | sediment |
|---|---|---|---|---|---|---|
| **70022 Beebe Creek, Garcia River** | **mainstem Garcia** | Measured out from bankful at 3 riffles (same spot as bankful and pebble cts.). averaged from 3 sites for overall v.w. for reach. | Aerial photos 1952 & 1988. LFA. L-P SYP 1997 Channel Sensitivity map from slope and confinement; method unknown. (LFA) | | L-P SYP 1997 Channel Substrate Predicted Particle Size map. . | |
| | **Beebe Creek** | | L-P SYP 1997 Channel Sensitivity map from slope and confinement; method unknown. (LFA) | | F&G stream survey 1989. L-P SYP 1997 Channel Substrate Predicted Particle Size map. GWAG observations. | |
| | | | | | | |

| SWRCB no., Subwatershed | monitoring reach | embeddedness | pebble counts | woody debris | pools | temperature |
|---|---|---|---|---|---|---|
| **70022 Beebe Creek, Garcia River** | **mainstem Garcia** | | Wolman pebble cts. in 3 potential spawning riffles. 100 particles. Several indices of substrate size calculated and averaged for reach. | (CFL) Inventories within bankful channel for entire reach, as per Bilby and Ward (1989). | 3 pools/reach residual depth, residual length, and residual width. V=(1/12pi)x(l, w, d) | FrOG collected near Hot Springs Camp Aug.-Oct. 1994. GWAG notes mainstem wide with warm temps. |
| | **Beebe Creek** | | | | | |
| | | | | | | |

| SWRCB no., Subwatershed | monitoring reach | dissolved oxygen | fish | redds/spawning substrate | carcasses | habitat types & distributions |
|---|---|---|---|---|---|---|
| **70022 Beebe Creek, Garcia River** | **mainstem Garcia** | | | | | GWAG notes mainstem wide with shallow pools. |
| | **Beebe Creek** | | F&G 1969 pop. survey using Smith-Root Type VII electrofisher. | | | F&G 1989 fish pop. stream survey of 100 ft. w/ hab. types. |
| | | | | | | |

| SWRCB no., Subwatershed | monitoring reach | canopy | instream cover | invertebrates/ food supply | barriers |
|---|---|---|---|---|---|
| **70022 Beebe Creek, Garcia River** | **mainstem Garcia** | (CFL) % closure visually est. above bankful at 100 ft. intervals (decid. & everg.), averaged for reach. | GWAG notes mainstem wide with shallow pools. | | |
| | **Beebe Creek** | | F&G 1989 fish pop. stream survey of 100 ft. noting cover. | F&G 1989 stream survey reported insects. | GWAG observations of bedrock barrier near Garcia Haul Road. |
| | | | | | |

| SWRCB no., Subwatershed | monitoring reach | flow | channel gradient | cross-sections | longitudinal profiles | bankful width | bankful depth |
|---|---|---|---|---|---|---|---|
| **70023 South Fork** | **mainstem Garcia** | F&G 1967 stream survey w/ summer flows and winter predictions. | CDF GIS. L-P Channel Network map in SYP, 1997. | | | GWAG notes wide channel. | |
| | **South Fork** | F&G stream surveys Aug. 1987, Oct. 1988, 89,91,92. GWAG notes 1997. | CDF GIS (source??). L-P Channel Network map in SYP, 1997. GWAG notes. | | | F&G 1987-92. L-P SYP 1998. | |
| | **Fleming Creek** | F&G stream surveys measured flow in Aug. 1987 & Oct. 1989, 90, Nov. 1991 & Oct. 1992. | From topos. L-P SYP Channel Network Map 1997. | | | F&G 1987-89 & 1991 -92 stream surveys. | |
| | **Little South Fork** | | | | | | |
| | | | | | | | |

| SWRCB no., Subwatershed | monitoring reach | valley width | confinement | turbidity | substrate composition | sediment |
|---|---|---|---|---|---|---|
| **70023 South Fork** | **mainstem Garcia** | | 1952 & 1988 aerial photos. L-P Channel Sensitivity Map SYP 1997. | | L-P SYP 1997 Channel Substrate Predicted Particle Size model. | GWAG notes braided/aggraded sediment load. |
| | **South Fork** | | L-P Channel Sensitivity Map SYP 1997. | | F&G stream surveys 1887-89 & 1991-92, est. sub. comp. L-P Channel substrate Predicted Particle Size map. | |
| | **Fleming Creek** | | GWAG notes upper reaches well confined. L-P SYP 1997 reports. | | F&G stream surveys 1887-89 & 1991-92, est. sub. comp. L-P Channel substrate Predicted Particle Size map. F&G McNeil samples at mouth in late 1980's. | GWAG notes high instream-stored sediment. |
| | **Little South Fork** | | | | | |
| | | | | | | |

| SWRCB no., Subwatershed | monitoring reach | embeddedness | pebble counts | woody debris | pools | temperature |
|---|---|---|---|---|---|---|
| **70023 South Fork** | **mainstem Garcia** | | | | | FrOG hobo temps on mainstem above S.Fork.1995. CFL consultant 1995 installed hobo. |
| | **South Fork** | | | L-P 1995 stream survey. | L-P 1995 stream survey pool depths. Salmon Trollers 1989-90 spawning survey, mean pool depth. | Salmon Trollers winter spawning survey 1989-90. FrOG hobo temp at mouth 1995-96. L-P 1994-95 stowaways at mouth. GWAG notes. |
| | **Fleming Creek** | | | | | GWAG notes good canopy, prob. good temps. |
| | **Little South Fork** | | | | | |
| | | | | | | |

| **SWRCB no., Subwatershed** | **monitoring reach** | **dissolved oxygen** | **fish** | **redds/spawning substrate** | **carcasses** | **habitat types & distributions** |
|---|---|---|---|---|---|---|
| **70023 South Fork** | **mainstem Garcia** | | F&G 1967 stream survey reported poor spawning hab. due to high winter flows. GWAG notes spawning downstream of mouth of S. Fork. | | | F&G 1967 stream survey. GWAG notes nice bedrock pools. |
| | **South Fork** | | F&G stream surveys 1987-89 and 1991-92 counted fish/m2. F&G 1988 planted Noyo River coho. Salmon Trollers spawning survey 1989-90, 90-91 & 96-97. L-P 1994-96 pop dist #s at 3 locs on S. Fork. GWAG notes 1997 of abundant steelhead and hist coho. | Salmon Trollers spawning survey 1989-90, 1990-91 1996-97. F&G stream surveys est. spawning substrate/hab. & 1991-92. | Salmon Trollers spawning survey 1989-90, 1990-91 1996-97. | F&G stream surveys 1987 89 and 1991 -1992. L-P 1995 stream survey. |
| | **Fleming Creek** | | F&G stream surveys 1987-89 & 1991-92 counted fish/m2. L-P 1994-96 pop dist. #s | F&G stream surveys est. spawning substrate/hab. 1987-89 & 1991-92. | | F&G stream surveys 1987 89 & 1991-92. |
| | **Little South Fork** | | GWAG notes 1997 of abundant steelhead and hist. coho. | | | |
| | | | | | | |

| SWRCB no., Subwatershed | monitoring reach | canopy | instream cover | invertebrates/ food supply | barriers |
|---|---|---|---|---|---|
| **70023 South Fork** | **mainstem Garcia** | | GWAG notes 1997 simple channel, little cover. | | |
| | **South Fork** | F&G stream surveys 1987 89, 1991-92. | F&G stream surveys 1987 89 and 1991 -92. L-P 1995 stream survey. | | GWAG notes sediment barriers where water flows underground in late summer. |
| | **Fleming Creek** | F&G stream surveys 1987 89, 1991-92. | F&G stream surveys 1987 89 & 1991-92. | | GWAG notes culvert which blocks fish passage. |
| | **Little South Fork** | | | | |
| | | | | | |

| SWRCB no., Subwatershed | monitoring reach | flow | channel gradient | cross-sections | longitudinal profiles | bankful width | bankful depth |
|---|---|---|---|---|---|---|---|
| **70024 Rolling Brook** | **mainstem Garcia** | MCWA 1996-97. | CDF GIS | 2 x-secs at Eureka Hill Bridge, (Jackson, 1996) | | | |
| | **Mill Creek** | GWAG notes subsurface flows during summer due to sediment delta at mouth. F&G 1967 stream survey. | CDF GIS. L-P Channel Sensitivity map and Channel Network map, SYP 1997. | | | F&G 1967 stream survey. | |
| | **Rolling Brook** | F&G 1967 est. at mouth. F&G 1987 measured summer flow. | CDF GIS. L-P Channel Sensitivity map and Channel Network map, SYP 1997. | | | F&G 1987 stream survey. F&G 1987. L-P 1995 habitat survey. | F&G 1967 stream survey. |
| | **Lee Creek** | F&G 1989 stream survey. L-P 1996 pop. dist. survey. | CDF GIS. L-P Channel Sensitivity map and Channel Network map, SYP 1997. | | | F&G 1989 stream survey. | |
| | **Hutton Gulch** | F&G 1987 stream survey estimates. Save Our Salmon memo 1986 observation of underground flow. CDF confirms. | CDF GIS. L-P Channel Sensitivity map and Channel Network map, SYP 1997. GWAG notes. | | | F&G 1967 stream survey. | |
| | | | | | | | |

| SWRCB no., Subwatershed | monitoring reach | valley width | confinement | turbidity | substrate composition | sediment |
|---|---|---|---|---|---|---|
| **70024 Rolling Brook** | **mainstem Garcia** | | | | Oct. 1992, USGS measured surface bed material along transect. Dec 1992-Feb 1993 USGS measured particle dist. of bedload. | USGS Dec 1992-May 1993 measured suspended sediment from Eureka Hill Bridge (PWA gravel management report). |
| | **Mill Creek** | | F&G 1967 stream survey. L-P Channel Sensitivity map, SYP 1997. | | F&G 1967 stream survey. L-P Channel Substrate Predicted Particle Size map, SYP 1997. | GWAG notes subsurface flows due to sediment delta mouth. |
| | **Rolling Brook** | | F&G 1967 stream survey notes. L-P Channel Sensitivity Map, SYP 1997. | | F&G stream survey in 1967 & 1987. L-P 1995 hab. typing est. subsurface fines. L-P Channel Substrate Predicted Particle Size map, SYP 1997. | GWAG notes subsurface flows due to sediment delta mouth. |
| | **Lee Creek** | | L-P Channel Sensitivity Map SYP 1997. | | F&G 1989 stream survey. L-P SYP 1997 Channel Substrate Predicted Particle Size model. | |
| | **Hutton Gulch** | | L-P Channel Sensitivity Map SYP 1997. GWAG notes. | | F&G 1967 stream survey. F&G 1978 THP review. 1986 Save Our Salmon memo. CDF memo 1987. L-P SYP 1997 Channel Substrate Predicted Particle Size model. GWAG notes | |
| | | | | | | |

| SWRCB no., Subwatershed | monitoring reach | embeddedness | pebble counts | woody debris | pools | temperature |
|---|---|---|---|---|---|---|
| **70024 Rolling Brook** | **mainstem Garcia** | | | | | |
| | **Mill Creek** | | | | F&G 1967 stream survey notes. | F&G 1967 stream survey notes. FrOG at mouth since 1995. |
| | **Rolling Brook** | L-P 1995 hab. typing est. pool tail embedd. | | | | F&G 1967 and 1987 measured temp. FrOG at mouth since 1994. L-P 1995 summer temps. |
| | **Lee Creek** | | | | F&G 1989 stream survey. | F&G 1989 stream survey. FrOG summer temps since 1994. |
| | **Hutton Gulch** | | | | F&G 1967 stream survey predicting. | F&G 1967 stream survey. F&G 1977. FrOG from mouth in 1995. |
| | | | | | | |

| SWRCB no., Subwatershed | monitoring reach | dissolved oxygen | fish | redds/spawning substrate | carcasses | habitat types & distributions |
|---|---|---|---|---|---|---|
| **70024 Rolling Brook** | **mainstem Garcia** | | | | | |
| | **Mill Creek** | | L-P pop. dist. survey by electroshock, 1996. F&G 1967 stream survey counted fish. | F&G 1967 stream survey notes. | | F&G 1967 stream survey notes. L-P pop. dist. survey 1996. |
| | **Rolling Brook** | | F&G 1967 notes, F&G 1987 electrofished. L-P 1994-96 electrofished. GWAG notes. | F&G 1967 stream survey notes spawning gravels. | | F&G 1967 stream survey notes nab. types and spawning gravels. F&G 1987 nab. types. L-P 1995 hab. typing one one reach. GWAG notes instream structures in lower 1 mile. |
| | **Lee Creek** | | F&G 1989 stream survey observations. L-P 1996 pop. dist. survey. GWAG notes hist, coho migrations. | | | F&G 199 (sic) stream survey. GWAG notes instream structures. |
| | **Hutton Gulch** | | F&G 1967 stream survey observations. GWAG notes 1997. Save Our Salmon raised salmonids in ponds at mouth in 1970s&80s. | | | F&G 1967 stream survey. |
| | | | | | | |

| SWRCB no., Subwatershed | monitoring reach | canopy | instream cover | invertebrates/ food supply | barriers |
|---|---|---|---|---|---|
| **70024 Rolling Brook** | **mainstem Garcia** | | | | |
| | **Mill Creek** | | F&G 1967 stream survey notes. | F&G 1967 stream survey notes. | F&G 1967 stream survey noted log jam barrier to migration and gradient in 2nd and 3rd tribs. |
| | **Rolling Brook** | | F&G stream survey 1967, 1987. L-P habitat typing 1995. | F&G 1967 notes. | F&G 1967 notes. |
| | **Lee Creek** | | F&G 1989 stream survey. | | |
| | **Hutton Gulch** | | F&G 1967 stream survey. | | F&G 1967 stream survey noted steep gradient. F&G, CDF and Save Our Salmon all note subsurface flows. |
| | | | | | |

| SWRCB no., Subwatershed | monitoring reach | flow | channel gradient | cross-sections | longitudinal profiles | bankful width | bankful depth |
|---|---|---|---|---|---|---|---|
| **70025 North Fork** | **North Fork** | Late summer flows measured (WEP 1992). 0.5 miles up from mouth water goes sub-surface in summer** (LFA, 1997). | (CFL) 3 sites with clinometer at 100ft. intervals along sample reaches and averaged, from topos, (LFA, 1997) | CFL (1989-96). | | (CFL) bankful channel width at 3 prominent riffles w/ a surveying tape | (CFL) Average of 10 equally spaced depths across bankful channel at 3 riffles w/ stadia rod. |
| | **Alder Creek** | | | | | | |
| | **Olsen Gulch** | | CDF GIS (LFA 1997). | MCRCD 1995. | | F&G 1967. | F&G 1967. |
| | **John Olsen Creek** | GWAG (LFA 1997). | GWAG (LFA 1997). | | | | |
| | **Garcia River** | discharge at bankful higher than expected (Cafferata), steep hydrographs. MCWA, (1996-97) | CDF GIS (LFA 1997). | 3 x-secs at Connor Hole (MCWA, RCD WA 1991; Jackson, 1997), MCWA 1996-97. | | GWAG notes wide channel (LFA, 1997), Jackson, (1997). | Jackson 1997 (LFA, 1997) |
| | | | | | | | |
| **70026 Hathaway Creek** | **Hathaway Creek** | F&G survey 1986. | CDF GIS (LFA 1997). | | | | |
| | **Allen Gulch** | | LFA 1997. | | | | |
| | **lower 7 miles & estuary** | Late summer flows measured by Pygmy flowmeter (WEP 1992). Discharge at bankful higher than expected (Cafferata), steep hydrographs. | CDF GIS (LFA 1997). | 40 x-secs (WEP 1992). 2 x-secs on Kendall property, (MCWA, RCD WA 1991; Jackson, 1996). | Done for WEP 1992, from topos. | WEP, 1992. Leopold & McBain 1996. | WEP, 1992. Leopold & McBain 1996. |

| SWRCB no., Subwatershed | monitoring reach | valley width | confinement | turbidity | substrate composition | sediment |
|---|---|---|---|---|---|---|
| **70025 North Fork** | **North Fork** | Measured out from bankful at 3 riffles (same as bankful and pebble cts.). averaged from 3 sites for overall v.w. for reach. | Very confined ** (LFA, 1997). | CFL (199?). | I967 F&G survey. CDF memo 1989 (LFA, 1997). McNeil samples (CFL, 1989-1995; G-P 1994). | McNeil samples (CFL, 1997; G-P 1994) |
| | **Alder Creek** | | | | | high sediment in creek "(LFA). |
| | **Olsen Gulch** | | F&G 1967. | | 1967 F&G survey. | lots of sediment instream** (LFA, 1997). |
| | **John Olsen Creek** | | GWAG (LFA 1997). | | GWAG (LFA 1997). | |
| | **Garcia River** | | RWCQB, EPA(LFA, 1997), Jackson (1997). | | Jackson (1997). | |
| | | | | | | |
| **70026 Hathaway Creek** | **Hathaway Creek** | | LFA (1997). | | F&G survey 1986. | |
| | **Allen Gulch** | | Flooded at mouth channel confined ((LFA, 1997). | | | |
| | **lower 7 miles & estuary** | WEP, 1992. Leopold & McBain 1996. | WEP, 1992. Leopold & McBain 1996. | | WEP 1992 pebble counts, AT&T sed. sampling (Pacific Watersheds Assoc., 1994), P. Williams 1996. | Sediment strata trenches at 4 estuary sites and one adjoining field. AT&T sed. sampling (Pacifc Watersheds Assoc., 1994) |

| SWRCB no., Subwatershed | monitoring reach | embeddedness | pebble counts | woody debris | pools | temperature |
|---|---|---|---|---|---|---|
| **70025 North Fork** | **North Fork** | | (CFL 1997) Wolman pebble cts. in 3 potential spawning riffles. 100 particles. Several indices of substrate size calculated and averaged for reach. | (CFL) Inventories within bankful channel for entire reach, as per Bilby and Ward (1989). (LFA, 1997). | 3 pools/reach residual depth, residual length, and residual width. V=(1/12pi)x(l,w,d ) Good pools upstream (LFA, 1997) | G-P 1994. |
| | **Alder Creek** | | | | | |
| | **Olsen Gulch** | | | Sections w/ good LWD** (LFA, 1997). | Sections w/ good pools" (LFA, 1997). | F&G, 1967. |
| | **John Olsen Creek** | | | | | GWAG (LFA 1997). |
| | **Garcia River** | | | | | USGS (1964-79) |
| | | | | | | |
| **70026 Hathaway Creek** | **Hathaway Creek** | | | | | FrOG (??) |
| | **Allen Gulch** | | | | | |
| | **lower 7 miles & estuary** | WEP Habitat Typing 1992 | WEP 1992 pebble counts | | Pool depth Improving, pool bottoms may be low In DO (LFA, 1997) | Habitat typing recorded late summer temps, for river mile .86-8.31, (WEP 1992), FrOG 1994-97. MCWA, 1997. |

| SWRCB no., Subwatershed | monitoring reach | dissolved oxygen | fish | redds/spawning substrate | carcasses | habitat types & distributions |
|---|---|---|---|---|---|---|
| **70025 North Fork** | **North Fork** | | WEP 1992, Direct Underwater Observation Method, (Hankin and Reeves,) and ocular est. river mile 0.5-5.9. F&G 1967. G-P 1994. | G-P (1994). | G-P (1994). | MCRCD WEP 1992 Hab. typing, river mile .5-5.05; CDF&G (1967, 1983), CFL 1997 |
| | **Alder Creek** | | F&G survey**(LFA). | | | |
| | **Olsen Gulch** | RWQCB 1989-90, MCWA 1996 | F&G 1967 (LFA, 1997). | | | F&G 1967. Monschke 1995 (LFA, 1997). |
| | **John Olsen Creek** | | no modem fish data | Silted gravels, ok for spawning?** (LFA, 1997). | | GWAG (LFA 1997). |
| | **Garcia River** | MCWA 1996 | 1952 F&G study, active spawning. Cressey 1993 electrofished. | potential spawning and rearing habitat | | F&G 1953, P. Williams 1996. |
| | | | | | | |
| **70026 Hathaway Creek** | **Hathaway Creek** | | F&G survey 1986 | | | F&G survey 1986. |
| | **Allen Gulch** | | no modem fish sightings (LFA, 1997). | | | |
| | **lower 7 miles & estuary** | MCWA 1997, Water Quality tests by NCRWQCB 1989-90. | WEP 1992, Direct Underwater Observation Method, and ocular est. Three sites in estuary seined. P. Williams & Assoc. (1996), F&G 1953. | | | Habitat typing, river mite .86-8.31, RCD for WEP (1992). F&G 1987, P. Williams & Assoc. (1996). |

| **SWRCB no., Subwatershed** | **monitoring reach** | **canopy** | **instream cover** | **invertebrates/ food supply** | **barriers** |
|---|---|---|---|---|---|
| **70025 North Fork** | **North Fork** | (CFL) % closure visually est. above bankful at 100 ft. intervals (decid. & everg.), averaged for reach. Good alder canopy** (LFA, 1997). | | F&G 1967. | F&G, log Jam barriers. (1967). Waterfall 2-4 miles from mouth (LFA, 1997). |
| | **Alder Creek** | | | | mouth perched above NF forming barrier** (LFA, 1997). |
| | **Olsen Gulch** | | F&G 1967. | F&G 1967 (LFA, 1997). | F&G 1967 (LFA, 1997) |
| | **John Olsen Creek** | GWAG (LFA 1997). | | | |
| | **Garcia River** | | | | |
| | | | | | |
| **70026 Hathaway Creek** | **Hathaway Creek** | F&G 1986. | F&G survey 1986. | | |
| | **Allen Gulch** | | | | |
| | **lower 7 miles & estuary** | | F&G 1987, P. Williams & Assoc. (1996). | AT&T bentonite spill survey, Huffman & Assoc. (1992). | Habitat typing river mile .86-8.31 identified barriers, (WEP 1992) |

key

AW - Adopt-a-Watershed
CDF - Calif. Dept. of Forestry and Fire Protection
CDFG - Calif. Dept. of Fish and Game
CFL - Coastal Forestlands, Ltd.
FrOG - Friends of the Garcia River
G-P - Georgia Pacific
L-P - Louisiana-Pacific
MCRCD - Mendocino County Resource Conservation District
MCWA - Mendocino County Water Agency