Report of Waste Discharge

Stitz Creek Watershed

Humboldt County, CA

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Submitted by:

Humboldt Redwood Company, LLC

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1.0 Introduction

This report comprises an Application/Report of Waste Discharge for sediment discharges and temperature effects from timber harvesting activity conducted by Humboldt Redwood Company, LLC, in the Stitz Creek watershed, tributary to the Eel River, Humboldt County.

California Water Code section 13260 requires that persons discharging or proposing to discharge waste that could affect the quality of waters of the State shall file a Report of Waste Discharge (ROWD).

Most forestry and silvicultural operations conducted pursuant to an approved Timber Harvesting Plan in the North Coast Region are permitted through either the General Waste Discharge Requirement or Categorical Waiver of Waste Discharge Requirements. However, to address previously identified adverse cumulative impacts to water quality as a result of past timber harvesting operations in the Stitz Creek watershed, the NCRWQCB Executive Officer has requested individual Watershed-wide Waste Discharge Requirements (WWDR) be developed as the permitting framework under which future timber operations be conducted[1]. In response to this request, Humboldt Redwood Company, LLC (HRC) is submitting this ROWD to assist in the establishment of WWDRs which will provide for restoration of beneficial uses and continued forest management in the Stitz Creek Watershed.

The report provides information regarding past, current, and planned future forestry activities, and identifies specific measures and actions to be implemented for the protection and restoration of water quality (sediment and temperature) as part of anticipated Watershed-Wide Waste Discharge Requirements (WWDRs).

1.1 Site Description

1.1.1 Site Location

Stitz Creek is a tributary to the Eel River, which drains to the Pacific Ocean. The Stitz Creek watershed is located in coastal northern California approximately 3.5 river miles upstream of the town of Scotia in Humboldt County (Figure 1-1). Stitz Creek's legal description at the confluence with Eel River is Township 1N Range 1E Section 22 (lower Eel HUC 18010105).

[1] California Regional Water Quality Control Board North Coast Region letter from Robert Klamt, Interim Executive Officer, to Dr. Jeff Barrett and Mr. Mike Miles, The Pacific Lumber Company (predecessor to Humboldt Redwood Company), dated February 27, 2008.

1.1.2 Facility Defined

The Stitz Creek Watershed encompasses approximately 2,572 acres (4 mi^2), of which HRC owns approximately 100%. The "Facility" covered by this WDR application includes only those lands owned and managed by HRC and rights-of-ways over roads on lands owned by others (Figure 1-2).

The 'Facility' is managed by HRC for growing conifer trees for the production of saw logs and other renewable forest products.

1.1.3 Topography

The topography for the site is provided in hill-shade form displayed on Figure 1-2. As the map illustrates, Stitz Creek has a dendritic drainage pattern deeply incised into steep hillslopes. Elevations range from close to 1700 feet on the ridge defining the southern hydrologic divide to about 70 feet above sea level at the confluence with the Eel River. Ridge-top areas can be fairly gentle but slopes quickly become steep within the interior of the basin.

1.1.4 Climate

Rainfall data collected at nearby Scotia, CA, indicates an average annual rainfall of 48.7 inches[2]. The majority of precipitation falls in the form of rain, with snowfall a rare event. The rainfall pattern is Mediterranean, with the majority of annual average rainfall occurring during the months of October through April. The storm seasons in hydrologic years 2003 and 2006 were the first significant precipitation events since the implementation of the HCP.

A more detailed characterization of the climate can be found in the Appendix A report titled *Landslide Inventory for the 2003, 2006, and 2010 Storm Seasons, Stitz Creek, Humboldt County, California* (pages 5-9).

1.1.5 Geology

Sediments within the Stitz Creek drainage derive primarily from the Miocene to Pleistocene aged Wildcat Group. The Wildcat Group consists of five distinct lithologies representing a marine regression indicated by the coarsening-up stratigraphic sequence. The lithologies, from oldest to youngest, are the Pullen, Eel River, Rio Dell, Scotia Bluffs, and Carlotta Formations. Undifferentiated Wildcat Group is also present in Stitz Creek. Undifferentiated Wildcat is more or less homogeneous in texture and fabric and lacks distinctive bedding or indicator fossils present in the other formations. Undifferentiated Wildcat is commonly characterized as poorly indurated sandy siltstone. A relatively small portion of the drainage is underlain by the Yager terrane, characterized as marine argillite, sandstone, and conglomerate dating to the Paleocene to late Eocene.

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[2] California Date Exchange Center (http://cdec.water.ca.gov/cgi-progs/profile?s=SCA&type=precip)

A more detailed characterization of the Stitz Creek geologic setting can be found in the Appendix A report titled *Landslide Inventory for the 2003 and 2006 Storm Seasons, Stitz Creek, Humboldt County, California* (pages 2-5).

2.0 Site Use and Regulation

Land use within the watershed is consistent with timber production zoning (TPZ) and is predominantly devoted to timber production. Near the southernmost tip of the watershed a County road (Shively Road) crosses Stitz Creek near its confluence with the Eel River.

2.1.1 Regulatory Agencies and Permitting Requirements

Agencies with regulatory oversight of timber harvest and related activities in the watershed are as follows:

- North Coast Regional Water Quality Control Board
- California Department of Forestry and Fire Protection (Cal-Fire)
- California Department of Fish and Wildlife
- California Geological Survey
- North Coast Air Quality Management District
- County Agriculture Commissioner
- U.S. Fish and Wildlife Service
- NOAA Fisheries
- Humboldt County Public Works
    - Owns and maintains the Shively Road right-of-way approximately 1,500 feet upstream from the mouth.

2.1.2 CEQA Requirements

Adoption of watershed-wide waste discharge requirements by the NCRWQCB will require compliance with the California Environmental Quality Act (CEQA).

2.1.3 Timber Harvesting Permitting

The CEQA Lead Agency for timber harvesting operations is the California Department of Forestry and Fire Protection (CAL-FIRE). The Secretary of Resources has certified that regulation of timber harvesting operations by CAL-FIRE is exempt from CEQA's requirements to prepare an Environmental Impact Report (EIR) or Negative Declaration. A Timber Harvesting Plan (THP) that is approved by CAL-FIRE is considered a Functional Equivalent of an EIR under CEQA.

NCRWQCB staff review Timber Harvesting Plans as a formal 'Review Team' member, participate in pre-harvest inspections, and submit comments and recommendations to CAL-FIRE to address concerns over potential adverse effects to water quality.

2.1.4 Habitat Conservation Plan

All of HRC ownership in the Stitz Creek watershed is covered by a multi-species state and federal Habitat Conservation Plan (HCP) approved in 1999. The HCP Aquatic Conservation Plan for aquatic species including Chinook salmon, Coho salmon, cutthroat trout, steelhead trout, southern torrent salamander, tailed-frog, red-legged frog, foothill-yellow legged frog, and the northwestern pond turtle are most relevant to protection of the Beneficial Uses of Stitz Creek. The management measures for water quality protection of the HCP were the subject of the federal Environmental Impact Statement and state Environmental Impact Report which led to the issuance of the HCP in conformance with the state and federal Endangered Species Acts.

2.1.5 Waste Discharge Requirements

California Water Code section 13260 requires that persons discharging or proposing to discharge waste that could affect the quality of waters of the State shall file a Report of Waste Discharge (ROWD). The ROWD is the start of the application process for Waste Discharge Requirements (WDRs).

Watershed-wide WDRs are being required and sought in an effort to ensure the mandate of the NCRWQCB is fulfilled while timber harvesting proceeds in the watershed.

2.1.6 Stream Alteration Permits

Any activity proposed by HRC that may alter the streambed or bank of any stream must first be issued a permit by the California Department of Fish and Wildlife (DFW) 1600 process. Such activities include new or reconstructed stream crossings, stream restoration or water drafting. These permits are subject to CEQA requirements and analysis prior to issuance by DFW.

2.1.7 Beneficial Uses

The North Coast Basin Plan lists the Beneficial Uses of Water Quality for Stitz Creek as:

- Municipal and Domestic Supply (MUN)
- Agricultural Supply (AGR)
- Industrial Service Supply (IND)
- Industrial Process Supply (PRO, potential)
- Groundwater Recharge (GWR)
- Freshwater Replenishment (FRSH)

- Navigation (NAV)
- Power Generation (POW, potential)
- Water Contact Recreation (REC-1)
- Non-Contact Water Recreation (REC-2)
- Commercial and Sport Fishing (COMM)
- Cold Freshwater Habitat (COLD)
- Wildlife Habitat (WILD)
- Rare, Threatened and Endangered Species (RARE)
- Migration of Aquatic Organisms (MIGR)
- Spawning, Reproduction and/or Early Development (SPAWN)
- Aquaculture (AQUA, potential)

While the extent to which these beneficial uses actually apply to Stitz Creek varies with respect to the list above, the most obvious beneficial use is by residential cutthroat and rainbow trout upstream of the Shively Road crossing. This crossing was originally constructed by Humboldt County Public Works in the mid 1950's. The existing culvert was reconstructed in 1965. Currently, there is an eleven foot vertical drop from the culvert outlet plunging to the creek bed. This plunge is considered a barrier to anadromous salmonids including coho, Chinook, and steelhead. Approximately 2.8 miles of fish-bearing stream habitat can be found in the watershed.

Like most of the rivers on the Northern Coast of California, Stitz Creek is currently included on the 303d list of impaired water bodies for sediment/siltation and temperature, listed under that of the Eel River Delta, Eel River HU, Lower Eel HA; California watershed i.d. 11111032. The United States Environmental Protection Agency (EPA) established Total Maximum Daily Loads (TMDLs) for sediment and temperature in the Lower Eel River in 2007.

3.0 Site History

3.1.1 Past Land Management Activities

Timber Harvest and Road Construction History

Old-growth redwood and Douglas-fir timber harvesting in the Stitz Creek watershed began in the early 1900s. Initial logging utilized steam donkeys coupled with a railroad built up the main channel of Stitz Creek. Stitz Creek was not re-entered until the mid-1970s.

In the early 1970's approximately one mile of road was constructed from Shively Road at the southern extent of the drainage. The first significant harvest re-entry occurred in 1974 on 185 acres in the northern portion of the watershed. Between 1974 and 1997 approximately 19 miles of road were constructed and approximately 73 percent of the watershed had been re-entered for timber operations. Harvest was conducted under a variety of silviculture methods including clearcut, seedtree removal, and shelterwood removal. Implementation of the HCP in 1999 greatly changed the logging and road construction practices on the ownership. After 1999 less than one mile of road was built and since that time, 270 acres (10% of HRC ownership in the watershed) have been harvested. This most recent period of harvest was conducted under a variety of silviculture methods including clearcut, selection, and shelterwood removal. No significant harvesting has taken place in the Watershed since 2008. Approximately 27 acres of selection harvest was logged in 2013 (THP 1-07-161HUM) under a waiver agreement with NCRWQCB.

A focused effort to improve the entire road system began in 1997 with a sediment source assessment of active and potential road-related sediment sources conducted by Natural Resource Management Corporation (NRM). A new inventory was conducted by R&J Miller Consulting in 2012. This inventory identified 42 sites along the road system recommended for 'treatment'. Of these, 6 sites have already contributed or have potential to contribute approximately 168 yds^3 of sediment and are scheduled for treatment. Since 1999, an estimated 10.4 miles of road has been storm-proofed within the watershed and 9 sediment saving sites have been treated for an estimated savings of 1,016 cubic yards of sediment.

Figures 3-1 and 3-2 summarize harvest and road construction history.

An additional account of the Stitz Creek land use history can be found in the Appendix B report titled *Sediment Source Investigation and Sediment Reduction Plan for the Stitz Creek Watershed, Humboldt County, California; Natural Resources Management, 1998* (pages 5-6).

4.0 Existing Sediment Sources

This section explains the methods by which HRC maintains an inventory, and prioritizes treatment of controllable sediment discharge sources[3] (CSDS) in the Stitz Creek watershed.

[3] "Controllable sediment discharge source" means sites or locations, both existing and those created by proposed timber harvest activities, within the Project area that meet all the following conditions:

1. Is discharging or has the potential to discharge sediment to waters of the state in violation of applicable water quality requirements,
2. was caused or affected by human activity, and
3. may feasibly and reasonably respond to prevention and minimization management measures.

Current inventories and treatment schedules are included as Appendices A and C. These sediment discharge sources are linked primarily to landslides and roads, including a combination thereof. Contemporary sediment delivery from surface erosion caused by logging-related ground disturbance (i.e. skid roads, cable-yarding corridors, and site preparation activities including broadcast burning) is minimal due to HCP and FPR mitigation measures (see Section 6.0) and the curtailment of recent logging activities.

4.1 Landslides

4.1.1 Methods for Maintaining Complete and Current Inventory of Landslide-related Sediment Sources

HRC maintains a complete and current inventory of landslide-related sediment sources through periodic aerial photograph assessment, helicopter fly-overs, and on-ground reporting. The purpose of these assessments is to locate and characterize new or re-activated landslides which deliver sediment to streams and determine if sediment delivery mitigation options exist (i.e. bio-remediation, drainage alteration, armoring, excavation, etc.).

The most recent watershed-wide comprehensive landslide inventory was conducted by a Professional Geologist in 2015 (Watkins 2015). This inventory used 2003, 2006, and 2010 aerial photographic interpretation to identify and characterize all new and/or active landslides in the Stitz Creek watershed. Methods used during this landslide inventory are described in the report (Appendix A). Future inventories of this nature will be conducted using similar methodologies consistent with guidelines presented in California Geological Survey Note 52, Guidelines for Preparing Geologic Reports for Regional-Scale Environmental and Resource Management Planning (2001), and will occur at no more than 5 year intervals or be determined in part by the occurrence of triggering events such as large earthquakes or storms as well as the availability of aerial photographs.

HRC will also conduct a watershed-wide reconnaissance level investigation for mass wasting events utilizing established protocols (SOP-08) following triggering events in or near the Stitz Creek watershed, defined as (1) greater than 3 inches of rainfall within 24 hours as measured at Scotia; (2) a significant earthquake. Determining if an earthquake is a “triggering event” is based upon earthquake magnitude and distance of epicenter from the watershed referencing Figure 2, Graph A of Keefer (1984).

On-ground reporting consists of HRC staff (i.e. Forestry and Forest Sciences) contacting the HRC Geology Department in the event a new or recently active landslide is observed during the course of daily duties (i.e. road inspections, wildlife surveys, aquatics monitoring, THP layout and logging supervision).

4.1.2 Current Inventory, Prioritization Strategy, and Source Remediation Schedule

The current inventory of landslide-related sediment sources can be found in Appendix A (Watkins 2015). This investigation mapped and analyzed landslide activity in the Stitz Creek drainage following the 2003, 2006, and 2010 storm seasons. Aerial photographs were used to make estimates of sediment production and delivery to watercourses for each storm event, and landslide attributes were analyzed to quantify associations with geomorphic and management criteria. The 2003 and 2006 storm seasons were significant when compared with historical precipitation data, set several records for seasonal and monthly totals, and are considered landslide-triggering events because of the widespread landsliding experienced across the region.

In brief summary, the Stitz Creek Landslide Inventory mapped 166 landslides for the 2003 storm season, 10 for the 2006 season, and 1 for the 2010 season with a total of 177 individual landslides mapped. Of the 177 individual landslides 59% were determined to be reactivations of pre-existing failures. About 71%, 77%, and 88% of failures in the 2003, 2006, and 2010 seasons, respectively were determined not to be associated with roads. It appears that few landslides are connected to the modern road network rather with abandoned roads and disconnected skid trails. 21% were not associated with any reported harvest activity or in non-operational areas of THPs. Within the “Timing of Management-Related Failures” section of Appendix A, Watkins points out that the comparison between pre- and post-HCP landslides shows a significant reduction in the rate of landsliding after the implementation of the HCP. This is attributed to avoidance or mitigated operations on and adjacent unstable areas resulting in a significant improvement over the rate of failures associated with pre-HCP harvest operations.

Of the 166 landslides mapped for the 2003 season, 43% were determined to have delivered to a watercourse. An estimated 82,944 yds^3 of sediment was displaced during the 2003 storm season with an estimated 17,591 yds^3 of sediment delivered to watercourses. During the 2006 storm season, 54% of the landslides delivered to a watercourse and of the estimated 33,502 yds^3 of sediment displaced an estimated 10,662 yds^3 delivered to watercourses. It was determined that 50% of the landslides delivered during the 2010 season with 6,395 yds^3 displaced and 5,083 yds^3 delivered.

Historic pre-HCP harvest practices (large acreage/low retention silviculture and excessive road/skid trail construction) combined with poorly consolidated bedrock and precipitation-driven triggering events are identified as the leading association between timber management activities and landslide occurrence. HRC is committed to the mandates for minimizing sediment delivery set forth in the California Forest Practice Rules and the HCP. The Erosion Control Plan (ECP) implemented under the General Waste Discharge Requirements can also be implemented under the WDR. Potential erosion control measures may include, but are not limited to: re-vegetation (e.g. tree planting, seeding, willow waddles), excavation, drainage modification, and buttressing or armoring of unstable areas.

Further history of landsliding in the Stitz Creek drainage includes an inventory dating back to 1947 aerial photographs and can be found in the Appendix B report titled *Stitz Creek Sediment Source Assessment and Sediment Reduction Recomendations,* prepared by Natural Resources Management Corporation *(1998)*.

4.2 Roads

4.2.1 Methods for Maintaining Complete and Current Inventory of Road-Related Sediment Sources

HRC maintains a complete and current road-related sediment source inventory for roads under its control. In the Stitz Creek watershed, this inventory was initiated with a 2012 complete road inventory conducted within the Stitz Creek watershed.

Road inventories of active or potential sediment sources are kept current through implementation of an **Annual Road Inspection Program (ARIP)** (HCP 6.3.3.5.1). This program requires all roads to be inspected at least once annually between May 1 and October 15 to ensure that drainage structures and facilities are intact and fully functional, and to identify any active or imminent road-related failures of the road prism, cutbanks, or fills which may have occurred during the previous winter and can deliver sediment to streams (i.e. development of new sediment sources).

Additional road inspections throughout the year are not uncommon and include:

1. **Storm-triggered Road Inspections** (HCP 6.3.3.5.2) - All accessible roads are inspected as soon as conditions permit following any storm event that generates 3 inches or more of precipitation in a 24-hour period, as measured at the Scotia rain gauge. The most recent road inspection triggered storm event occurred in March of 2012. The entire maintained road system across the property is currently being inspected. Road maintenance sites that are discovered will be added to the database and schedule for repair.
2. **Timber Harvest Plan** development - Roads appurtenant to planned timber harvest operations are reviewed during individual Timber Harvest Plan (THP) development to determine if roadwork is required to achieve or maintain an 'upgraded' or 'storm-proofed' standard (HCP 6.3.3.9).
3. **THP Erosion Control Plans (ECP)** - Require three annual inspections of the THP project area including appurtenant roads and harvest units where timber operations are or have been active during the life of the ECP. Discharges in potential violation of the Basin Plan are reported to the NCRWQCB upon discovery.

Information regarding discovered maintenance sites, including new or developing sediment sources, is recorded in a centralized Roads Database. These records are maintained for scheduling of work and in some instances post-treatment monitoring (e.g. WDR ECP inspections). The database is updated with completion dates as individual sites are treated.

The HRC Roads Department is contacted immediately in instances where significant active delivery or preventive imminent failure is discovered so that control measures can be enacted as soon as environmental conditions permit.

Collectively, these measures provide routine inspection and maintenance of the road system and a current road-related sediment source database from which to prioritize, schedule, implement, and monitor road-related sediment source remediation.

4.2.2 Current Inventory, Prioritization Strategy, and Source Remediation Schedule

An inventory conducted in the fall of 2012 by R&J Miller Consulting identified 6 road-related sediment source sites. The 6 CSDS sites have already contributed or have potential to contribute approximately 168 cubic yards of sediment. The current inventory of all known road-related sediment sources and road maintenance work orders are included in Appendix C. HRC proposes assessing and repairing all 6 identified CSDS sites in the first 5 year period following establishment of the Stitz Creek WDR. All sites have been scheduled for repair following WDR approval. Refer to Figure 4-1 for location of identified road-related sediment source sites.

The road inspection by R&J Miller Consulting identified 36 repair/maintenance sites not associated with CSDS within the Stitz Creek watershed. These sites were not contributing sediment and the majority requires removal of over steepened fill slopes, road surface drainage improvements, and culvert maintenance or replacement. These sites require an approved MATO permit from DFW and a WDR from WQ before treatment can occur. These sites are scheduled for maintence as presented in Appendix C upon procurement of required permits.

Controllable sediment discharge sources identified by ARIP, Storm-triggered road inspections, or individual THP ECP inspections are typically scheduled and treated within one year of discovery during the drier months of the year (May – November).

Individual sites with potential for sediment delivery to watercourses are ranked as ‘high’, ‘moderate’, or ‘low’ based upon level of erosion activity and volume of potential delivery. With some exception, the prioritization for treatment/control of individual sediment sources is based on a ‘cluster’ approach evaluation, in which active or potential sediment sources on individual roads are looked at cumulatively in order to prioritize treatment. Road segments with the greatest potential for sediment delivery over the shortest period of time (highest cumulative ranking) are prioritized for treatment over road segments with less potential future sediment delivery. The exception is where identified individual sites pose a significant threat to human safety or water quality resources, in which instance these sites are moved up in priority regardless of the rest of the road condition in that vicinity.

Annual road work plans for HCP-covered lands are formulated in the first quarter of each year and available for NCRWQCB staff review by April 15th of each year.

Additional non-scheduled routine minor maintenance (i.e. shaping of road surface, cleaning of inboard ditches and culvert inlets, maintenance of energy dissipation/downspouts, and roadside brush maintenance) may occur as needed in response to road inspection results and management needs.

4.3 Streamside Sources

Since 1999, streamside harvest operations in the watershed have been substantially restricted by the landowner's HCP including no harvest equipment exclusion zones with varying distances from 100 to 170 feet or greater on each side of Class I and II streams. These measures have minimized riparian disturbance and limited potential for creation of streamside sediment sources (not already captured by road and landslide inventories). Modern practices including enforceable FPR erosion control standards and limitations on use of ground-based equipment on moderate to steep slopes also reduce the likeliness of sediment delivery to streams as a result of harvest operations.

Focused field inspections for surface erosion associated with past harvest activities have been conducted on HRC's ownership as part of the HCP Watershed Analysis program (Freshwater 2002, Van Duzen 2003, LEED 2004, Upper Eel and Elk/Salmon 2005, Bear River 2007, Yager/Lawrence 2009). These inspections have found localized rill and gully erosion to rarely deliver to watercourses due to the effectiveness of the HCP Riparian Management Zones (RMZs) and FPR erosion control measures. Rapid site re-vegetation following harvest was also observed as normal for the region and contributed to minimizing post harvest surface erosion as years following harvest increased.

5.0 Future Forestry Operations

Planned timber operations including harvest and road use, construction, and re-construction are described in this section. Planned watershed restoration activities are referenced in Sections 4.0 and 8.0.

Humboldt Redwood Company LLC applies the following general harvest guidelines across the ownership:

- Well stocked conifer stands will be managed with an uneven-aged silviculture (i.e. selection/group selection/transition), typically retaining between 1/3 to 2/3 of the pre-harvest basal area. HRC has discontinued the use of the clearcut silviculture and the harvest of large Old Growth trees across the ownership.

- Variable retention (VR) and rehabilitation silvicultural methods are used on HRC lands as an interim hardwood removal or stand improvement silviculture targeted specifically for forest restoration of understocked areas. Both of these silvicultures will be applied in a manner that retains 10 to 40 percent of the original stand post harvest, providing ecological structure while creating sufficient opportunity to plant and regenerate redwood and Douglas-fir species.
- Cable yarding is used on slopes greater than 40 percent, where feasible, including areas previously tractor yarded, to minimize or avoid unnecessary site disturbance, soil compaction, and associated increased potential for sediment delivery.
- Roads no longer required for harvesting (e.g. due to transition from tractor to cable yarding) or other forestry purposes (e.g. wildlife surveys, monitoring, etc.) are closed.

5.1 Timber Harvest

HRC anticipates harvesting approximately 30 percent (770 acres) of the total watershed area over the next decade (2019-2029) using primarily Selection and Group selection (<2.5 acre openings) silviculture (14CCR 913.2). Canopy conditions in selectively harvested areas will typically range from 40-60 percent immediately following harvest and will increase over time in response to open light conditions.

Variable Retention or Rehabilitation of Understocked Area silvicultural methods (14CCR 913.4) may be used for harvesting stands currently dominated by hardwood species but capable of growing conifer species. This hardwood component is often the result of earlier pre-Forest Practice Act logging operations when re-establishment of conifer regeneration following harvest was not required. Conifer stands which have been damaged by animals (typically referring to redwood stands with extensive impacts from bears feeding on the cambium layer), past timber operations, or previously high-graded may also use Variable Retention as a regeneration method to establish a new age class or to improve forest health and productivity. Where suitable (i.e. stable) slope conditions exist within the logging area, these harvest methods may remove up to 60-90 percent of the forest canopy (outside of riparian management zones) allowing for planting of redwood and/or Douglas-fir seedlings following logging operations. HRC anticipates harvesting up to 125 acres (Approximately 5% of watershed) over the next decade utilizing these two silvicultural methods.

Logging (yarding) methods will be selected based on suitability to terrain. In general, ground-based yarding operations will be constrained to slopes ≤ 40 percent. High-lead and full suspension cable yarding will typically be used on slopes >40 percent. Figure 5-1 illustrates these two general slope classes in the Stitz Creek drainage and infers where each yarding method will typically be used. Helicopter yarding will be used as necessary to access areas where topography and/or slope stability prevents conventional yarding access (e.g. no existing road access; new road construction not advisable) or where topography otherwise prevents use of more conventional yarding means (e.g. blind leads, poor deflection, etc.).

Under current HCP prescriptions, no harvesting will occur adjacent to Class I and II watercourses or on unstable slopes leading to watercourses. Slope stability will be assessed by a licensed geologist using landslide inventory data, landslide hazard modeling, and California Geologic Survey standards for Engineering Geologic Reports for Timber Harvest Plans (CGS Note 45). ***See Section 6.0 for details regarding Sediment and Adverse Stream Temperature Prevention and Minimization Measures***.

Figure 5-2 shows the locations of potential THPs which are currently scheduled for harvest over the next ten years (2019-2029).

5.1.1 Road Condition, Use, and New Construction

As of today, approximately 12.1 miles of the road system is open and 6.7 miles have been closed/abandoned within the Stitz Creek watershed. Currently 10.4 miles have been constructed to HRC's HCP 'storm-proofed standard' (HCP 6.3.3.9). Storm-proofed roads are designed, constructed, and maintained to minimize the delivery of fine sediment from roads and drainage facilities to streams, as well as to minimize, to the extent feasible, sediment discharge resulting from large magnitude, infrequent storms and floods.

There are currently approximately 8.4 miles of non-storm-proofed roads in the watershed. Of these non-storm-proofed miles approximately 5.3 miles have been classified as closed/abandoned and are currently inaccessible and unfeasible to treat due to mass wasting. The disturbance caused to access these road miles would outweigh the benefits of treatment. The remaining 3.1 miles of the non-storm-proofed miles are open road which have been inventoried and scheduled for storm-proofing over the next 2 years pending establishment of the WDR (Figure 3-2).

Future road construction over the next decade is primarily limited to spur roads ranging from 150 to 500 feet in length across mostly gentle to moderate slopes (<50%). A feasibility assessment for the construction of new roads within Stitz Creek will be done concurrently with future THP development and will use input from licensed geologists when potentially unstable areas are identified. Slope stability (e.g. presence of inner gorge slopes, debris slide slopes, and other unstable areas) and future maintenance considerations will be the determiners as to what extent, if any, new road construction is feasible. If feasible, construction of new roads will prove beneficial to the landowner by reducing harvesting costs, improving access for reforestation, wildlife management, and wildfire control activities. The scoping of a potential road alignment will be conducted by a registered professional forester and reviewed by a licensed geologist and if considered feasible will be proposed and evaluated as part of the CEQA-equivalent, multi-agency THP review process.

Wet Weather Road Use and road construction/re-construction restrictions and requirements, to be implemented for the protection of water quality, are described in Section 6.0.

6.0 Sediment and Adverse Stream Temperature Prevention and Minimization Strategy

This section identifies measures to be implemented during future forestry activities for:

- Riparian and Watercourse Protection
- Landslide Prevention
- Harvest-Related Sediment Prevention
- Road-Related Sediment Prevention

6.1 HCP Watershed Analysis Prescriptions (LEED 2004)

All timber operations in the Stitz Creek watershed are subject to the Lower Eel/Eel Delta (LEED 2004) Watershed Analysis Prescriptions.

These enforceable forestry prescriptions were established as part of the HCP Watershed Analysis process (HCP 6.3.2) in collaboration with state and federal HCP signatory wildlife agencies including DFW, NOAA Fisheries, and USFWS. The prescriptions prevent or minimize sediment delivery to streams and maintain and restore riparian forests for the benefit of shade canopy and large woody debris recruitment through restrictions and/or specific requirements for timber harvest and road construction/re-construction activities in riparian areas, steep streamside slopes, and unstable areas.

LEED Prescriptions Based on Watershed Analysis are provided in Appendix D.

Some key elements of the prescriptions include:

1. 100 foot no-harvest zones adjacent Class I and II watercourses, with licensed geologic review and additional harvest restrictions applicable up to 300 feet slope distance from the watercourse, dependent upon watercourse classification and slope condition (e.g. >50% slope) [*sediment; temperature; LWD recruitment*];
2. licensed geologic assessment required for proposed harvest on slopes greater than 50% within 300 feet of a Class III watercourse [*sediment*];

3. licensed geologic assessment (per CGS note 45) and retention of a minimum of 150 ft^2 of basal area per acre required for harvest in headwall swale areas connected to Class I, II, or III watercourses [*sediment*];
4. No timber harvest or road construction/re-construction on unstable areas (e.g. inner gorge, headwall swale, earthflow, debris slide slope) and/or slopes >60% without on-site licensed geologic assessment including due consideration of risk to downslope aquatic habitat [*sediment*];
5. Ground-based equipment exclusion zones (EEZ) adjacent to watercourses [*sediment*]:
    a. Class I watercourses – minimum 150 feet
    b. Class II watercourses – minimum 100 feet
    c. Class III watercourses – minimum 50 feet or hydrologic divide

Watershed Analysis prescriptions are subject to modification as a result of WA re-visitation or HCP adaptive management.

6.2 Control of Sediment from Roads and Other Sources

Section 6.3.3 of the HRC HCP establishes measures for control of sediment from roads and other sources. A brief synopsis of each relevant HCP section is provided in this section with full HCP sediment control measures provided in Appendix E.

6.2.1 Road Construction, Reconstruction, and Upgrades

HCP section 6.3.3.3 describes standards and guidelines for road construction, reconstruction, and upgrades. These measures are intended to prevent and minimize sediment delivery during and subsequent these activities.

6.2.2 Road Maintenance

HCP section 6.3.3.4 describes measures to be taken to prevent or minimize sediment delivery related with road maintenance activities.

6.2.3 Road Inspections

HCP section 6.3.3.5 outlines road inspection requirements to be conducted to insure roads maintenance needs are identified on an annual basis and in response to large storm events.

6.2.4 Wet Weather Road Use Restrictions

HCP section 6.3.3.6 describes conditions under which various types of road use – from log hauling to light vehicle use - is permitted during the wet weather period (October 15 – May 1). Roads are required to meet and be maintained to a specific 'permanent' standard designed to minimize sediment delivery if log hauling is to occur during dry periods of the wet weather period.

6.2.5 Measures to Minimize Surface Erosion in Riparian Areas

HCP section 6.3.3.8 describes specific environmental conditions relative to exposed soils in riparian areas that require application of effective erosion control measures and the timing within which application must occur.

6.3 Methodology for Conducting THP Geologic Review

HRC uses a multivariate approach for evaluating landslide hazards relative to proposed land use activities within the Stitz Creek watershed. Data generated from both qualitative and quantitative approaches are assessed.

As part of THP planning, a review of pertinent published technical data including landslide inventories, regional geomorphic maps, and historic stereo-paired aerial photographs are conducted to denote potential high risk slopes. The *Hillslope Management Check List* is used to identify regions susceptible to landslide processes based on the Lower Eel and Eel Delta Watershed Analysis (PALCO 2004).

Following the evaluation of available data, a ground based investigation is conducted, as warranted, to further examine mapped landforms and features previously unobserved as well as to determine the relation of mass wasting events (if present) to past land use activities. This investigation also includes the collection of general landslide attributes for use in the comprehensive watershed-wide landslide inventory.

A report containing pertinent data, conclusions, and remedial treatment recommendations is developed when site conditions, land use activities, and watershed analysis prescriptions warrant. This report is signed by a state licensed professional geologist (P.G.) and prepared in general conformance with California Geologic Survey (CGS) Note 45 guidelines. Hazard reduction measures prescribed in the report are developed in association with a state license professional forester (R.P.F) and follow procedures detailed in the Lower Eel and Eel Delta Watershed Analysis.

6.4 Watershed-Wide Harvest Rate

In addition to individual THP measures, HRC recognizes the NCRWQCB's concern over the potential for cumulative adverse effects if too much harvest occurs in the watershed over too short a time period.

In order to insure meeting the NCRWQCB's mandate for restoration of all the beneficial uses of Stitz Creek, HRC proposes establishing (within the WDR), a maximum watershed-wide harvest rate of no greater than 30 percent of the total watershed area within a ten year time period (2013-2022).

Details regarding planned harvest over the next ten years are provided in Section 5.0 of this document.

6.5 California Forest Practice Rules and Department of Fish and Wildlife Code 1600

The following California Forest Practice Rule (FPR) requirements and restrictions on timber operations are designed to prevent and/or minimize adverse effects to watershed and water quality values including those potentially resulting from sediment delivery and removal of streamside riparian canopy. These rules are enforced by CAL-FIRE.

Reference	Description	Citation
FPR	Erosion Hazard Rating	912.5
FPR	Cumulative Impact Assessment	912.9
FPR	Post Harvest Stocking	913
FPR	Tractor Ops Limitations	914.2 (f)
FPR	Site Preparation Addendum	915
FPR	Servicing of Logging Equipment	914.5
FPR	Waterbreaks	914.6
FPR	Winter Ops	914.7
FPR	Tractor Crossings	914.8
FPR	Watercourse and Lake Protection	916
FPR	Domestic Water Supply Protection	916.10
FPR	Logging Practices	921.5
FPR	Logging Roads and Landings	923 et. Seq.
FPR	Road Maintenance Period	923.4
FPR	LTO Requirements	1022.1

A THP prepared by a registered professional forester must be approved by California Department of Forestry prior to conducting timber operations. The plan is subject to multi-disciplinary state and federal review as well as review by the public prior to approval. Site specific recommendations for the protection of water quality and related beneficial uses may be made and incorporated into the THP during this review process.

In addition, formal agreements must be reviewed and approved by the California Department of Fish and Wildlife prior to lake or streambed alteration which includes the construction and/or removal of stream crossings where such activities may affect aquatic habitat. Site-specific DFW recommendations for the benefit of water quality and related beneficial uses may be made and incorporated into these agreements.

6.6 THP Monitoring and Reporting

HRC proposes the following THP monitoring and reporting program for areas of active operations:

Active harvest areas including harvest units, appurtenant roads and individual erosion control sites will be inspected a minimum of three times per year. 'Active' is defined as project areas where timber operations have commenced.

1. Inspect harvested areas, appurtenant roads, and ECP sites by November 15 assure project areas are secure for the winter; and/or immediately following cessation of winter period timber harvest activities.
2. Inspect harvested areas, appurtenant roads, and ECP sites again following 10 inches of cumulative rainfall between November 15 and March 1 to assess the effectiveness of management measures designed to address controllable sediment discharges and to determine if any new controllable sediment discharge sources have developed.
3. After April 1 and before June 15, asses the effectiveness of management measures designed to address controllable sediment discharges and to determine if any new controllable sediment discharge sources have developed.

Inspection records will be maintained for each THP and reported to the NCRWQCB annually. Discharges in potential violation of the Basin Plan will be reported to the NCRWQCB at the time of discovery. Inspections will be continued until a final completion report has been received from CAL-FIRE and an ECP Notice of Termination submitted to the NCRWQCB.

No ECP inspections will be required where timber harvest activities have not commenced.

7.0 Water Quality Monitoring

Turbidity and suspended sediment concentration monitoring has not been conducted in the Stitz Creek watershed by HRC.

HRC briefly monitored a number of habitat quality characteristics in Stitz Creek, which established baseline data to guide future adaptive management practices in the watershed and [to a lesser extent] determine trends in habitat quality/quantity over time.

The monitoring program was initiated in 1999 by conducting a longitudinal thalweg profile along a 180 meter long reach and a cross-sectional profile of the channel at a location which would later become ATM Station 171 (established in 2000). These channel surveys were then repeated the following year in the summer of 2000, with the establishment of ATM Stations 171 and 172. Comprehensive habitat characteristics were measured at both locations in 2000, including surface substrate size distributions, pool dimension & frequency, and large woody debris piece frequency. Both ATM stations were discontinued after just one year of habitat data collection, although stream temperatures were monitored for several additional years at Station 171 (2004-2018) and once at Station 172 (2016) due to an erroneous placement of the temperature logger. Stream temperature data collection will continue at ATM Station 171 into the future until further notice.

HRC's Water Quality Monitoring Summary for the Stitz Creek Watershed (1999-2018) is included as Appendix F and includes methodology, results summary, and discussion of trends observed.

8.0 Salmonid Habitat Restoration Assessment

Stitz Creek riparian conditions were dramatically affected by mid-twentieth century and subsequent pre-HCP logging activities which removed streamside shade canopy and had adverse effects on slope stability which, in combination with earthquakes and significant storm events, has resulted in periods of elevated stream temperature and landslide-derived sediment blanketing the channel for much of the Class I (fish-bearing) reach of the stream. The most recent watershed-wide disturbing storm event occurred in December 1996, which caused disruptions to both channel and habitat characteristics. Recognition of these events and their effects is the basis for the NCRWQCB's request for watershed-wide waste discharge requirements.

Based on HRC's current knowledge of Class I extent, Stitz Creek and its tributaries provides approximately three miles of suitable spawning, rearing, and overwintering habitats for resident steelhead and cutthroat trout. Chinook and coho salmon have also been observed in years prior, but are restricted to the lower portion of the watercourse due to the culvert beneath the Shively Road crossing which is thought to be a barrier to anadromy.

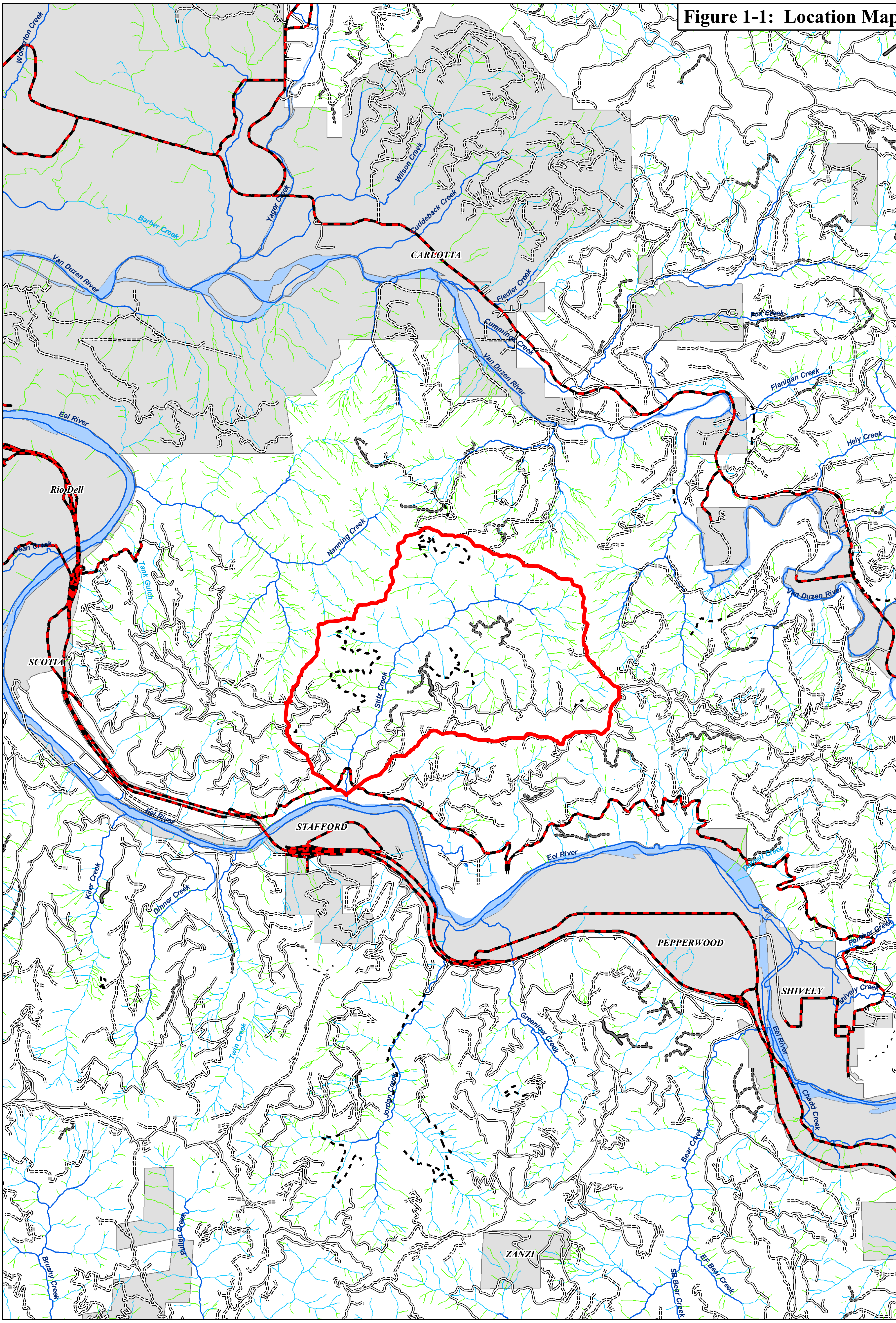
The California Department of Fish and Wildlife (CDFW) conducted two separate stream inventory assessments in the summers of 1992 and 2010 (see appendixes G and H). Each of these surveys collected comprehensive data on habitat characteristics and provided recommendations for future restoration activities to enhance Stitz Creek as an anadromous, natural production Class I watercourse. Most notably, modifications to the Shively Road culvert should be considered to restore anadromous fish passage and allow woody debris accumulations (LDAs) to pass downstream at an uninterrupted rate. Strategic modifications to existing LDAs may allow the mobilization of woody material and slow release of fine sediments trapped within. Where feasible, it was recommended that log/root wad structures be engineered and strategically placed in flatwater habitat units to increase the overall frequency, depth, and complexity of pool habitats to support rearing juvenile salmonids.

HRC may be interested in partnering with state and federal agencies, non-profits, and Humboldt County in the development and implementation of an instream/riparian plan and barrier modification to improve anadromous fish habitat in Stitz Creek.

9.0 List of Figures

10.0 List of Appendices

Figure 1-1: Location Map



Humboldt Redwood Company, LLC

Title

Feet
4,000 2,000 0 4,000

Paved Roads	Legacy Abandoned Road	Class 1	River
Rocked Roads	Closed Rocked Roads	Class 2	Other Private
Dirt Roads	Decommissioned Roads	Class 3	HRC
Closed Dirt Roads			Stitz Creek

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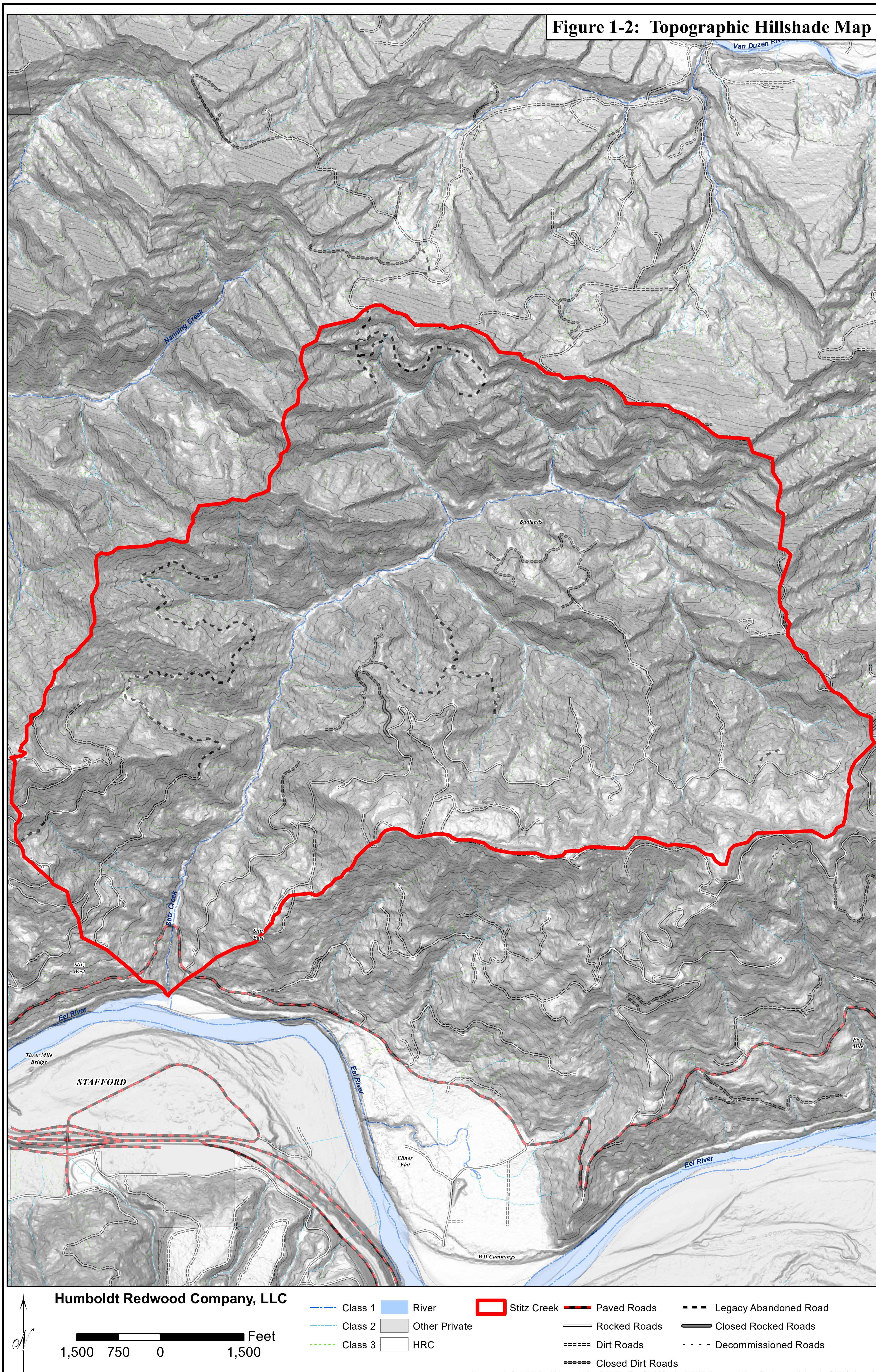


Figure 1-2: Topographic Hillshade Map

Figure 3-1 Stitz Creek Harvest Acreage History*

Silviculture	Pre 1954	1954-1966	1966-1974	1974-1985	1986-1989	1990-1999	2000-2007	2008-2010
CC/Seed tree	2381	176		551	1115	399	130	
CC/Rehab							0	
Partial Harvest**						203	44	
Shelter wood and Shelterwood Removal						88	68	
Alternate Rx							28	
Total	2381	176	0	551	1115	690	270	0

* Harvest History includes acreage of subsequent re-entries to previously harvested areas

** Partial Harvest includes selection, seed tree removal, and commercial thinning silviculture

Figure 3-2 Stitz Creek Road Miles Construction History

Road Construction History	Pre 1999	1999-2016	Unknown		Total
HRC Ownership	17.9	0.8	0.1		18.8

Current Road Condition (HRC Ownership)	Storm-Proofed	Non-Storm-Proofed	Total
Open*	9.0	3.1	12.1
Closed/Abandoned**	1.4	5.3	6.7
Total miles	*10.4*	*8.4*	*18.8*

Surface Type for Open Roads	Paved	Rock	Native	Closed/ Abandond	Total
HRC	0	6.8	6.7	5.3	18.8
Other Owner***	0.4	0	0	0	0.4
Total miles	*0.4*	*6.8*	*6.7*	*5.3*	*19.2*

* 'Open' roads include permanent all-season, permanent seasonal, and temporary roads with temporary stream crossings removed after use

** ‘Closed/Abandoned’ roads include those where stream crossings have been decommissioned and future use of the road is unlikely.

***Other owner is Humboldt County Public Works

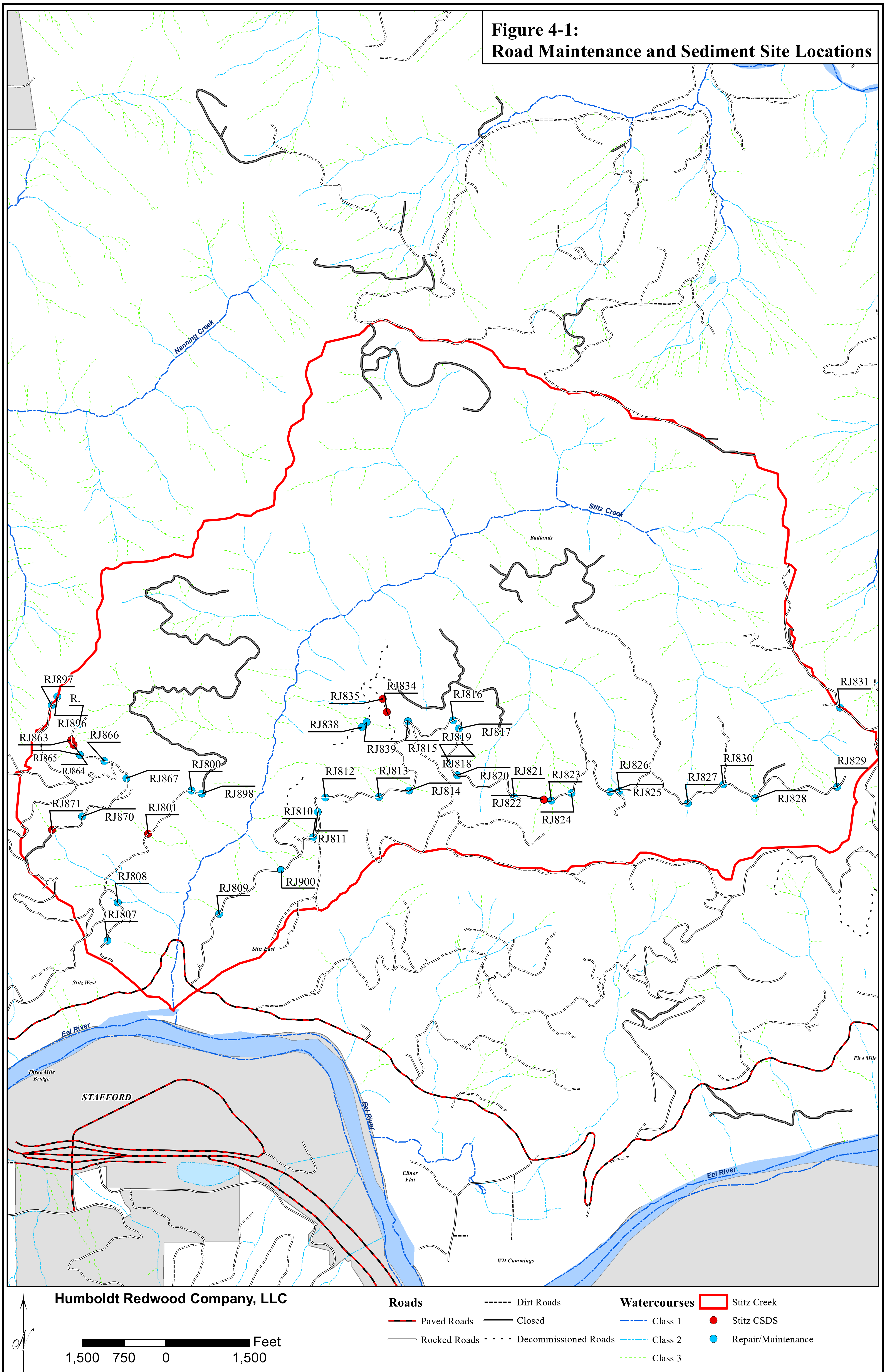
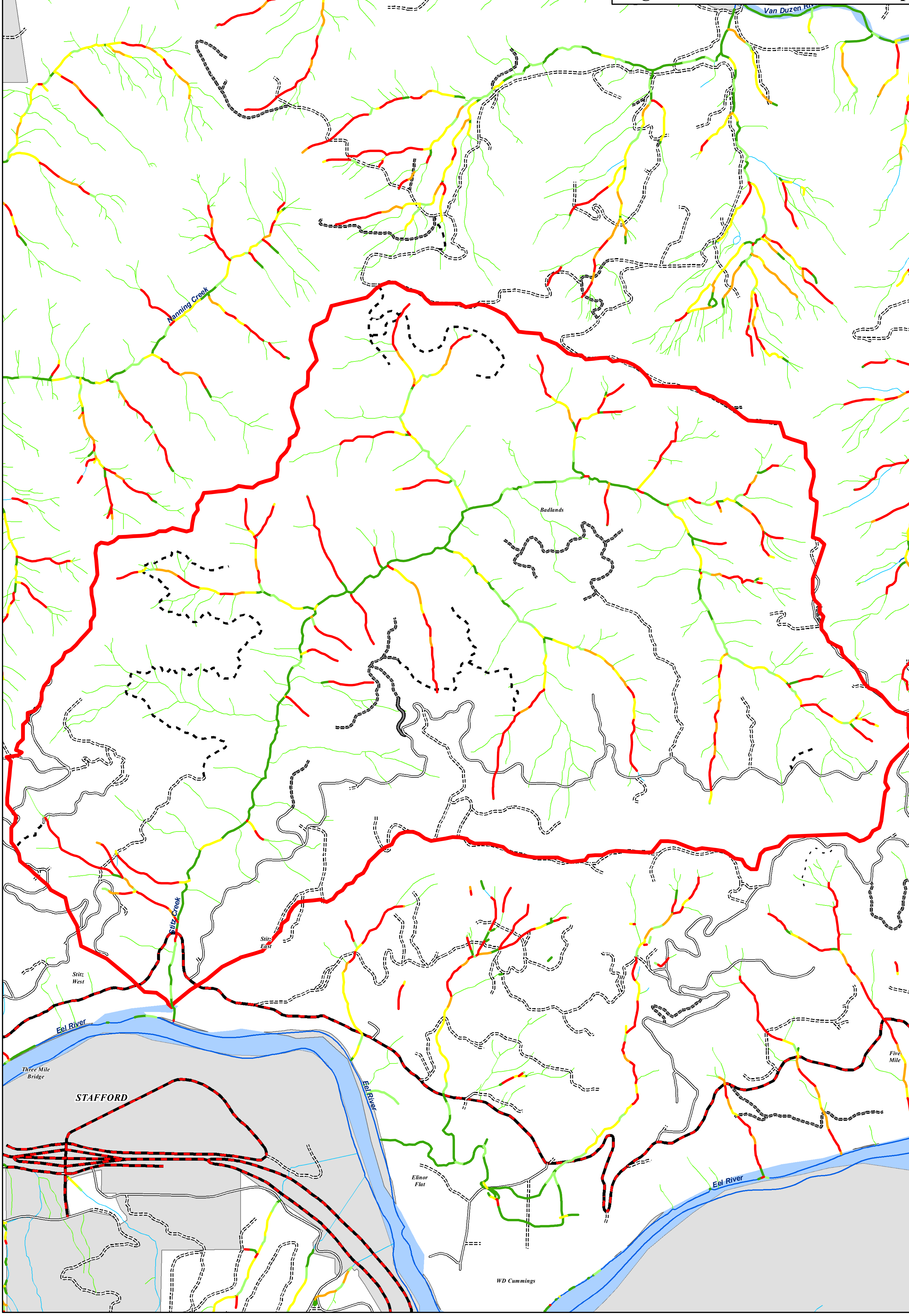


Figure 4-1:
Road Maintenance and Sediment Site Locations
Nanning Creek
Stitz Creek
Badlands
RJ897
RJ896
RJ863
RJ865
RJ864
RJ866
RJ867
RJ800
RJ898
RJ871
RJ870
RJ801
RJ808
RJ807
RJ809
RJ900
RJ810
RJ811
RJ812
RJ813
RJ814
RJ835
RJ834
RJ838
RJ839
RJ815
RJ816
RJ817
RJ819
RJ818
RJ820
RJ821
RJ822
RJ823
RJ824
RJ826
RJ825
RJ827
RJ830
RJ828
RJ829
RJ831
Stitz East
Stitz West
Eel River
Three Mile Bridge
STAFFORD
Elinor Flat
WD Cummings
Five Mile
Humboldt Redwood Company, LLC
Feet
1,500 750 0 1,500
Roads
Paved Roads
Rocked Roads
Dirt Roads
Closed
Decommissioned Roads
Watercourses
Class 1
Class 2
Class 3
Stitz Creek
Stitz CSDS
Repair/Maintenance
Document Path: S:\SCOPAC\Forestry\Private\THPWork\watkins\Stitz Creek ROWD\figure 4_1Road status, maintenance, and sed site map.mxd

Figure 4-2: Stream Gradient Map



Humboldt Redwood Company, LLC

Feet
1,500 750 0 1,500

Stream Gradient
0-4%
5-8%
9-16%
17-20%
>20%
Stitz Creek

Class 1
Class 2
Class 3
River
Other
HRC
Paved Roads
Rocked Roads
Dirt Roads
Closed Dirt Roads
Legacy Abandoned Road
Closed Rocked Roads
Decommissioned Roads

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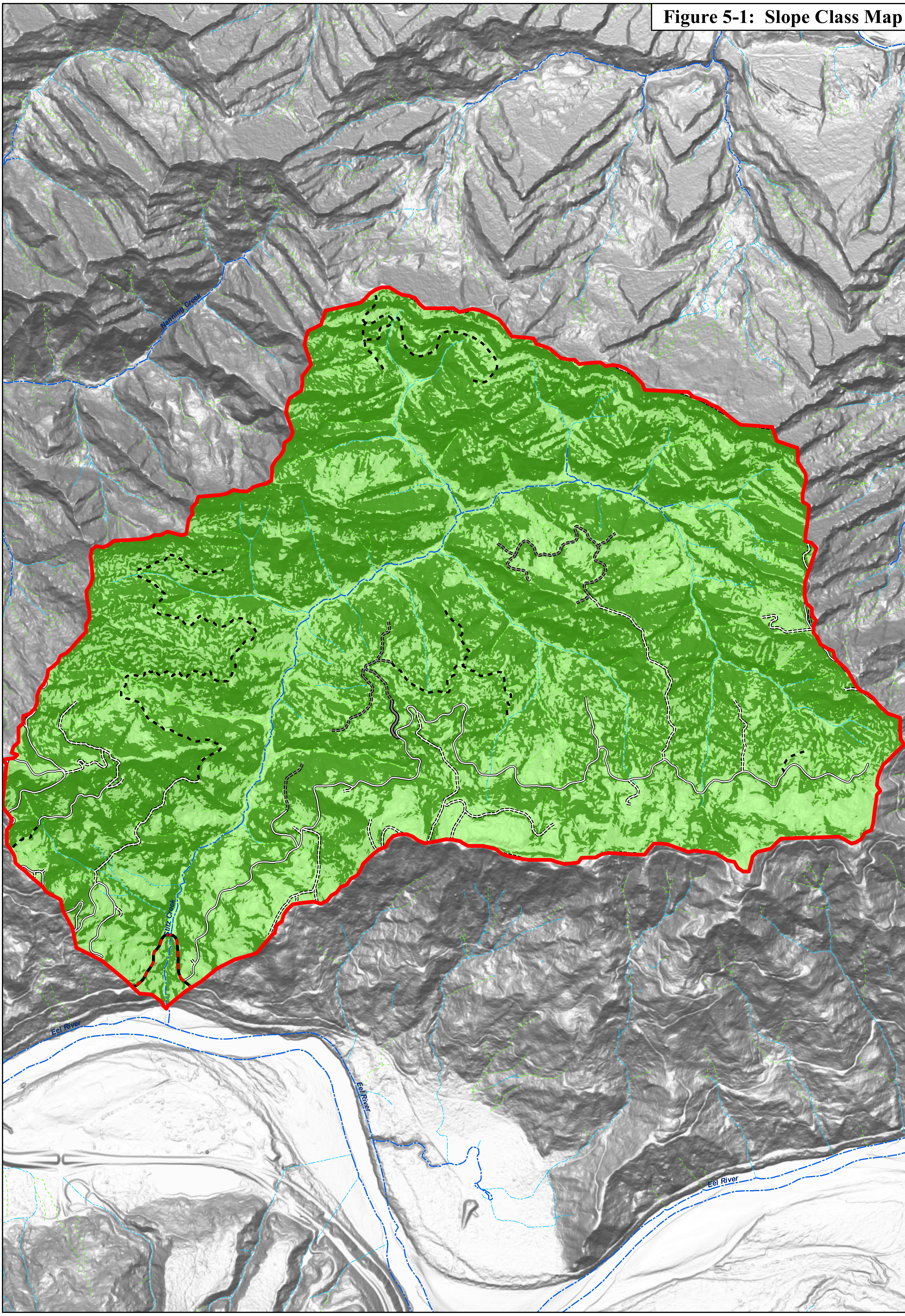
Figure 5-1: Slope Class Map



Humboldt Redwood Company, LLC

N

1,500 750 0 1,500 Feet

Slope

0 - 40%

> 40%

Stitz Creek

Paved Roads

Rocked Roads

Dirt Roads

Closed Dirt Roads

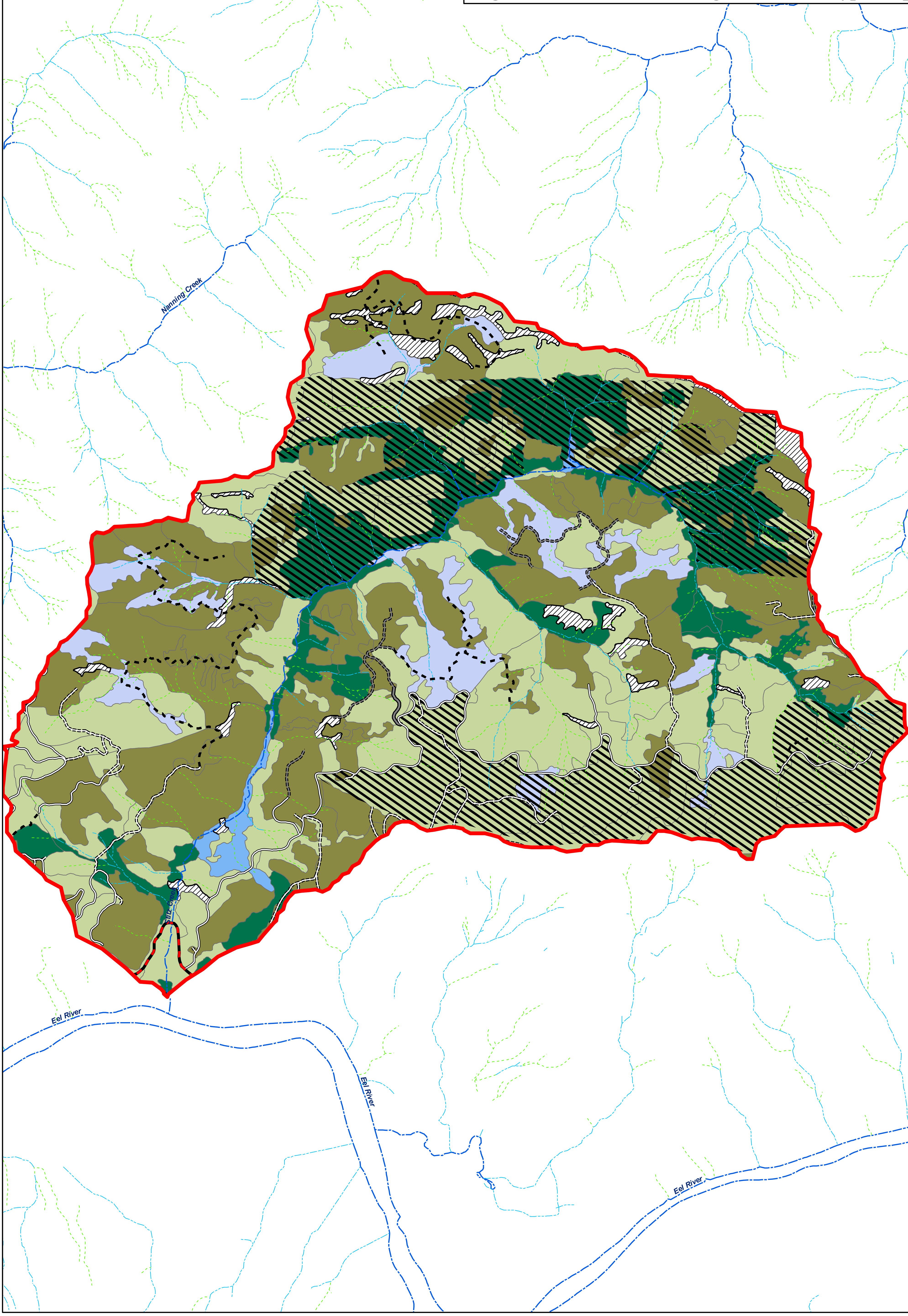
Legacy Abandoned Road

Closed Rocked Roads

Decommissioned Roads

Document Path: S:\SCOPAC\Forestry\Private\THPWork\watkins\Stitz Creek ROWD\maps and shape files\maps and shape files\Fig5-1 Slope Class Map.mxd

Figure 5-2: Harvest Planning and Timber Type Map



Humboldt Redwood Company, LLC

Feet
1,500 750 0 1,500

Stitz Creek

WA Boundary

Potential Harvest

Timber Type

Large_RWDF

Medium_RWDF

Young_RWDF

Medium_HW

Young_HW

NonT

Document Path: S:\SCOPAC\Forestry\Private\THPWork\watkins\Stitz Creek ROWD\maps and shape files\maps and shape files\Fig5-2 Harvest Planning and Timber Type Map.mxd

Humboldt Redwood™
NATURALLY STRONG, NATURALLY BEAUTIFUL

LANDSLIDE INVENTORY FOR THE 2003, 2006, AND 2010 STORM SEASONS, STITZ CREEK, HUMBOLDT COUNTY, CA

Prepared for:

North Coast Regional Water Quality Control Board
5550 Skylane Blvd STE A
Santa Rosa, CA 95403

By:

Spencer Watkins, PG 9081
HRC Forestry Department

INTRODUCTION

Project Description

This report presents the results of a landslide inventory for the Stitz Creek watershed for the 2003, 2006, and 2010 Water Year (WY) conducted by Humboldt Redwood Company (HRC). Aerial photographs were used to identify landslides, estimate sediment production, and delivery to watercourses for each WY. Landslide attributes were recorded for each landslide and were subsequently analyzed to quantify associations with potential geomorphic and/or management related influences.

Rainfall during the 2003 and 2006 WY represents the first two major storm events since the implementation of HRC's Habitat Conservation Plan (HCP). Precipitation during the 2010 WY was above average but less intense than 2003 and 2006. Landsliding was widespread throughout the region during these storm seasons and are considered landslide-triggering events.

Study Area

Stitz Creek is located in the Lower Eel River Watershed in northern California. The watershed contains approximately 2,575 acres and drains to the Eel River about 3 miles east of the town of Scotia, California. The deeply incised watercourses of Stitz Creek form a dendritic drainage pattern on slopes ranging from 1,680 feet in elevation along the ridge forming the southeastern boundary of the watershed to approximately 80 feet in elevation at the confluence with the Eel River. Pertinent location information is listed in Table 1.

Table 1: Pertinent Location Information	
Legal Description	Section 2, 10, 11, 12, 13, 14, and 15 Township 1N, Range 1E, HB&M.
USGS Quadrangle	Scotia 7.5-minute quadrangle.
Cal Watershed	Jordan Creek 1111.120202

Methods

High-angle, stereo paired, aerial photographs scaled at 1:12,000 were reviewed to identify landslides that occurred in response precipitation associated with 2003, 2006, and 2010 WY. Our scope of work included identification of mass wasting features on aerial imagery taken in the summer of 2003, 2006, and 2010; plotting features on 10-foot DEM topographic maps produced from LiDAR; and recording pertinent landslide attributes. Slide attributes such as type of failure, dimensions, geomorphic associations, land use association, percent delivery, and discharge volumes for individual events was documented in spread sheet data forms.

In the absence of field data, landslide dimensional attributes were recorded from aerial photographs using a 20/inch engineering scale (resolution of ~25 feet). Landslide depths were modeled between 3 to 5 feet for shallow events (S) and 10 to 12 feet for deep events (D). The area-volume relationships developed by Cruden and Varnes (1996) were used to calculate the landslide displacement volumes with the half ellipsoid equation: $1/6\,\pi\,LWD$. L = length, W = width, D = depth.

Landslide classification was used in general accordance with California Geologic Survey Note 50 (1997) and Cruden and Varnes (1996).

Mass wasting mapping was restricted to those areas that exhibited evidence of recent movement (raw or sparsely vegetated with brush/ grass). A small portion of the landslides were evaluated in the field to acquire true dimensional attributes. Surface erosion was not evaluated. Road and watercourse GIS layers were used to identify road and watercourse associations relative to landslide locations.

STRUCTURAL/GEOLOGIC SETTING

Regional Structural Setting

The Stitz Creek watershed is located within the Northern Coast Ranges Province of California, which is characterized by north-northwest oriented ranges that reflect the dominant regional structural trend. In the northern most part of the province, the structural trend is dominated by northwest striking, northeast dipping thrust faults and northwest trending fold axes that accommodate northeast directed shortening. Shortening is in response to convergence of the North American and Gorda Plates across the Cascadia subduction zone. In the southern part of the province, the local structural grain is dominated by north-northwest trending strike-slip faults associated with the San Andreas transform margin between the North American and Pacific Plates. Between the northern and southern portions of the province, the northwest trending structure is overprinted with west-northwesterly trending folds and thrust faults. The superimposed west-northwest trending structures are generally accepted to be a result of the northward migration of the Mendocino Triple Junction (Kelsey and Carver, 1988; Aalto et al., 1995). The Mendocino Triple Junction (MTJ) marks the location where the Cascadia subduction zone to the north transitions to the San Andreas transform margin to the south.

Seismotectonic Setting

Stitz Creek is located within a seismically active area. Because of the seismotectonic setting there are numerous sources for potentially large earthquakes. In general, the seismic sources are a manifestation of the interaction between the North American, Gorda, and Pacific Plates. There is an estimated ten percent chance of 0.6-0.9 g (60 to 90 percent of the acceleration due to gravity) being exceeded in fifty years (Petersen et al., 1996). The estimated ground accelerations are approximate and not intended for use in site-specific investigations (Petersen et al., 1996).

No active faults are mapped passing through the project area, and no part of the plan lies within and/or adjacent to an Alquist-Priolo Earthquake Fault Zone. The nearest known fault that is "zoned" as active is the Little Salmon fault (Hart and Bryant, 1997) (3.5 mile north). This particular structure is a northwest-trending, northeast-dipping thrust fault zone that dissects slopes along the northern valley wall of the Van Duzen River basin. It is part of a broad, 15-mile wide fold and thrust belt that accommodates onshore deformation associated with the Cascadia Subduction Zone.

Ground motion affiliated with a large seismic event in this semi-mountainous/steep terrain would likely trigger or reactivate landslides within the project area. It is well documented that earthquake-induced landslides often occur at localities where slopes are naturally unstable under nonseismic conditions (Keefer, 1984). Consequently, there is the potential that some landslides could be triggered on slopes within the Stitz Creek area following a significant seismic event. Site response during strong ground motion will depend on a complex interaction between site-specific conditions of earth materials, topography, lithology, hydrology, earthquake wave travel path and distance to source.

Geologic Setting

Published literature and geologic maps of the region (Ogle, 1953; Spittler, 1982; Kilbourne, 1985; McLaughlin and others, 2000) indicate the study area is predominantly underlain by bedrock associated with Middle Miocene to Late Pleistocene age Wildcat Group sediments, specifically the Pullen, Scotia Bluffs, and Carlotta formations as well as the Undifferentiated Wildcat Group. Approximately 130 acres at the mouth of the basin is mapped as underlain by the Tertiary to Cretaceous age Yager terrane of the Coastal Belt of the Franciscan Complex.

The Wildcat Group consists of five sedimentary formations that were unconformably deposited onto Coastal Belt bedrock of Franciscan Complex in the ancestral Eel River Basin. These formations represent an upward-coarsening sequence ranging from inner-shelf, fine-grain sandstone, siltstone, and mudstone to nearshore sands and gravels (marine and non-marine). This upward coarsening of lithologies demonstrates the transition (regression) from a deep-water offshore environment (Pullen formation) to a near-shore marine or terrestrial alluvial environment (Carlotta formation).

The Pullen formation is the oldest unit of the Wildcat Group and extends into the southwestern portion of the study area overlying the Yager terrane in angular unconformity. The section is thickest and most complete along the Eel River near Scotia and thins in all directions. No exposures have been identified north of the Little Salmon Fault. The lithology varies greatly within the unit but is generally comprised of dark-blue gray mudstones and cream colored diatomaceous mudstones and siltstones low in the section and transitioning to greenish brown sandstones.

In the early 1950s Ogle (1953) classified Wildcat Group sediments northeast of the Little Salmon fault as undifferentiated, because of the poor exposures and general lack of distinctive lithologies and indicator fossils. Undifferentiated Wildcat underlies approximately half the Stitz Creek basin, as mapped by Ogle (1953). Regional compilation mapping by Spittler (1982) identifies similar lithologies and contact locations as the previous mapping by Ogle (1953). Sediments associated with the Undifferentiated Wildcat Group are commonly described as moderately indurated, fine- to medium-grained sandstone, siltstone, and claystone with minor pebble- and cobble-bearing conglomerate. Shell hash observed in portions of the study area suggests that some of the Undifferentiated Wildcat Group sediments could possibly be re-categorized as Rio Dell Formation.

The Scotia Bluffs Formation, which unconformably overlies the Rio Dell Formation is comprised of near-shore, fine-grained, massive sandstone intermixed with minor amounts of siltstone, mudstone, and conglomerate. Sandstone affiliated with the Scotia Bluffs Formation is moderately- to well- consolidated and weathers to a grayish or light brown color. Conglomerates in the Scotia Bluffs Formation are generally made up of well-rounded, pebble-sized clasts of sandstone, chert, schist, and quartz. These sediments are derived from Franciscan Complex Coastal and Central belt lithologies that are commonly located to the south of the basin. Narrow ridges with near-vertical bluff faces are also commonly affiliated with this formation.

The Carlotta Formation is atop and interlaid with the Scotia Bluffs sandstone forming a gradational contact. Deposition of the Carlotta likely occurred in near shore and non-marine environments based on massive coarse conglomerates, poorly sorted sandstones, bedded and massive siltstones and mudstones, and the occurrence of redwood logs found in some deposits. The massive conglomerate beds often grade up from coarse to fine sand, which grades to fine gray silt and claystone. The massive sandstone beds are generally dirtier and coarser than the typical sandstone of the Scotia Bluffs formation, and weathers to a brown color. The thickest and most complete section of the unit occurs within the Eel River syncline and thins to the north and west.

The Yager terrane is a 5,000 foot thick section representing the uppermost limits of the Franciscan Complex likely dating to the Eocene, but could extend into the Oligocene and/or the Paleocene. The rocks include argillite, sandstone, and conglomerate forming thin-beds of turbidity mudstone interbedded with sandstone bearing organics resulting in carbonate concretions and carbonate layers in the mudstone (McLaughlin and others, 2000). The turbidity beds indicate that this terrane was formed near the continental margin, likely near a delta. Rocks of the Yager terrane are less sheared than the older Franciscan formation and much more consolidated than the overlying Wildcat Group resulting in greater relief due to differential erosion.

Geomorphic Setting
The bedrock contacts within the drainage are reflected in the topographic expression which is distinctly different in the northern, upslope, portion of the drainage underlain by Scotia Bluffs and Carlotta formations. These northerly dipping beds exhibit differential weathering resulting in pronounced cuesta morphology. Asymmetric, east-west trending ridgelines consist of moderately inclined north-facing dip-slopes and precipitously steep, south-facing end-slopes (bluffs) that do not support robust timber stands. Where present, intersecting fracture planes produce wedge failures, also rock topple events occur on the more prominent end-slope bluffs resulting in deposition of colluvial aprons at their base. Dip-slopes, ranging from 20 to 35 degrees, are prone to debris slides and flows especially within watercourses and on streamside slopes. Watercourses underlain by Scotia Bluffs have a tendency to follow the bluff alignments due to the northward dipping beds and south-facing bluffs.

Slopes underlain by the Undifferentiated Wildcat sediments are void of distinct bluffs with moderate to steep slopes regularly transitioning from concave to convex in response to the dense stream network. Tributaries within this bedrock unit typically extend upslope to steep headwalls. Alluvium within the main stem of Stitz Creek form low gradient terraces. The active channel has incised the alluvium forming steep, easily erodible banks which expose poorly graded silts and sands. Deposition and formation of the stream terraces predate the initial harvest entry (circa 1900-1920) based on the terrace surfaces being used for the construction of a railroad grade. Historic aggradations of the terrace surfaces due to overbank flooding is evidenced by the partial burial of remaining old growth stumps and saw cut timbers associated with railroad trestles. Generally, watercourse morphology within the basin displays a deeply entrenched dendritic pattern characteristic of initial incision into a region of gentle slope with secondary structural control (Bloom, 1978). This is consistent with uplift, deformation, and erosion of a regionally gently inclined coastal plain and entrenchment of an antecedent drainage network.

As expected, the entrenched drainage network, coupled with underlying geologic formations, strongly correlates with landslide distribution and frequency of both shallow and deep-seated landslides; with shallow landslides concentrated in steeply inclined streamside slopes and deep-seated landslides often encompassing the entirety of tributary drainages. Where the watercourses have eroded into the end-slopes of the Scotia Bluffs and Carlotta formations, shallow landsliding appears increasingly frequent while slopes underlain by Undifferentiated Wildcat appear more prone to deep-seated landsliding. Geomorphic mapping conducted for watershed analysis and the HCP used eight sets of aerial photographs, spanning a 50 year period following the initial harvest entry. The mapping for watershed analysis did not identify landforms, such as inner gorges, headwall swales, and debris slide slopes, however, the areas identified as shallow landslides strongly correlate with previous mapping of these landforms compiled by the California Geologic Survey (1999). This correlation is reinforced by the conclusions of watershed analysis that inner gorge slopes, steep streamside slopes, and headwall swales present the highest hazard of failure and delivery of sediment to a watercourse under management conditions and formulated prescriptions to address the hazard (PALCO, 2004). The landslide inventory previously developed for watershed analysis is an essential tool for determining if observed landslides are reactivations of previous mapping.

HYDROLOGIC DATA

Oswald Geologic (2008a and 2008b) compiled annual, monthly, and daily precipitation data for 2003, 2006, and 2010 WY for the Reports of Waste Discharge (ROWD) for Bear Creek and Jordan Creek Watershed Landslide Inventories. Rainfall data present in the landslide inventory reports (Oswald Geologic, 2008a; 2008b) was measured at the NOAA weather stations in Scotia and on Woodley Island, California.

The function of the precipitation data presented by Oswald Geologic (2008a and 2008b) is to highlight the relation between precipitation and landslide frequency. The climate data analysis presented in the Bear and Jordan Creek Landslide Inventories is complete and accurate; this report builds upon those studies and draws additional conclusions observed in the data recorded since 2008.

The proximity of the study area to Jordan Creek (1.8 miles) and Bear Creek (4.3 miles) suggests the data, as previously presented, is applicable and at least as accurate based on the location of Stitz Creek in relation to the Scotia gauging station, which was used for the annual and monthly climate data presented in the previous Landslide Inventories (REF.).

Regional Climate

The climate of the study area is strongly influenced by the proximity to coastal mountains. Coastal influence provides a temperate climate with high humidity and steep terrain creating orographic effects that focus precipitation onto upland slopes. Winter storms created by offshore low-pressure systems bring moisture-laden air from the east Pacific focusing intense and prolonged periods of precipitation on the region. The storm season lasts from October to April and generally accounts for approximately 90% of the annual precipitation.

Annual Precipitation

Average annual rainfall in Scotia California, through 2016 WY, is 47.07 inches. This average is 1.63 inches less than the average reported by Oswald Geologic (2008a and 2008b). Two factors contribute to this discrepancy: the four year drought occurring between 2011 and 2015, and this record begins in 1926 rather than 1932. The 2003 and 2006 WY brought above average rainfall and rank 9th and 5th respectively for wettest on record. The 2010 WY was also above average (ranking 16th wettest on record) but was only 9.4 inches above average while 2003 and 2006 were 17.91 inches and 23.73 inches above average respectively. Figure 1 shows annual precipitation totals recorded at the Scotia weather station from 1926 to 2016 with the 2003, 2006, and 2010 WY totals labeled, as well as the average annual rainfall for reference.

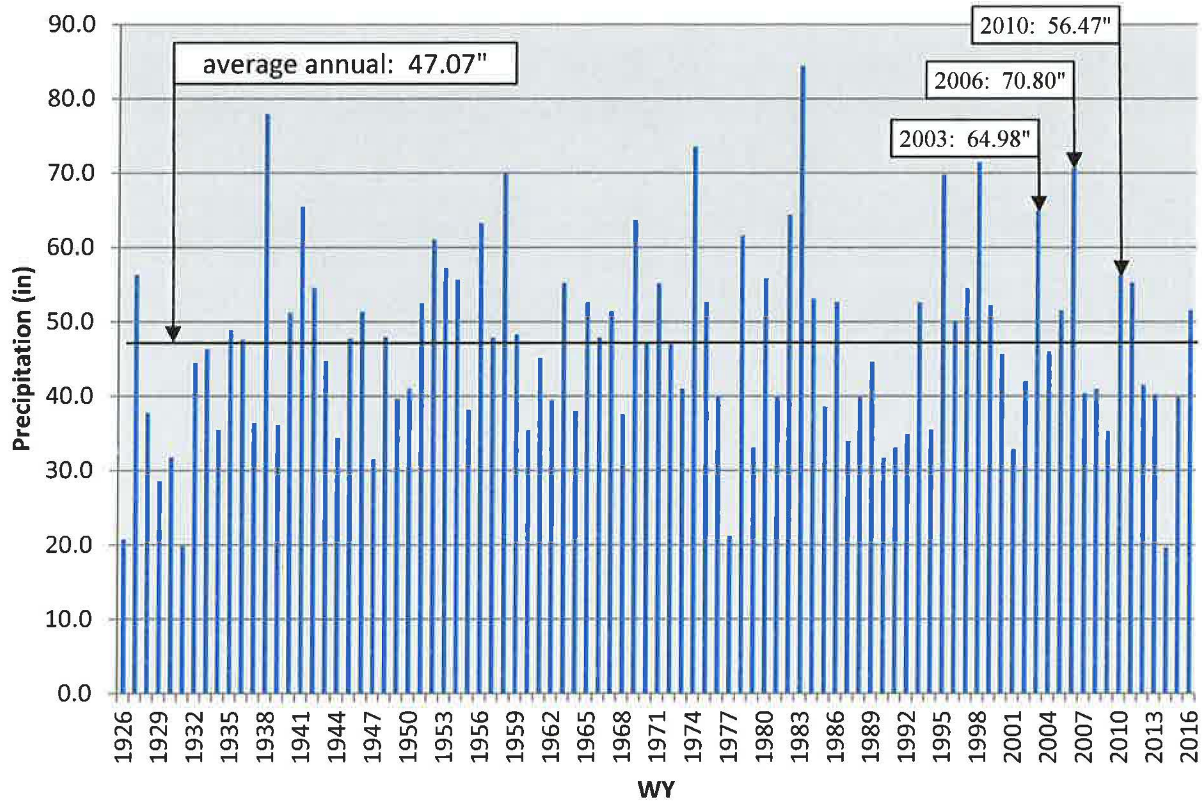


Figure 1: Annual Precipitation at the Scotia CA, NOAA Weather Station from 1926 to 2016.

Monthly Precipitation

Oswald Geologic (2008a and 2008b) attributes landsliding from 1997 to be influenced by strong ground accelerations generated from the M>6.5 earthquakes on the Cape Mendocino fault between 1992 and 1994. Other research has demonstrated that ground shaking can weaken resisting forces inherent to hillslopes and create conditions prone to landslides during ensuing rain events (Dadson et al., 2004; Keefer, 1984). While annual totals for 1997 WY were only slightly above average, rainfall between December, 1996 and January, 1997 had well above average rainfall. The 2003 and 2006 storm seasons were not preceeded by earthquakes large enough to influence regional landsliding but did receive significantly above average rainfall, especially later in the season (i.e. March and April) when antecedent soil-moisture levels were elevated and could provide a mechanism for regional precipitation-driven landsliding.

The 2010 HY produced above average annual precipitation. The monthly totals, presented in Figure 2, show January and April made the two larges departures above monthly averages. May and June also had above average totals but less than 4 inches of rain fell during each of those months. The months of October through December each received 4 to 5 inches of rain and February and March recorded 5 to 6 inches. Although the annual total was above average, there were not consecutive months of percistent, torrential rainfall that lead to saturated soil conditions.

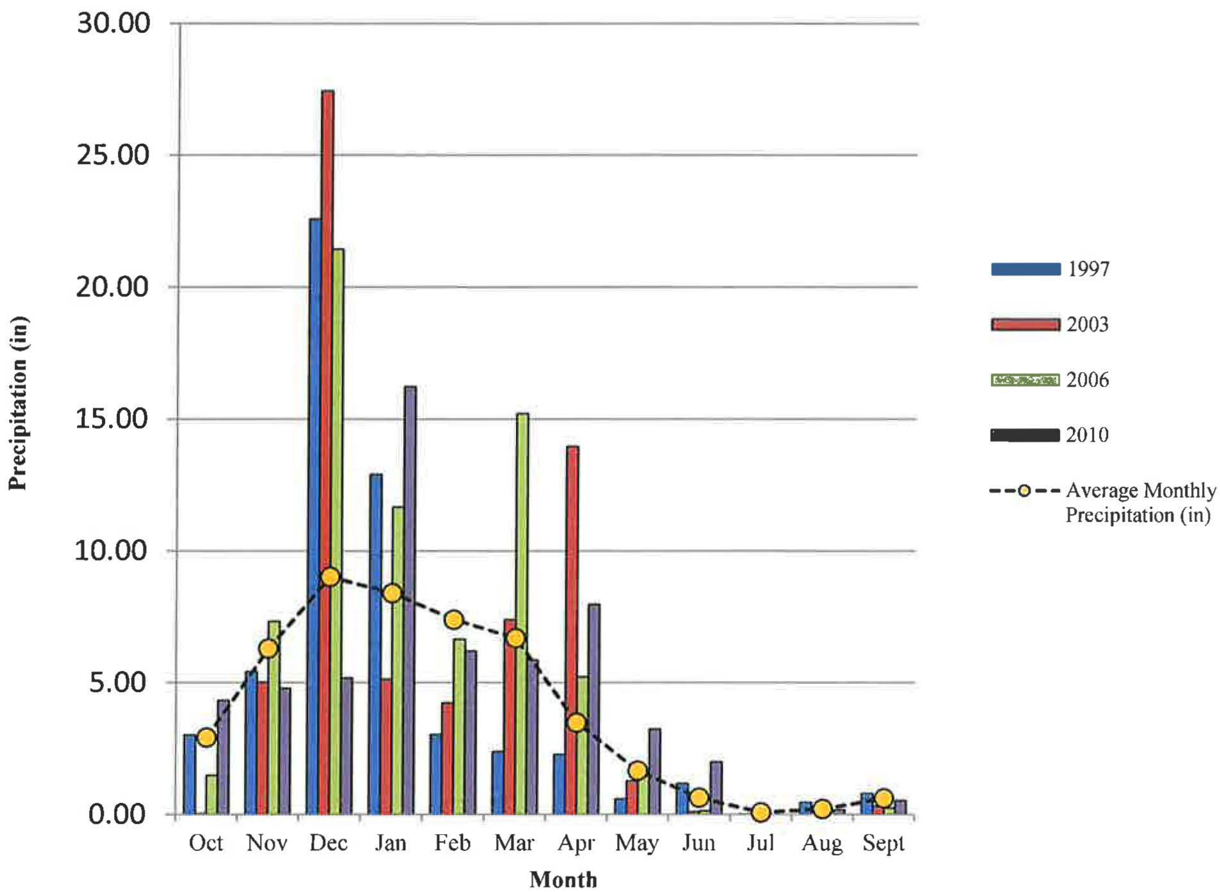


Figure 2: Monthly rainfall totals for 1997, 2003, 2006, and 2010 HY with 90 year average.

Daily Precipitation

This section contains a brief summary of daily precipitation for 2003, 2006 and 2010 WY. The 2003 WY experienced nine rainfall records (Table 2) including 4.68 inches in a 12-hour period in late December. While significant rain events occurred throughout the 2003 WY, late season rainfall in early April produced an array of landslides reported throughout the county.

Table 2: Climate Records for Eureka CA, 1887-2014		
12 Hour Maximum	4.68	Dec 27, 2002
24 Hour Maximum	6.85	Dec 27-28, 2002
1 Calendar Day Maximum	6.79	Dec 27, 2002
2 Calendar Day Maximum	8.82	Dec 27-28, 2002
3 Calendar Day Maximum	9.04	Dec 27-29, 2002
4 Calendar Day Maximum	10.49	Dec 27-30, 2002
5 Calendar Day Maximum	11.11	Dec 27-31, 2002
15 Calendar Day Maximum	18.39	Dec 14-28, 2002
Greatest in Calendar Month	23.31	Dec 2002

Precipitation data for the 2006 WY (Figure 3) indicates one inch of rainfall in a 24 hour period was exceeded 6 times, and between late December and early February over ½ inch of rain per day occurred for most of that time period. On December 31, 2005 the Eel River recorded a historic crest of 53.13 feet which ranks the 6th highest for the period of record. The series of storms that generated the crest caused widespread flooding and landsliding so severe that Humboldt County was declared a State disaster area.

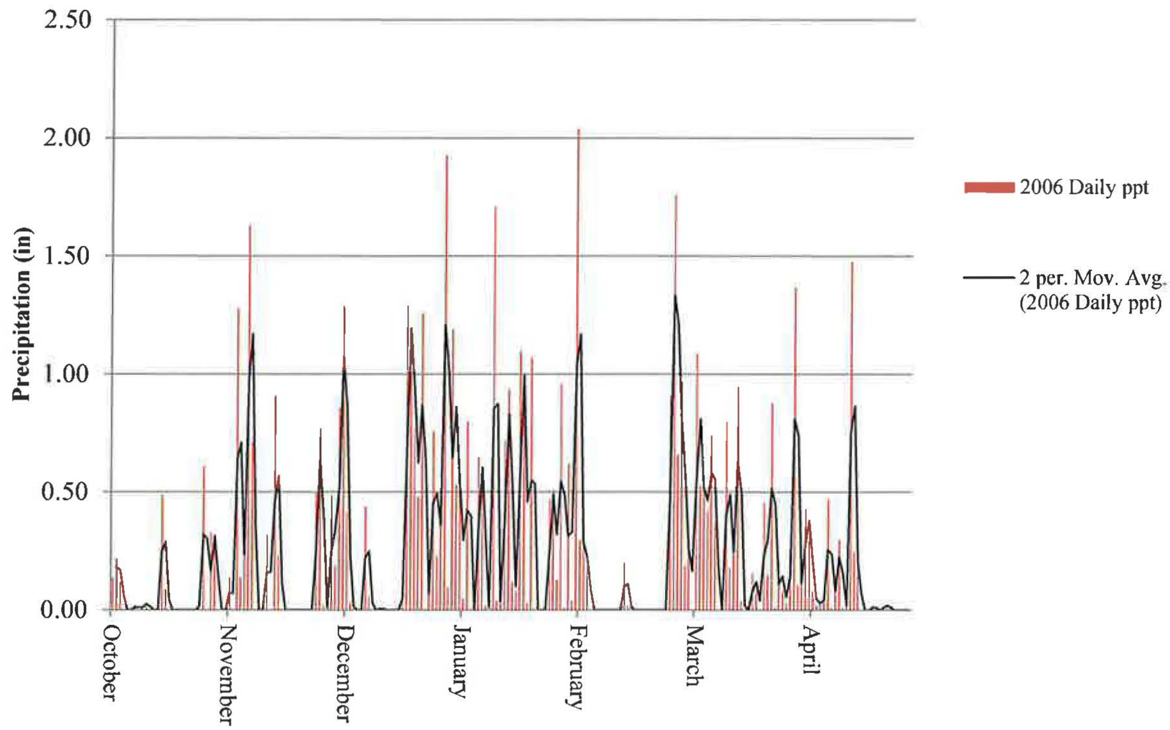


Figure 3: Daily precipitation totals measured at the NOAA weather station in Eureka for the 2006 WY with 2-day moving average.

The daily precipitation data compiled for 2010 WY are displayed in Figure 4. The 2-day moving average shows that one inch of precipitation in a 24 hour period was exceeded 3 times; twice as many occurrences took place in 2006. Although several daily precipitation totals exceeded one inch during 2010, the temporal distribution of these events appears relatively evenly spaced throughout the wet season. The sustained precipitation between late December and early February noted in the 2006 record is absent in 2010, and no time-period in 2010 had significant sustained precipitation between large storms comparable to the 2006 wet season. The total annual rainfall in 2006 WY was 14.33 inches greater than in 2010 WY.

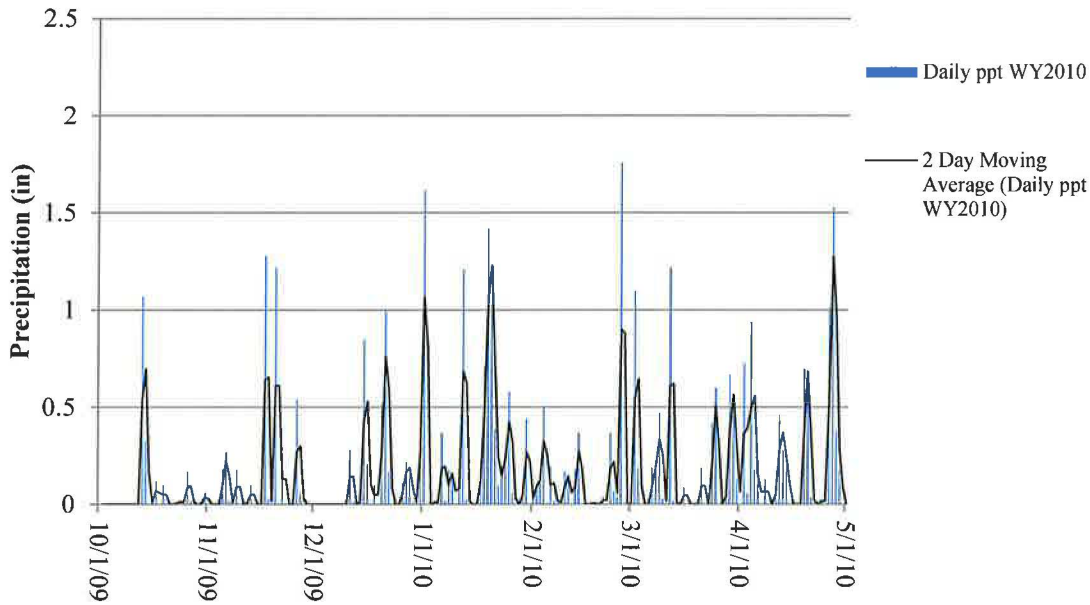


Figure 4: Daily precipitation totals mesured at the NOAA weather station in Eureka for the 2010 WY with a 2-day moving average.

Analysis of the precipitation data for the 2003 and 2006 WY show above average annual rainfall totals and above average selected monthly totals. Both of these storm seasons received significant precipitation volumes late in the season when antecedent soil-moisture levels were elevated and hillslopes were likely saturated from large December rainfall totals. Although the 2010 storm season was above average by comparison to 2003 and 2006, 2010 received substantially less rainfall with reduced duration and intensity of individual precipitation events. The climatic setting leading to the 2003 and 2006 precipitation-driven landslides were not present during the 2010 storm season as evidenced by the annual, monthly, and daily precipitation totals and reinforced by the number of landslides observed in during the respective years of study.

LANDSLIDE INVENTORY

Area-Frequency Relationships

Landslide frequency and magnitude in the Stitz Creek drainage-area dramatically decreased from 2003 to 2010. Mapping of the aerial photographic identified landslides is presented in Appendices A, B, and C for each year of review with the corresponding attribute tables presented in Appendices D, E, and F. Figure 5 plots the frequency against the estimated area of each landslide for each year of study. The distribution of landslide sizes is heavily skewed towards smaller landslides with few outliers of larger landslides. This skewed distribution is a characteristic of landslide inventories worldwide (Guzzetti et al., 2002; Malamud et al., 2004; Oswald, 2008a and 2008b). The largest landslide observed in 2003 was approximately $^4/_5$ of an acre and the largest in 2006 was $^9/_{10}$ of an acre. The largest landslide in 2010 was ½ of an acre. These larger slides also tend to be the largest contributors to the landslide sediment budget.

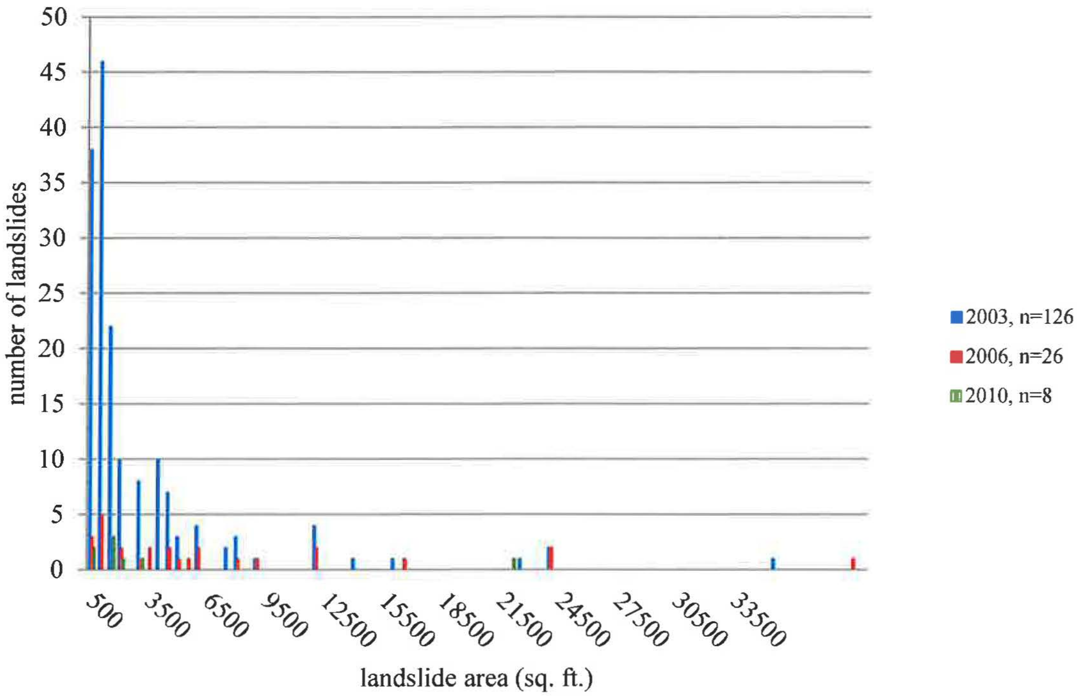


Figure 5: Number of landslides per area of displacement for 2003, 2006, and 2010.

Figures 6-8 show the landslide area-frequency distribution plotted on a log-log graph and, demonstrate completeness of the inventory. The cumulative area-frequency curve for the 2003 season follows a straight line over the larger area landslides. A straight line on a log-log graph can be referred to as a log-transformed power law curve. This is advantageous for 2 reasons: it is easier to visualize the data, and it is easier to work with a linear function when doing statistical analysis. The deviation from the log-transformed power law correlation at the smaller landslide size is a result of the physical lower limit of landslide size before surface erosion processes dominate, and to some extent the ability to detect small landslides in a forested landscape, and also in part to limitations in observing small landslides in aerial photography (Malamud et al., 2004). A fall off of values from the power law at the larger sized landslides would indicate an incomplete catalog or under sampling in the mid-size range. Large earthflows/compound failures can be difficult to observe in aerial photography when rotational movement occurs with minimal translational displacement. This is not observed for the 2003 and 2006 inventory years. Due to the small sample size of landslides observed for the 2010 inventory the cumulative area-frequency graph is not well developed relevant to the power law correlation. It should be noted that significantly more small landslides were observed in 2003, with approximately 50% being less than 1,000 ft^2. Approximately 30% of 2006 landslide areas and 25% of the 2010 landslide areas were under 1,000 ft^2.

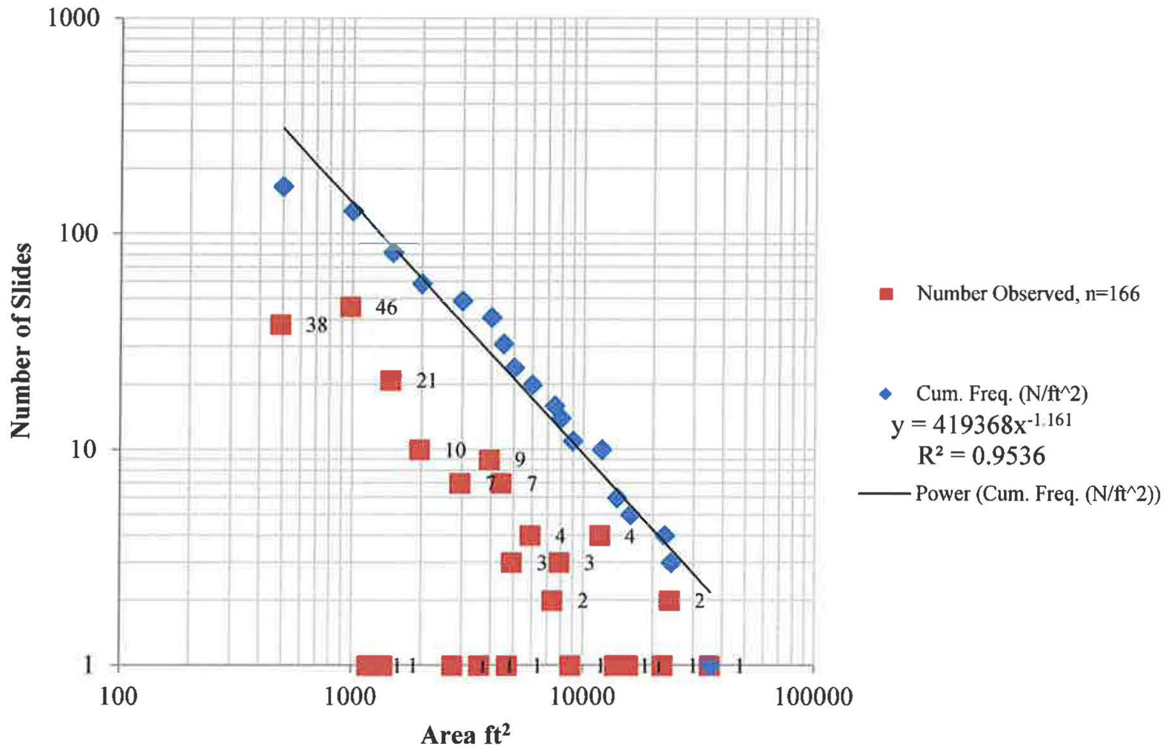


Figure 6: Log-log area-frequency distribution for 2003 landslide inventory. Trend line is a log transformed power function.

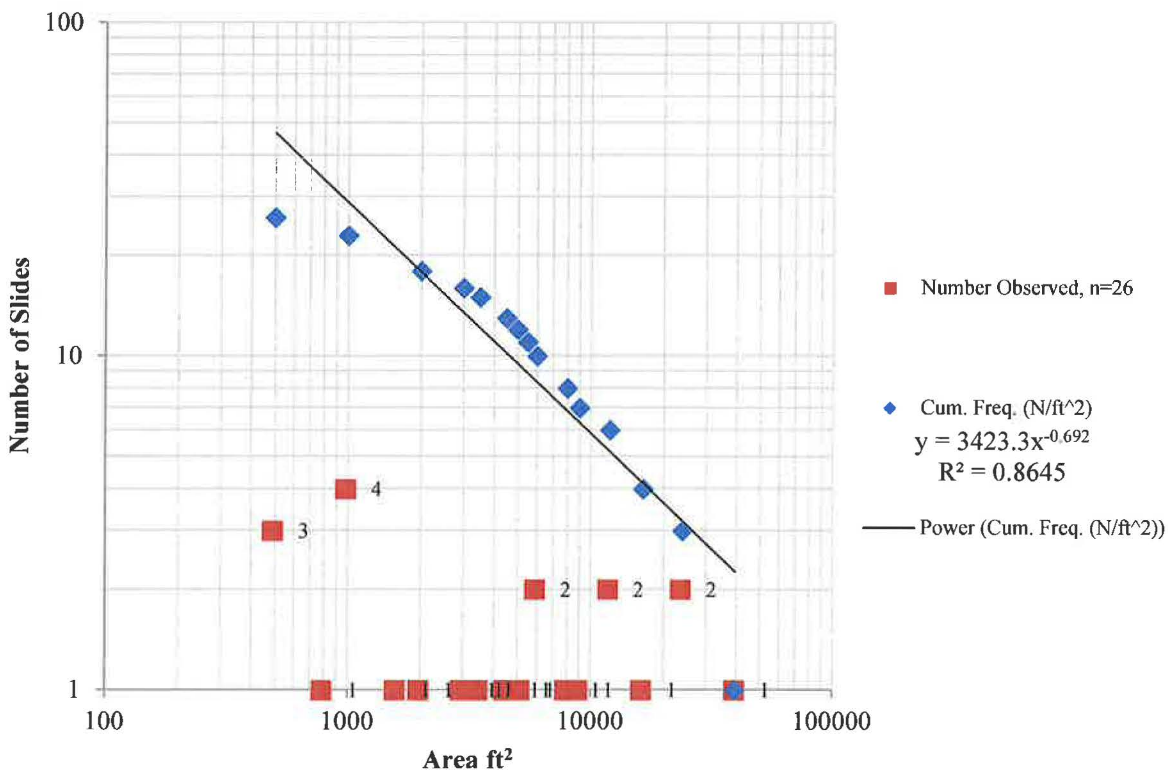


Figure 7: Log-log area-frequency distribution for 2006 landslide inventory. Trend line is a log transformed power function

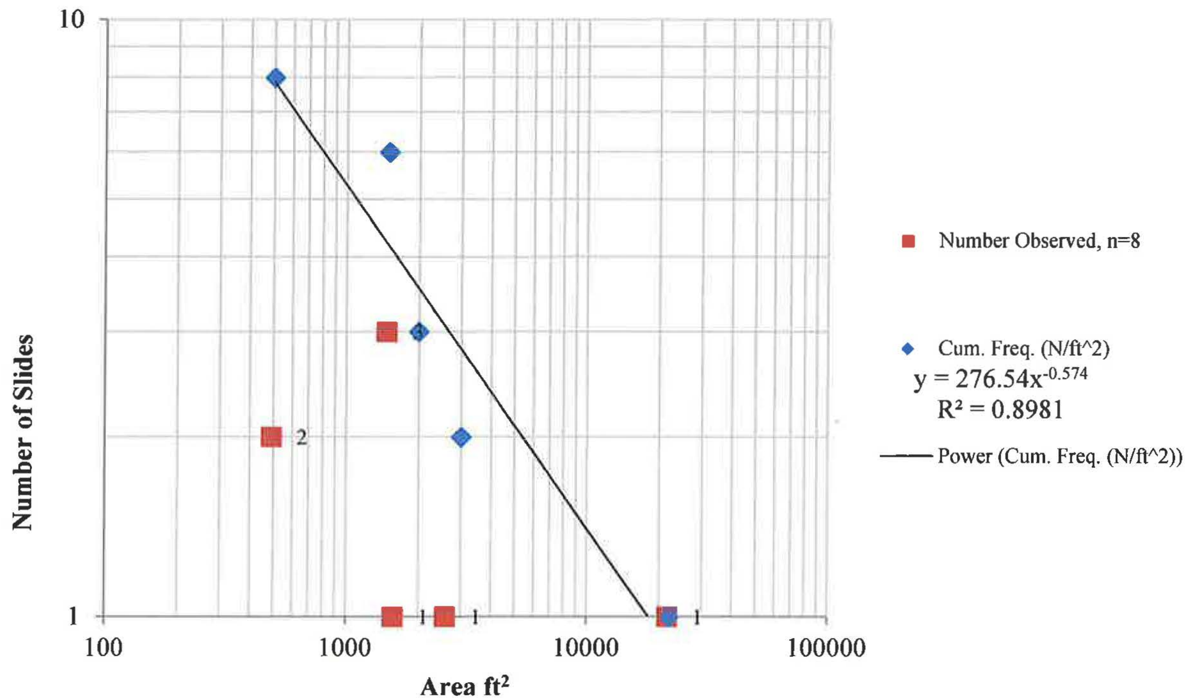


Figure 8: Log-log area-frequency distribution for 2010 landslide inventory. Trend line is a log transformed power function

Geomorphic Association

The majority of the landslides in all three aerial photographic years are associated with geomorphic landforms that developed on, or in conjunction with, steep to very steep slopes, particularly where adjacent watercourses. Swales (SW), bluffs (BL), break-in-slope (BIS), and inner gorge slopes (IG) are associated with the highest frequency of landsides. One hundred and fifty four (77%) of the mapped landslides initiated from within one of these four geomorphic terranes. Approximately 82% of all the landslides recorded in the 2003 inventory and slightly over 65% of all landslides for the 2006 season were associated with these morphologies. In the 2010 season, 75% of landslides occurred on one of these geomorphic associations.

Figure 9 is a graphical representation of landslide population and its relationship to the identified geomorphic associations. While intuitive that the slope gradient of landslide initiation sites are predominantly located on steep to very steep slopes, this data set reinforces that geomorphic landforms identified as associated with failure are more likely to occur on steeper slopes.

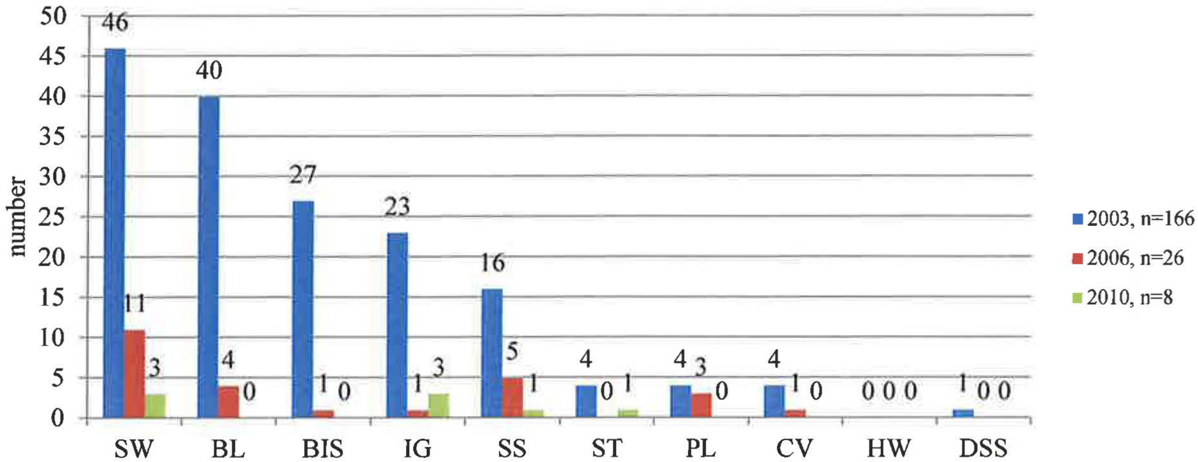


Figure 9: Geomorphic associations of landslides for the 2003, 2006, and 2010 landslide inventories.

Management Association

Several attributes presented in Figures 10-12 and discussed below, were gathered to compare landslide occurrences with management associations. Management activities included silvivulutral prescription and grading activities (i.e road/skid trail construction). In order to acquire a clearer picture of the influence of management-related activities on landslides, it is necessary to determine if each landslide is a reactivation, and its temporal relationship to management activities. The data indicates 56%, 73%, and 88% of the landslides were reactivations of pre-existing failures for the 2003, 2006, and 2010 WYs respectively. The significance of this relationship to current and future management strategies will be discussed later.

Land Use Associations

Land use categorizes included general levels of harvest (clearcut [CC], partial [PC], etc.,) noted through aerial imagery and review of past harvest plans in addition to instabilities that are directly linked to road-building activities (road cut [RC], road fill [RF], etc.). Land use association refers to the land use activity observed at the site of failure and is shown in Figure 10. Several types of road associations are listed but differ from road condition associations discussed below. When used in this category road associations indicate actual observed failure on a road prism, whereas road condition associations indicate roads that cross or lead to a failure and have a possible association with the failure that may only be spatial in nature.

Fifty-six failures occurred directly adjacent to or within road/skid trail travel ways, with 60% of these events initiating in fill embankments. Many of the failed segments occurred along roadways that were constructed in the mid 1980's. Road-related landslide activity from this era is often a reflection of un-engineered fill slopes and excessive cut slope heights resulting from poor route placement. Clear cuts and road fill slopes are significant contributors to management related landslides.

Partial harvesting (PC) accounts for the majority of these potential harvest-related landslides observed in 2003 (32%), 2006 (42%), and 2010 (25%). The most common partial harvest silviculture system used in Stitz Creek basin was a Seed Tree Removal which is an even-age management strategy. Few mature trees were retained over approximately 100 acre harvest blocks. HRC's harvest history data indicates 1,115 acres were harvested using even-age management between 1986 and 1989, an additional 510 acres of even-age management occurred between 1990 and 1999, and 232 acres of even-age management between

2000 and 2007. The aggressive management practices during decades prior to this landslide inventory likely had a negative impact on slope stability.

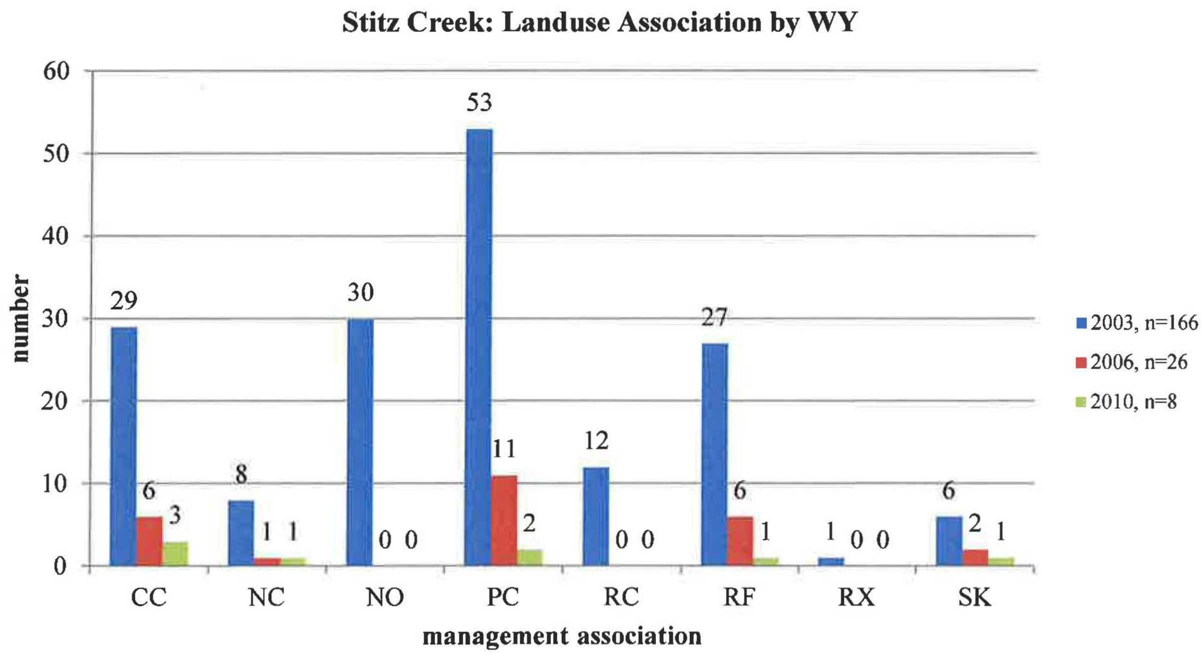


Figure 10: Land use associations for the 2003, 2006, and 2010 landslide inventories.

Road Condition Association

Approximately 71%, 77%, and 88% of failures in the 2003, 2006, and 2010 seasons, respectively, were categorized as not being road-related (Figure 11). Our survey also shows a decline in road-related failures during the inventory period. This is not surprising because of the sizable amount of decommissioning, upgrading, and storm proofing conducted since the implementation of the HCP.

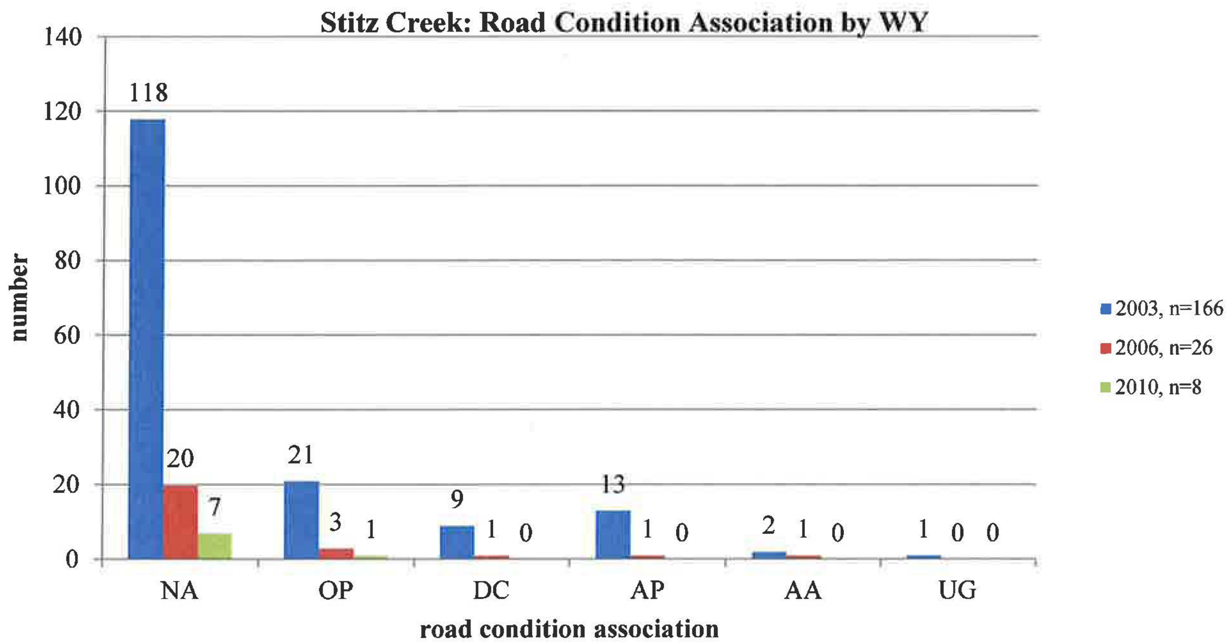


Figure 11: Road condition association for the 2003, 2006, and 2010 landslide inventories.

Stand Age

The 2003 season significantly increased the number of failures in the 10-20 year stand age class over the less than 10-year stand age (Figure 12). This is consistent with studies showing maximum loss of root strength cohesion occurs during the 7-10 year post harvest time range at which point the timing of large rain events is critical (Ziemer, 1981). The data shows a similar pattern for the 2006 season. This pattern is not present in 2010, likely due to the reduced number of observed landslides coupled with reduced acreage of stands less than 20 years old.

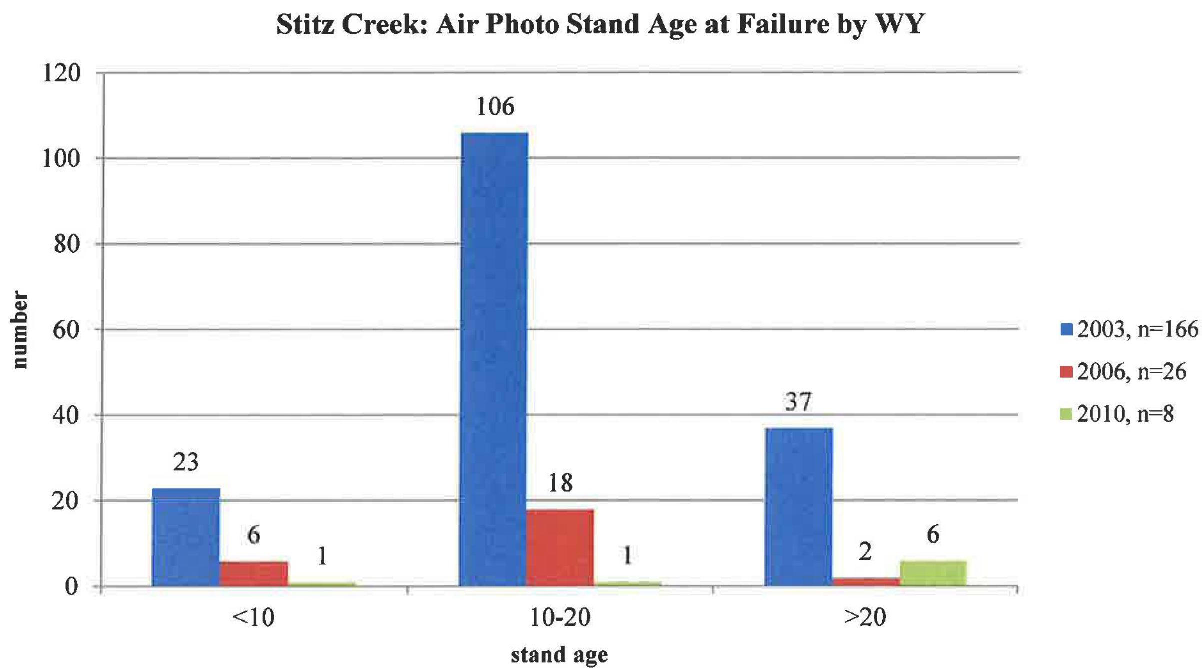
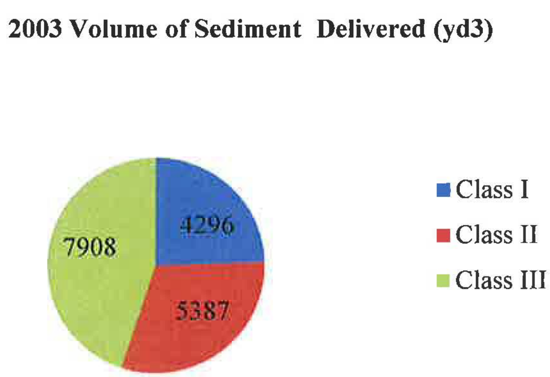


Figure 12: Air photo determined stand age at landslide locations for the 2003, 2006, and 2010 landslide inventories. Time intervals for histogram are <10, t=10 yr; <20, t=10, >20, t=30 ± 10yr; initial harvest circa 1900-1920.

Sediment Delivery Characteristics

Landslide volumes were estimated from aerial photograph measured areas and depth estimates. The volumes were calculated for displaced and delivered volumes. Percentage delivery of displaced volumes was estimated from aerial photographs. The volume estimates are crude and rely on several estimated parameters and likely contain some error. The volumes do allow for an order of magnitude estimate of sediment delivery associated with the respective years of study.



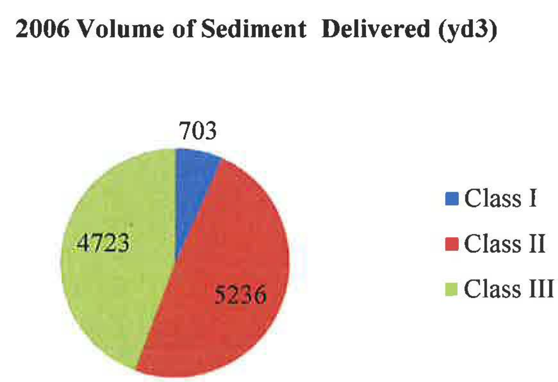


Figure 13: Volume of sediment delivered to watercourse by class for the 2003 and 2006 landslide inventories.

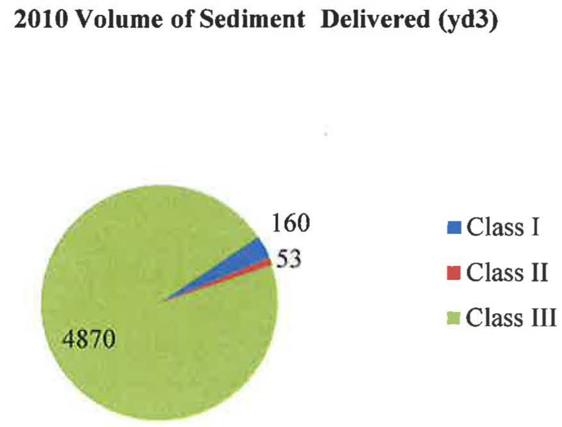


Figure 14: Volume of sediment delivered to watercourse by class for the 2010 landslide inventory.

Delivery Rate
Around half of the landslides for any given study year delivered sediment to a watercourse. In 2003, 43% of landslides delivered sediment to a watercourse, 54% delivered in 2006, and 50% delivered in 2010. Landslides that did not deliver are typically smaller and road related. Also, bluff failures/topples were less likely to delivery due to the failed material depositing at the base of the bluff with little to no runout.

Delivery Amount and Geomorphic Association
In 2003 approximately 82,944 cubic yards of earthen material was displaced by landslides. Of that, approximately 17,591 cubic yards delivered to a watercourse which equates to 21% of displaced sediment entering a watercourse in the 2003 WY. For the 2006 season 33,502 cubic yards were estimated to have been displaced and 10,662 cubic yards delivered resulting in 32% of displaced material delivering. Assessing the 2010 data indicates 6,395 cubic yards displaced with 5,083 cubic yards delivering for 79% of displaced material delivering to a watercourse. Although there is a sharp increase in percentages delivered, a significant reduction in total volume delivered occurred during the study period..

Watercourse Class
The aerial photographic inventory compiled the watercourse classification of streams that receive sediment using existing stream data. Figures 13 and 14 show delivered sediment volumes to watercourses by class. For the 2003 season, 24% of delivered sediment entered a Class I reach, 31% to Class II reaches, and 45% to Class III watercourses. Delivery characteristics for the 2006 season show 7% of delivered sediment entering a Class I reach, 49% entered a Class II reach, and 44% to a Class III. Continuing to 2010, 3% of delivered sediment entered a Class I reach, 1% to a Class II, and 96% entered a Class III watercourse. The 2010 delivery characteristics are heavily skewed due to a very small sample size (only four landslides delivered) with one large landslide entering a Class III watercourse. A potential reason for the reduced delivery volumes to the Class I streams in the 2006 season may be due the existing colluvium in the valley bottom, much of it transported there in the late 1990's. In many locations, it appears the watercourse is down-cutting within the colluvial wedge and not scouring the base of hillslopes forming the valley walls.

Timing of Management-Related Failures
A review of HRC's harvest history data was conducted to determine the timing and aerial extent of past management activities. This management layer was then overlaid across the landslide inventory layer and

used to determine landslide rates for pre- and post-HCP prescriptions (Appendix G). Rates of landsliding for pre-HCP (1984-1998) and post-HCP (1999-2010) THPs were calculated by taking total number of landslides reported within operational areas of THPs and dividing by total operational acreage and years of record. Landslides occurring in areas designated as no harvest are not included in rates for THP harvest acres, but are counted in rates for no THP and unharvested acres. Rates for no harvest areas or no THP areas were calculated over the entire period of record (1984-2010). The most recent harvest operations underlying the failure initiation site were determined and compiled for each failure.

Harvest history data goes back to 1984 for the Stitz Creek watershed. For large portions of the watershed, this is the second entry. The initial harvest entry occurred between 1900 and 1919. Harvest entries prior to 1984 were not evaluated for this analysis. A total of 177 individual landslides were mapped for the 2003, 2006, and 2010 landslide inventories. Of those, thirty-seven (21% of total) were not associated with any reported harvest activity or in non-operational areas of THPs. There are 135 (76%) landslides associated with operational areas of pre-HCP THPs. Post-HCP landslides within operational areas of THPs account for 5 (3%) of the total number of landslides.

Eight-six pre-HCP failures initiated on slopes within four harvest plans: 1-84-440HUM (34 landslides), 1-85-616HUM (12), 1-86-644HUM (18), and 1-87-342 (22). Several commonalities were observed between these four harvests. The harvest operations were conducted between 1984 and 1987 and all used the seed tree removal silviculture. Three of the four are over 100 acres and significant road construction was required to facilitate the harvests. Road-related landslides account for 42% of the landslides in these four plans. Lastly, these plans are all underlain by the Undifferentiated Wildcat bedrock which is less indurated and more prone to mass wasting then the other Wildcat Group formations present in the watershed.

There were eleven post-HCP harvest plan operations executed in Stitz Creek covering approximately 452 acres. Within these operational areas, five landslides occurred in two of the THPs: 1-01-152 HUM (2) and 1-04-139HUM (3). The silviculture prescriptions were shelterwood removal and commercial thin respectively and both were helicopter yarded. The two landslides in the 2001 THP were both road-related cut bank failures that did not deliver to a watercourse. The three landslides in the 2004 THP were all bluff failures with the only delivery occurring where a watercourse intersects the affected bluff.

The analysis of the most recent harvest history of Stitz Creek shows that approximately 83% of the watershed has undergone operations over the 26-year period (1984-2010) recognized for this study. Close to 65% occurred under pre-HCP Forest Practice Rules and 18% under post-HCP prescriptions. The landslide rate for pre-HCP THPs is calculated at $5.8\text{X}10^{-3}$ landslides acre^{-1} year^{-1}. The rate for post-HCP THP operational areas is calculated at $1.4\text{x}10^{-3}$ landslides acre^{-1} year^{-1}, over 4 times less than the pre-HCP rate. A landslide rate of $2.6\text{x}10^{-3}$ landslides acre^{-1} year^{-1} applies to 24% of the acres in the watershed classified as no harvest or areas with no THP recorded in the last 26 years. The no harvest/no THP acreage incorporates high hazard portions of the watershed avoided under pre- and post-HCP prescriptions, and possibly THPs operated on shortly before 1984.

The analysis of the timing and rate of failures combined with the majority (56%, 73%, and 88%) being reactivations of existing landslides that existed prior to 2003, 2006, and 2010 storms strongly suggests that landslides observed in the Stitz Creek watershed are overwhelmingly associated with pre-HCP operations. The review of the performance of pre-HCP and post-HCP THPs show the HCP interim and post-watershed analysis prescriptions appear to delineate and avoid or mitigate operations on and adjacent unstable areas resulting in a significant improvement over the rate of failures associated with pre-HCP harvest operations.

CONCLUSION

Previous mapping of the Stitz Creek watershed by the California Geologic Survey and HRC show that landsliding in Stitz Creek is strongly associated with inner gorges, bluff formations, and road construction. The HRC watershed analysis also indicated that pre-HCP and, in many cases, pre-California Forest Practice Rules management practices were responsible for many of the landslides. This investigation also shows association of pre-HCP management practices with landsliding in Stitz Creek.

The 2003 and 2006 seasons were significantly wetter and contained periods of relatively prolonged and intense rainfall when compared with the historical precipitation record. The two seasons should be considered precipitation-driven landslide-triggering events and are the first two events since management under the HCP began in 1999.

Review of the geomorphic and non-management associations with landsliding also points to the fact that most of the landslides in Stitz Creek are associated with inner gorges, steep streamside slopes, and vertical bluff faces. Slopes from which all of the landslide-delivering events originate are regulated under the HCP prescriptions for the Lower Eel Eel Delta watershed. The relative success of this management strategy is clearly seen in the difference in hillslope response between pre- and post-HCP THPs observed following the 2003, 2006, and 2010 seasons.

LICENSED SIGNATURE

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Humboldt Redwood Company

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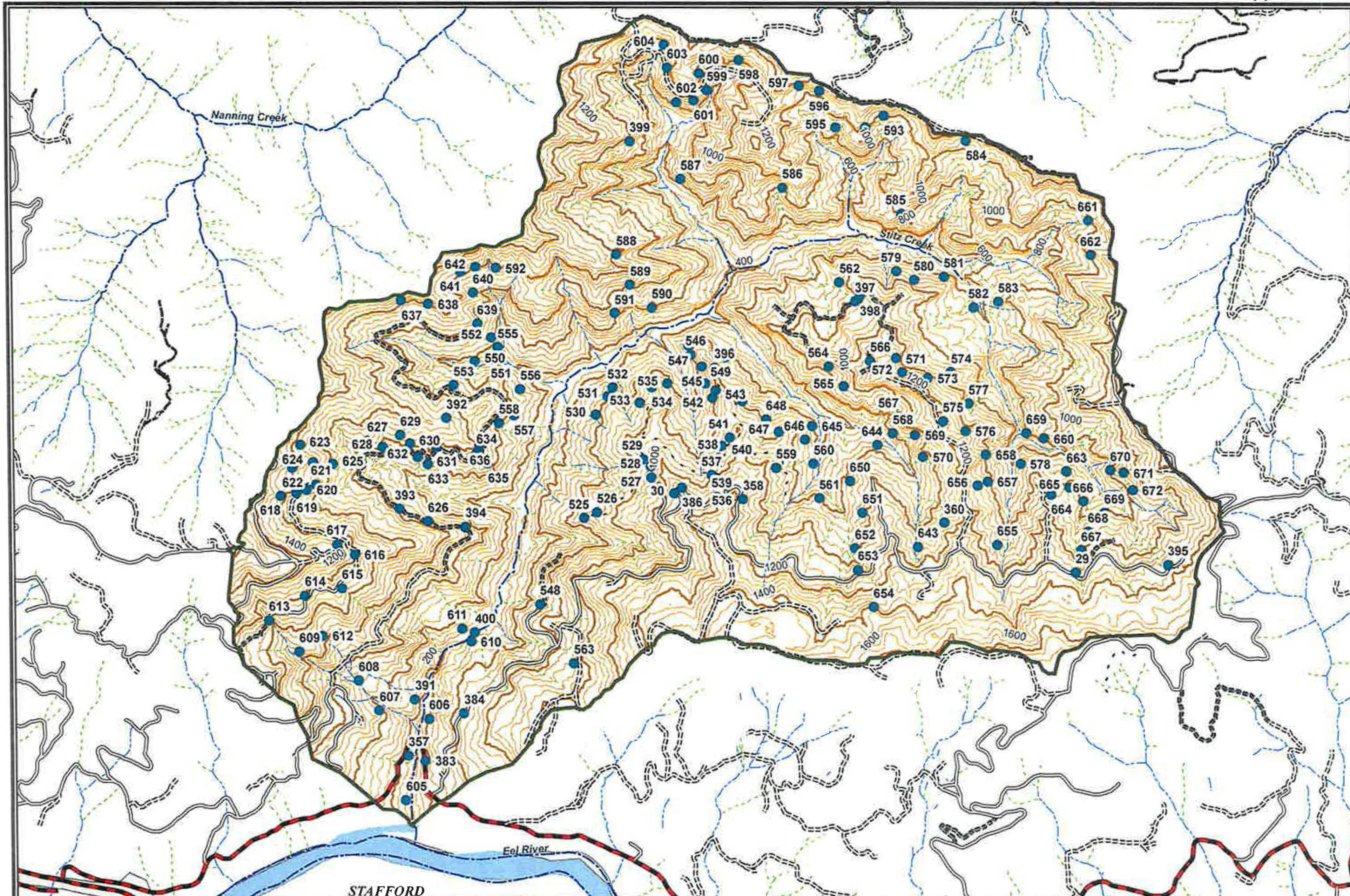


Humboldt Redwood Company, LLC

Stitz Creek, landslide inventory 2003 Air Photo

1 inch = 2,000 feet

2,000 1,000 0 2,000 Feet

● Stitz LS 2003

Stitz Creek Watershed

Class 1

Class 2

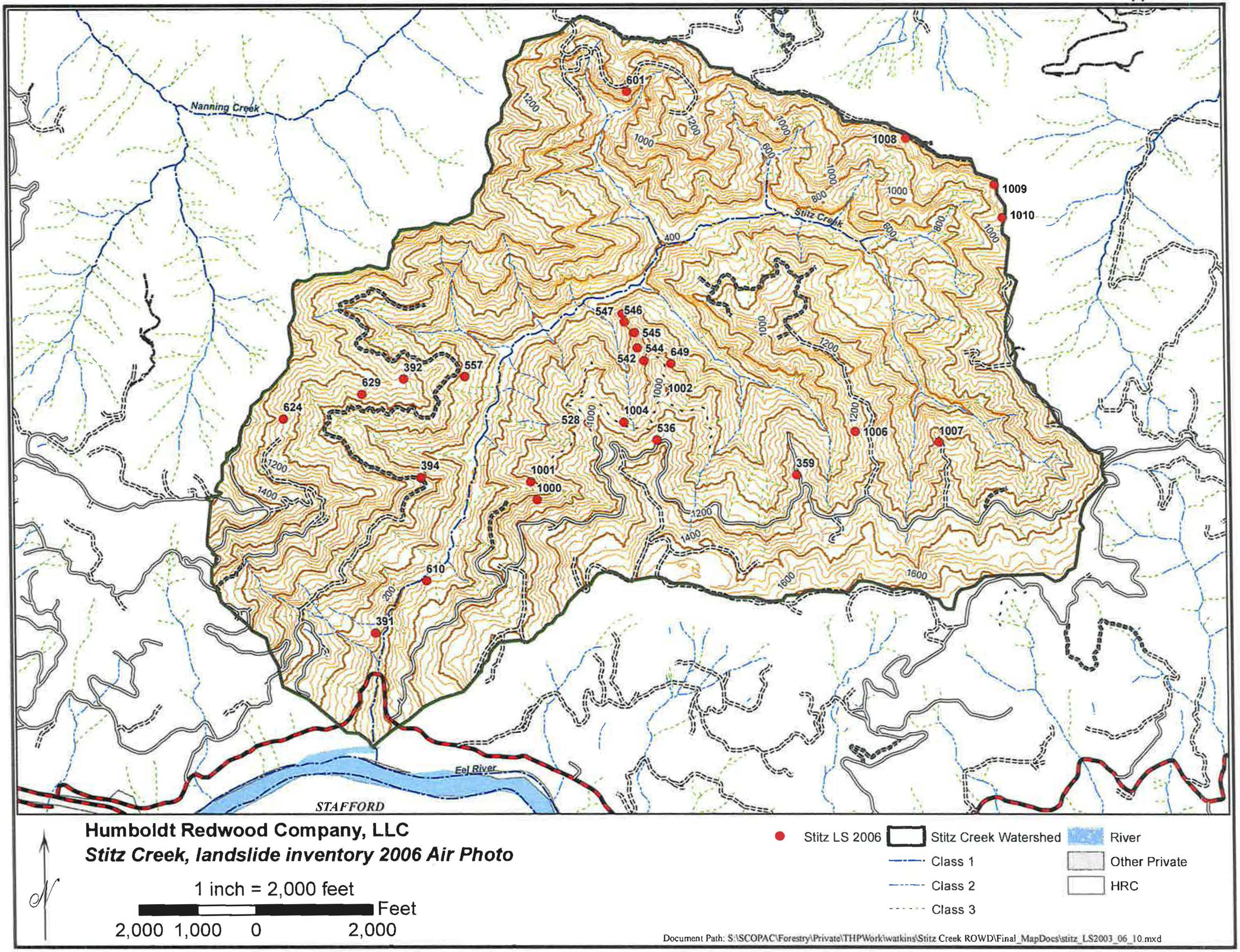
Class 3

River

Other Private

HRC

Document Path: S:\SCOPAC\Forestry\Private\THPWork\watkins\Stitz Creek ROWD\Final_MapDocs\stitz_LS2003_06_10.mxd


Nanning Creek
Stitz Creek
Eel River
STAFFORD
601
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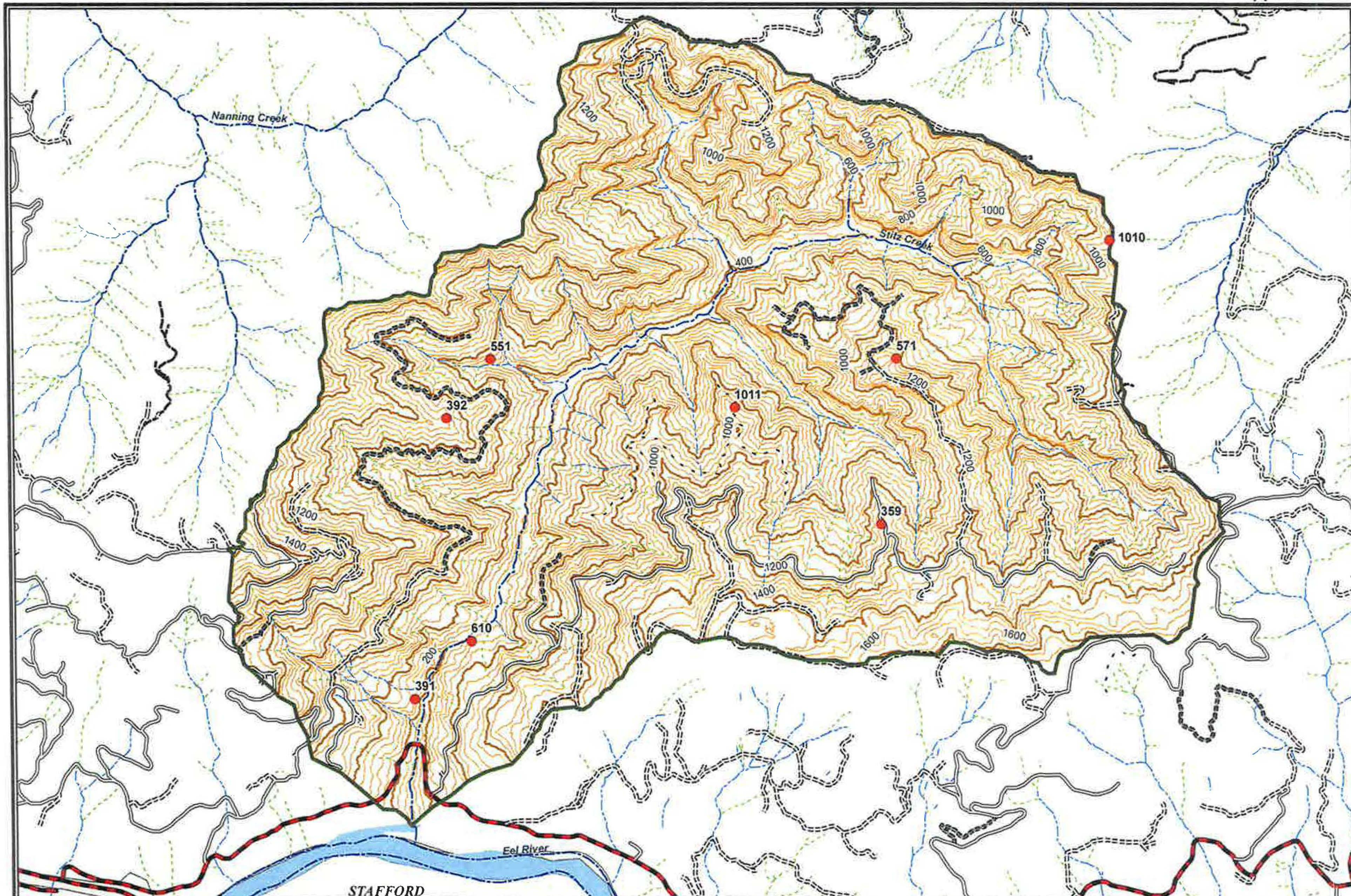
Humboldt Redwood Company, LLC
Stitz Creek, landslide inventory 2006 Air Photo
1 inch = 2,000 feet
2,000 1,000 0 2,000
Feet
Stitz LS 2006
Stitz Creek Watershed
River
Class 1
Other Private
Class 2
HRC
Class 3
Document Path: S:\SCOPAC\Forestry\Private\THPWork\watkins\Stitz Creek ROWD\Final_MapDocs\stitz_LS2003_06_10.mxd



Humboldt Redwood Company, LLC

Stitz Creek, landslide inventory 2010 Air Photo

N

1 inch = 2,000 feet

2,000 1,000 0 2,000 Feet

Stitz LS 2010

Stitz Creek Watershed

River

Class 1

Other Private

Class 2

HRC

Class 3

Document Path: S:\SCOPAC\Forestry\Private\THPWork\watkins\Stitz Creek ROWD\Final_MapDocs\stitz_LS2003_06_10.mxd

LS ID	Photo Year	AP #	Watershed	Subbasin	Failure Mode	Reactivation	Geomorphic Assoc.	Width (ft)	Length (ft)	Slide Area (ft^2)	Depth (ft)	Runout	Del	Stream Class	Road Condition (@time of AP)	SPR Y/N (@ time of slide)	Landuse Association	AP Stand Age	Volume Displaced (yd3)	% del est.	Volume Delivered (yd3)	Notes
29	2003	13-15	Lower Eel	Stitz	DS	N	CV	25	75	1473	4.4	NP	Y	3	OP	Y	RF	10-20	160	100%	160	fill failure @ DRC
30	2003	12-25	Lower Eel	Stitz	DS	Y	IG	25	75	1473	4.4	NP	N	NA	OP	Y	RF	10-20	160	0%	0	IG/SS Failure
357	2003	11-27	Lower Eel	Stitz	DFTT	Y	IG	25	75	1473	5	NP	Y	1	NA	N	NO	10-20	182	90%	164	IG failure on toe of larger existing LS
358	2003	12-25	Lower Eel	Stitz	DS	N	SW	70	50	2749	5	80	N	NA	OP	Y	RF	10-20	339	0%	0	small fill failure in broad swale
360	2003	13-15	Lower Eel	Stitz	DS	Y	SW	25	50	982	4.4	50	Y	3	NA	N	PC	10-20	107	25%	27	denser veg on left lat indicates reactivation
383	2003	11-27	Lower Eel	Stitz	DF	N	IG	50	125	4909	5	NP	Y	1	CTY RD	N	RF	>20	606	100%	606	fillslope failure on Shively Rd
384	2003	11-27	Lower Eel	Stitz	TR	N	IG	75	75	4418	10	NP	N	NA	OP	Y	RF	10-20	1091	0%	0	slumping fill from retrogression of IG, appears laid back
386	2003	12-25	Lower Eel	Stitz	DS	N	BIS	50	50	1963	4.4	50	N	NA	OP	Y	RF	10-20	213	0%	0	fill failure, lightly vegetated
391	2003	11-27	Lower Eel	Stitz	DS	N	IG	75	125	7363	4.4	NP	Y	1	NA	N	NC	<10	800	75%	600	downslope of <10 yr heli cc, within RMZ no cut
392	2003	11-28	Lower Eel	Stitz	TR	Y	SW	50	75	2945	4.4	75	Y	3	NA	N	PC	10-20	320	25%	80	retrogression of large existing LS (1997)
393	2003	11-28	Lower Eel	Stitz	DS	N	SW	75	75	4418	5	35	N	NA	AP	N	RF	10-20	545	0%	0	fill failure on steep slope
394	2003	11-28	Lower Eel	Stitz	DFTT	Y	SW	75	100	5890	15	300	Y	3	AP	N	RF	10-20	2182	75%	1636	reac. of large persistant fill failure
395	2003	13-15	Lower Eel	Stitz	DF	N	SW	25	50	982	4.4	125	Y	3	OP	Y	RF	10-20	107	25%	27	fill failure
396	2003	12-26	Lower Eel	Stitz	DF	Y	SW	75	150	8836	4.4	150	Y	2	NA	N	PC	10-20	960	10%	96	landing at head/rt lat. Retrogression of existing
397	2003	12-26	Lower Eel	Stitz	DS	N	ST	25	25	491	3	NP	Y	3	AA	Y	RF	<10	36	10%	4	slumping fill
398	2003	12-26	Lower Eel	Stitz	DS	N	SW	70	25	1374	5	NP	Y	3	AA	Y	RF	10-20	170	10%	17	fill failure/slump
399	2003	12-27	Lower Eel	Stitz	DS	Y	BL	25	50	982	4.4	NP	N	NA	NA	N	NO	>20	107	0%	0	bluff failure, bluff does not support timber
400	2003	11-27	Lower Eel	Stitz	DS	N	IG	25	25	491	4.4	NP	Y	1	NA	N	NO	10-20	53	100%	53	break in canopy adjacent 610 and 611, all in shadows, non-distinct
525	2003	12-25	Lower Eel	Stitz	DS	Y	BIS	100	150	11781	4.4	100	Y	3	DC	N	PC	10-20	1280	75%	960	top in DSS upslope of IG
526	2003	12-25	Lower Eel	Stitz	DS	N	SW	25	50	982	4.4	NP	N	NA	DC	N	RF	10-20	107	0%	0	fillslope failure
527	2003	12-25	Lower Eel	Stitz	DS	N	SW	65	70	3574	5	NP	N	NA	DC	N	PC	10-20	441	0%	0	fillslope failure
528	2003	12-25	Lower Eel	Stitz	TR	Y	SW	125	225	22089	11	NP	Y	3	DC	N	RF	10-20	6000	10%	600	fillslope failure retrogressing failure on rd downslope
529	2003	12-25	Lower Eel	Stitz	TR	N	SW	80	125	7854	9	NP	Y	2	DC	N	RF	10-20	1745	25%	436	fillslope failure to rd downslope
530	2003	12-26	Lower Eel	Stitz	TR	N	SS	100	75	5890	10	NP	Y	2	NA	N	NC	10-20	1454	25%	364	steep bluff formed on hogback ridge
531	2003	12-26	Lower Eel	Stitz	DS	N	BIS	25	25	491	4.4	NP	N	NA	NA	N	CC	10-20	53	0%	0	bluff on hogback ridge
532	2003	12-26	Lower Eel	Stitz	DS	N	CV	25	50	982	4.4	NP	N	NA	NA	N	CC	<10	107	0%	0	stopped short of retained creek trees
533	2003	12-26	Lower Eel	Stitz	DS	N	BIS	25	50	982	4.4	NP	N	NA	NA	N	PC	10-20	107	0%	0	small bluff failure
534	2003	12-26	Lower Eel	Stitz	DS	Y	SW	25	75	1473	4.4	NP	N	NA	DC	N	RF	10-20	160	0%	0	retrogress old LS, log drag @ landing edge
535	2003	12-26	Lower Eel	Stitz	DFTT	N	SW	25	75	1473	4.4	125	Y	2	NA	N	PC	10-20	160	25%	40	steep draw adj small bluff
536	2003	12-26	Lower Eel	Stitz	DF	N	BL	125	50	4909	5	NP	N	NA	OP	Y	PC	10-20	606	0%	0	bluff, poss. DRC outlet at bluff
537	2003	12-26	Lower Eel	Stitz	TR	Y	BL	150	200	23562	10	NP	N	NA	DC	N	RC	10-20	5818	0%	0	bluff intersection w/rd. old LS
538	2003	12-26	Lower Eel	Stitz	DS	Y	BL	150	200	23562	10	200	Y	2	DC	N	RC	10-20	5818	25%	1454	bluff intersection w/rd. old LS
539	2003	12-26	Lower Eel	Stitz	DS	N	BL	80	75	4712	5	NP	N	NA	OP	Y	RF	10-20	582	0%	0	fill failure
540	2003	12-26	Lower Eel	Stitz	TR	Y	CV	100	100	7854	10	400	N	NA	AA	N	PC	10-20	1939	0%	0	reac. of margin of large old fill failure
541	2003	12-25	Lower Eel	Stitz	TR	Y	CV	150	300	35343	15	NP	N	NA	DC	N	PC	10-20	13090	0%	0	raveling of large old T/R LS (1997)
542	2003	12-26	Lower Eel	Stitz	DFTT	Y	SW	25	100	1963	4.4	300	Y	2	NA	N	PC	10-20	213	80%	171	poor regeneration/brush. Top of narrow steep swale on DSS
543	2003	12-26	Lower Eel	Stitz	DF	Y	BIS	25	25	491	4.4	75	N	NA	NA	N	PC	10-20	53	0%	0	poor regeneration/brush. Top of narrow steep swale on DSS react.
544	2003	12-26	Lower Eel	Stitz	DF	Y	SW	25	25	491	4.4	NP	N	NA	NA	N	PC	10-20	53	0%	0	poor regeneration/brush. Top of narrow steep swale on DSS (headwall)
545	2003	12-26	Lower Eel	Stitz	DF	Y	BL	25	50	982	4.4	125	N	NA	NA	N	PC	10-20	107	0%	0	poor regeneration/brush. Top of narrow steep swale on DSS (headwall)
546	2003	12-26	Lower Eel	Stitz	DFTT	Y	BL	25	50	982	4.4	100	Y	2	NA	N	PC	10-20	107	10%	11	poor regeneration/brush. Top of narrow steep swale on DSS (headwall)
547	2003	12-26	Lower Eel	Stitz	DF	N	SW	50	125	4909	4.4	250	Y	1	NA	N	PC	10-20	533	50%	267	DSS on north facing dipslope ridge nose
548	2003	11-27	Lower Eel	Stitz	DFTT	N	ST	50	100	3927	4.4	400	Y	3	DC	Y	CC	10-20	427	100%	427	initiated at pulled rd xing
549	2003	12-26	Lower Eel	Stitz	DS	N	SW	25	75	1473	4.4	NP	N	NA	NA	N	PC	10-20	160	0%	0	dipslope failure
550	2003	11-29	Lower Eel	Stitz	DS	Y	IG	25	50	982	4.4	NP	Y	2	NA	N	PC	10-20	107	100%	107	IG failure large existing req'd LS cross stream
551	2003	11-29	Lower Eel	Stitz	DS	Y	IG	25	25	491	4.4	NP	Y	2	NA	N	PC	10-20	53	100%	53	IG failure
552	2003	11-29	Lower Eel	Stitz	DS	Y	IG	50	75	2945	4.4	25	Y	3	NA	N	PC	10-20	320	75%	240	reac. of portion of large IG scour
553	2003	11-29	Lower Eel	Stitz	DS	N	BIS	25	50	982	4.4	NP	N	NA	AP	N	RF	10-20	107	0%	0	fill failure
554	2003	11-29	Lower Eel	Stitz	DS	Y	IG	50	25	982	4.4	NP	Y	2	NA	N	PC	10-20	107	100%	107	IG failure
555	2003	11-29	Lower Eel	Stitz	DS	Y	IG	25	50	982	4.4	NP	Y	2	NA	N	PC	10-20	107	100%	107	IG failure
556	2003	11-28	Lower Eel	Stitz	DS	Y	SW	25	25	491	4.4	NP	N	NA	NA	N	PC	10-20	53	0%	0	reac. of sm portion of large LS (1997)
557	2003	11-28	Lower Eel	Stitz	DS	Y	SW	100	200	15708	10	NP	N	NA	NA	N	PC	10-20	3879	0%	0	retrogression of large existing LS
558	2003	11-28	Lower Eel	Stitz	DS	Y	BIS	25	25	491	4.4	NP	Y	3	AP	N	RF	10-20	53	75%	40	reac. of fill failure
559	2003	12-26	Lower Eel	Stitz	DF	Y	SW	50	100	3927	4.4	200	Y	3	OP	Y	RC	>20	427	75%	320	retrogression of large existng rd failure (unstable landform)
560	2003	12-26	Lower Eel	Stitz	TR	N	IG	100	175	13744	10	NP	Y	2	NA	N	CC	>20	3394	10%	339	large triangular T/R failure w/ds at toe
561	2003	12-26	Lower Eel	Stitz	DS	Y	IG	75	100	5890	4.4	NP	Y	2	NA	N	CC	>20	640	25%	160	IG failure
562	2003	12-26	Lower Eel	Stitz	DS	N	BL	25	50	982	4.4	NP	Y	3	NA	N	CC	<20	107	50%	53	steep bluff
563	2003	12-25	Lower Eel	Stitz	DS	N	SW	50	150	5890	3	75	N	NA	UG	N	RF	>20	436	0%	0	sm landing failure. No del.
564	2003	12-26	Lower Eel	Stitz	DS	Y	BIS	25	25	491	4.4	NP	N	NA	NA	N	CC	<20	53	0%	0	sm. failure from bluff
565	2003	12-26	Lower Eel	Stitz	DS	Y	BIS	25	25	491	4.4	NP	N	NA	NA	N	CC	<20	53	0%	0	bluff failure
566	2003	12-26	Lower Eel	Stitz	DS	Y	SW	75	75	4418	4.4	NP	N	NA	AP	Y	CC	<20	480	0%	0	rd crossing bluff w/large existing LS downslope (1997)
567	2003	12-26	Lower Eel	Stitz	DS	Y	SW	25	50	982	4.4	NP	Y	3	NA	N	NO	>20	107	25%	27	IG failure
568	2003	12-26	Lower Eel	Stitz	DS	Y	IG	50	25	982	4.4	NP	Y	2	NA	N	NO	>20	107	50%	53	IG failure
569	2003	13-16	Lower Eel	Stitz	DS	Y	IG	25	50	982	4.4	NP	Y	3	NA	N	NO	<10	107	10%	11	ravel of toe region of large existing slide (1997)
570	2003	13-16	Lower Eel	Stitz	DS	Y	IG	50	25	982	4.4	NP	N	NA	NA	N	PC	<10	107	0%	0	retrogression of IG slope failure
571	2003	12-26	Lower Eel	Stitz	DS	Y	BL	25	75	1473	4.4	NP	N	NA	NA	N	CC	<20	160	0%	0	bluff failure
572	2003	12-26	Lower Eel	Stitz	DS	Y	SW	75	50	2945	4.4	NP	N	NA	NA	N	CC	<20	320	0%	0	bluff failure
573	2003	13-16	Lower Eel	Stitz	DS	Y	BL	50	100	3927	4.4	NP	N	NA	NA	N	CC	<20	427	0%	0	steep slope/bluff failure
574	2003	13-16	Lower Eel	Stitz	DS	Y	BL	25	50	982	4.4	NP	N	NA	NA	N	CC	<20	107	0%	0	steep slope/bluff failure
575	2003	12-26	Lower Eel	Stitz	DS	N	BIS	25	25	491	4.4	NP	N	NA	OP	Y	CC	>20	53	0%	0	fill failure

LS ID	Photo Year	AP #	Watershed	Subbasin	Failure Mode	Reactivation	Geomorphic Assoc.	Width (ft)	Length (ft)	Slide Area (ft^2)	Depth (ft)	Runout	Del	Stream Class	Road Condition (@time of AP)	SPR Y/N (@ time of slide)	Landuse Association	AP Stand Age	Volume Displaced (yd3)	% del est.	Volume Delivered (yd3)	Notes
576	2003	12-26	Lower Eel	Stitz	DS	Y	SW	25	25	491	4.4	NP	N	NA	NA	N	CC	>20	53	0%	0	reac. of larger existing LS (1997)
577	2003	13-16	Lower Eel	Stitz	DFTT	Y	SW	25	75	1473	4.4	50	Y	3	NA	N	CC	>20	160	50%	80	reac. of existing LS (1997)
578	2003	13-16	Lower Eel	Stitz	DS	Y	IG	25	75	1473	4.4	NP	Y	2	NA	N	CC	>20	160	50%	80	IG failure
579	2003	12-26	Lower Eel	Stitz	DS	N	BIS	25	100	1963	4.4	NP	N	NA	NA	N	CC	<20	213	0%	0	old dormant LS mainscope?
580	2003	13-17	Lower Eel	Stitz	DFTT	Y	SW	25	50	982	4.4	NP	Y	3	NA	N	CC	<20	107	50%	53	reac. of existing LS (1997)
581	2003	13-17	Lower Eel	Stitz	DS	N	BIS	25	25	491	4.4	NP	N	NA	NA	N	CC	<20	53	0%	0	steep slope (dipslope)
582	2003	13-18	Lower Eel	Stitz	DS	N	SS	25	25	491	4.4	NP	Y	2	NA	N	CC	<20	53	50%	27	bank scour/slump
583	2003	13-17	Lower Eel	Stitz	DS	Y	IG	75	200	11781	4.4	NP	Y	2	NA	N	NO	>20	1280	50%	640	IG SS failure, partially obscured by shadows
584	2003	13-18	Lower Eel	Stitz	DS	Y	BL	75	200	11781	4.4	150	Y	3	NA	N	NO	<10	1280	75%	960	bluff failure, 2001 heli CC down slope
585	2003	12-27	Lower Eel	Stitz	DS	Y	BL	25	50	982	4.4	NP	N	NA	NA	N	NO	>20	107	0%	0	bluff failure
586	2003	12-27	Lower Eel	Stitz	DS	Y	BL	25	25	491	4.4	NP	N	NA	NA	N	NO	>20	53	0%	0	bluff failure
587	2003	12-27	Lower Eel	Stitz	DS	Y	BL	25	50	982	4.4	NP	N	NA	NA	N	NO	>20	107	0%	0	bluff failure
588	2003	12-27	Lower Eel	Stitz	DS	Y	BL	25	25	491	4.4	NP	N	NA	NA	N	NO	>20	53	0%	0	bluff failure
589	2003	12-27	Lower Eel	Stitz	DS	Y	BL	25	25	491	4.4	NP	N	NA	NA	N	NO	>20	53	0%	0	bluff failure
590	2003	12-27	Lower Eel	Stitz	DFTT	Y	SS	25	50	982	4.4	75	Y	1	NA	N	NO	>20	107	100%	107	bluff crossing stream
591	2003	12-27	Lower Eel	Stitz	DS	Y	SW	25	50	982	4.4	NP	N	NA	NA	N	NO	>20	107	0%	0	bluff/swale failure
592	2003	11-29	Lower Eel	Stitz	DS	Y	BL	25	50	982	4.4	NP	N	NA	NA	N	NO	>20	107	0%	0	bluff failure
593	2003	12-28	Lower Eel	Stitz	DS	Y	BL	25	50	982	4.4	NP	N	NA	NA	N	NO	<10	107	0%	0	bluff failure
594	2003	12-28	Lower Eel	Stitz	DS	Y	BL	25	50	982	4.4	NP	N	NA	NA	N	NO	<10	107	0%	0	bluff failure
595	2003	12-28	Lower Eel	Stitz	DS	Y	BIS	25	50	982	4.4	NP	N	NA	NA	N	NO	<10	107	0%	0	bluff failure
596	2003	12-28	Lower Eel	Stitz	DS	Y	BL	50	75	2945	4.4	NP	N	NA	NA	N	CC	<10	320	0%	0	bluff failure, legacy road upslope
597	2003	12-28	Lower Eel	Stitz	DS	Y	BL	25	50	982	4.4	100	N	NA	NA	N	NO	>20	107	0%	0	bluff retrogression
598	2003	12-28	Lower Eel	Stitz	TR	Y	BL	50	100	3927	4.4	NP	N	NA	NA	N	CC	<10	427	0%	0	cutbank/bluff failure
599	2003	12-28	Lower Eel	Stitz	DFTT	Y	BL	25	50	982	4.4	100	Y	2	NA	N	PC	>20	107	75%	80	IG failure
600	2003	12-28	Lower Eel	Stitz	DS	N	SW	75	25	1473	4.4	NP	N	NA	NA	N	SK	>20	160	0%	0	dip-slope failure
601	2003	12-28	Lower Eel	Stitz	DFTT	N	SW	25	75	1473	4.4	200	Y	2	NA	N	CC	>20	160	25%	40	steep swale, legacy road upslope
602	2003	12-28	Lower Eel	Stitz	DS	Y	BL	50	75	2945	4.4	100	Y	2	NA	N	PC	>20	320	25%	80	bluff failure
603	2003	12-28	Lower Eel	Stitz	DFTT	N	SW	25	50	982	4.4	200	Y	2	OP	N	RF	>20	107	50%	53	pulled crossing failure
604	2003	12-28	Lower Eel	Stitz	DS	N	PL	25	50	982	4.4	75	Y	2	NA	N	PC	>20	107	50%	53	cutbank failure
605	2003	11-27	Lower Eel	Stitz	DF	Y	IG	50	100	3927	9	NP	Y	1	NA	N	NO	>20	873	50%	436	IG failure at mouth of Stitz
606	2003	11-27	Lower Eel	Stitz	DS	Y	PL	75	75	4418	5	NP	Y	1	NA	N	SK	<10	545	100%	545	reac. of large IG failure toe of huge deep LS toe @ LS 384
607	2003	11-27	Lower Eel	Stitz	DS	N	SS	25	25	491	4.4	NP	Y	2	NA	N	NC	>20	53	100%	53	Class II retention CC both sites <10 yr old CC
608	2003	11-27	Lower Eel	Stitz	DS	N	SS	25	25	491	4.4	NP	Y	2	NA	N	NC	>20	53	100%	53	Class II retention pre HCP CC bank scour
609	2003	11-27	Lower Eel	Stitz	DS	Y	IG	25	25	491	4.4	NP	Y	2	NA	N	NC	>20	53	100%	53	bank slump in IG
610	2003	11-27	Lower Eel	Stitz	DS	Y	SS	75	75	4418	10	NP	Y	1	NA	N	NC	>20	1091	100%	1091	IG scour on outside bend of Stitz
611	2003	11-27	Lower Eel	Stitz	DS	Y	IG	50	100	3927	4.4	NP	Y	1	NA	N	NO	<20	427	100%	427	reac. of toe of large IG failure (1997)
612	2003	11-27	Lower Eel	Stitz	TR	N	SW	75	75	4418	4.4	NP	N	NA	NA	N	PC	>20	480	0%	0	slump I swale adj WC
613	2003	11-27	Lower Eel	Stitz	DS	N	SS	50	100	3927	7	NP	Y	2	OP	N	RF	<10	679	75%	509	fill failure at crossing reac. of larger LS/withn RMZ pulled xing
614	2003	11-27	Lower Eel	Stitz	TR	N	BIS	25	75	1473	4	NP	N	NA	OP	N	RC	<10	145	0%	0	cutbank failure
615	2003	11-27	Lower Eel	Stitz	DS	N	ST	25	50	982	5	NP	Y	3	OP	N	RX	<10	121	25%	30	fill slup @ xing
616	2003	11-27	Lower Eel	Stitz	DS	N	BIS	50	30	1178	3	NP	N	NA	OP	N	RC	<10	87	0%	0	cutbank ravel
617	2003	11-27	Lower Eel	Stitz	DS	Y	SW	25	100	1963	4.4	NP	N	NA	OP	N	RC	10-20	213	0%	0	reac. of existing larger cutbank failire
618	2003	11-28	Lower Eel	Stitz	TR	Y	BIS	50	100	3927	4.4	NP	N	NA	NA	N	NO	10-20	427	0%	0	reac. of existing LS mostly translatinal
619	2003	11-28	Lower Eel	Stitz	TR	N	BL	50	75	2945	4.4	NP	N	NA	OP	N	RC	10-20	320	0%	0	cutbank slump onto road surface
620	2003	11-28	Lower Eel	Stitz	DS	N	BL	25	25	491	4.4	NP	N	NA	OP	N	RF	10-20	53	0%	0	fill failure
621	2003	11-28	Lower Eel	Stitz	DS	N	BL	75	75	4418	4.4	NP	N	NA	OP	N	RF	10-20	480	0%	0	fill failure - landing
622	2003	11-28	Lower Eel	Stitz	DS	N	BL	25	50	982	4.4	NP	N	NA	NA	N	NO	10-20	107	0%	0	bluff slump
623	2003	11-28	Lower Eel	Stitz	DS	Y	SW	25	25	491	4.4	NP	N	NA	NA	N	NO	10-20	53	0%	0	reac. of portion of larger existing LS (1997)
624	2003	11-28	Lower Eel	Stitz	DS	Y	BL	50	50	1963	4.4	NP	N	NA	NA	N	PC	10-20	213	0%	0	raveling mainscarp of existing larger LS
625	2003	11-28	Lower Eel	Stitz	DS	Y	BL	25	75	1473	4.4	NP	N	NA	NA	N	PC	10-20	160	0%	0	retrogression of rt. lat. of existing large LS (1997)
626	2003	11-28	Lower Eel	Stitz	DFTT	Y	SW	25	50	982	3	50	Y	3	AP	N	RF	10-20	73	10%	7	persistant fill failure, larger before
627	2003	11-28	Lower Eel	Stitz	DS	Y	BIS	25	50	982	4.4	200	N	NA	NA	N	SK	10-20	107	0%	0	reac. of existing larger LS (1997)
628	2003	11-28	Lower Eel	Stitz	TR	N	BIS	50	50	1963	3	NP	N	NA	AP	N	RC	10-20	145	0%	0	cutbank slump
629	2003	11-28	Lower Eel	Stitz	DS	N	SW	25	25	491	4.4	NP	N	NA	NA	N	SK	10-20	53	0%	0	steep swale on ridgeline
630	2003	11-28	Lower Eel	Stitz	DS	Y	SW	50	100	3927	4	NP	N	NA	AP	N	RC	10-20	388	0%	0	reac. of older LS
631	2003	11-28	Lower Eel	Stitz	DS	Y	BIS	50	25	982	4.4	NP	N	NA	AP	N	RC	10-20	107	0%	0	cutbank reac.
632	2003	11-28	Lower Eel	Stitz	DS	N	SS	50	50	1963	4	50	Y	3	AP	N	RF	10-20	194	50%	97	fill slope failure
633	2003	11-28	Lower Eel	Stitz	DS	N	BIS	25	75	1473	4.4	NP	N	NA	NA	N	NO	10-20	160	0%	0	very steep slope
634	2003	11-28	Lower Eel	Stitz	DS	N	CC	25	75	1473	4.4	NP	N	NA	AP	N	RC	10-20	160	0%	0	cutbank failure
635	2003	11-28	Lower Eel	Stitz	DFTT	N	SW	25	50	982	4.4	150	N	NA	AP	N	RF	10-20	107	0%	0	landing fill failure
636	2003	11-28	Lower Eel	Stitz	DS	Y	BIS	50	50	1963	4.4	NP	N	NA	AP	N	RC	10-20	213	0%	0	retrogression of large exinting LS (1997,unstable landform)
637	2003	11-29	Lower Eel	Stitz	DS	Y	BL	25	75	1473	4.4	100	N	NA	NA	N	SK	10-20	160	0%	0	reac. bluff failure
638	2003	11-29	Lower Eel	Stitz	DS	Y	BL	25	75	1473	4.4	NP	N	NA	NA	N	SK	10-20	160	0%	0	reac. bluff failure
639	2003	11-29	Lower Eel	Stitz	DS	Y	SW	50	50	1963	4.4	NP	N	NA	NA	N	NO	10-20	213	0%	0	slump on top of SS slope
640	2003	11-29	Lower Eel	Stitz	DS	Y	ST	25	50	982	4.4	NP	Y	3	NA	N	NO	>20	107	75%	80	SS slump into scour by previous older large LS
641	2003	11-29	Lower Eel	Stitz	DS	N	BL	25	50	982	4.4	NP	N	NA	NA	N	NO	>20	107	0%	0	bare bluff failure
642	2003	11-29	Lower Eel	Stitz	DS	N	BL	25	25	491	4.4	50	N	NA	NA	N	NO	>20	53	0%	0	bare bluff failure
643	2003	13-15	Lower Eel	Stitz	DS	N	SS	25	25	491	4.4	NP	Y	3	NA	N	PC	10-20	53	50%	27	SS failure
644	2003	12-26	Lower Eel	Stitz	DS	Y	BIS	25	25	491	4.4	NP	N	NA	NA	N	PC	10-20	53	0%	0	raveling main scarp of dormant LS

LS ID	Photo Year	AP #	Watershed	Subbasin	Failure Mode	Reactivation	Geomorphic Assoc.	Width (ft)	Length (ft)	Slide Area (ft^2)	Depth (ft)	Runout	Del	Stream Class	Road Condition (@time of AP)	SPR Y/N (@ time of slide)	Landuse Association	AP Stand Age	Volume Displaced (yd3)	% del est.	Volume Delivered (yd3)	Notes
645	2003	12-26	Lower Eel	Stitz	DS	N	PL	25	25	491	4.4	NP	N	NA	NA	N	PC	10-20	53	0%	0	on planner slope ~ 75' upslope WC
646	2003	12-26	Lower Eel	Stitz	DS	Y	PL	25	25	491	4.4	NP	N	NA	NA	N	PC	10-20	53	0%	0	poor regen. Reac of DSS
647	2003	12-26	Lower Eel	Stitz	TR	Y	BIS	25	50	982	4.4	NP	N	NA	NA	N	PC	10-20	107	0%	0	poor regen. Reac of DSS
648	2003	12-26	Lower Eel	Stitz	DS	N	SS	50	25	982	4.4	50	Y	3	NA	N	PC	10-20	107	50%	53	SS failure
649	2003	12-26	Lower Eel	Stitz	DFTT	Y	SW	25	50	982	4.4	75	N	NA	NA	N	PC	10-20	107	0%	0	in toe of older longer LS (1997)
650	2003	12-26	Lower Eel	Stitz	DS	Y	SW	25	25	491	4.4	NP	Y	3	NA	N	PC	10-20	53	10%	5	reac. of body of existing large LS (1997)
651	2003	12-25	Lower Eel	Stitz	DS	N	BL	25	25	491	4.4	NP	N	NA	NA	N	PC	10-20	53	0%	0	bluff failure
652	2003	12-25	Lower Eel	Stitz	DS	N	SS	25	50	982	4.4	NP	Y	3	NA	N	PC	10-20	107	50%	53	SS failure
653	2003	12-25	Lower Eel	Stitz	DS	N	SS	100	100	7854	9	50	Y	3	OP	Y	RF	10-20	1745	75%	1309	landing fill failure @ xing
654	2003	12-25	Lower Eel	Stitz	TR	N	SW	75	125	7363	4.4	100	Y	3	NA	N	PC	10-20	800	25%	200	dipslope headwall swale
655	2003	13-15	Lower Eel	Stitz	TR	N	SS	100	150	11781	4.4	NP	Y	3	NA	N	PC	10-20	1280	25%	320	SS failure
656	2003	13-16	Lower Eel	Stitz	TR	Y	BIS	50	50	1963	4.4	NP	N	NA	NA	N	PC	10-20	213	0%	0	bluff failure/slump
657	2003	13-16	Lower Eel	Stitz	DS	Y	BIS	25	75	1473	4.4	NP	N	NA	NA	N	PC	10-20	160	0%	0	reac. of existing LS (1997)
658	2003	13-16	Lower Eel	Stitz	DS	N	BL	25	75	1473	4.4	NP	N	NA	NA	N	PC	10-20	160	0%	0	bluff failure
659	2003	13-16	Lower Eel	Stitz	DS	Y	IG	25	50	982	4.4	NP	Y	2	NA	N	NC	<10	107	100%	107	IG failure, 2 yr old CC upslope
660	2003	13-16	Lower Eel	Stitz	DS	Y	IG	25	25	491	4.4	NP	Y	2	NA	N	NC	<10	53	75%	40	IG failure, 2 yr old CC upslope
661	2003	13-17	Lower Eel	Stitz	DS	N	BL	25	25	491	4.4	25	N	NA	NA	N	CC	<10	53	0%	0	bluff failure
662	2003	13-17	Lower Eel	Stitz	DS	N	BL	25	50	982	4.4	NP	N	NA	NA	N	CC	<10	107	0%	0	bluff failure
663	2003	13-16	Lower Eel	Stitz	DF	Y	SW	25	50	982	4.4	25	N	NA	NA	N	PC	10-20	107	0%	0	reac. of existing LS
664	2003	13-16	Lower Eel	Stitz	DS	N	BIS	25	25	491	4.4	NP	N	NA	NA	N	PC	10-20	53	0%	0	fill slump failure
665	2003	13-16	Lower Eel	Stitz	DS	N	SW	25	25	491	4.4	NP	N	NA	NA	N	PC	10-20	53	0%	0	down slope from landing
666	2003	13-16	Lower Eel	Stitz	TR	N	SW	25	25	491	4.4	NP	N	NA	NA	N	PC	10-20	53	0%	0	open slope
667	2003	13-15	Lower Eel	Stitz	DS	N	SS	25	25	491	4.4	NP	Y	3	NA	N	PC	10-20	53	10%	5	~50' upslope from WC
668	2003	13-15	Lower Eel	Stitz	DS	Y	SS	25	25	491	4.4	NP	N	NA	NA	N	PC	10-20	53	0%	0	reac. of longer flow
669	2003	13-15	Lower Eel	Stitz	DS	Y	BIS	50	75	2945	4.4	NP	N	NA	NA	N	PC	10-20	320	0%	0	reac. of existing LS
670	2003	13-16	Lower Eel	Stitz	DS	N	BL	25	25	491	4.4	NP	Y	2	NA	N	CC	<10	53	10%	5	recent cut, bottom of unit 1a/SS, end slope
671	2003	12-28	Lower Eel	Stitz	DS	N	DSS	75	25	1473	4.4	NP	N	NA	NA	N	CC	<10	160	0%	0	bluff failure/recent cut
672	2003	13-16	Lower Eel	Stitz	TR	N	SS	25	75	1473	4.4	50	Y	2	NA	N	CC	<10	160	10%	16	on edge of Class II buffer

LS ID	Photo Year	AP #	Watershed	Subbasin	Failure Mode	Reactivation	Geomorphic Assoc.	Width (ft)	Length (ft)	Slide Area (ft^2)	Depth (ft)	Runout	Del	Stream Class	Condition (@time of	(@ time of slide)	SPR Bank Year	Landuse Association	AP Stand Age	Displace (yd3)	% del est.	Delivered (yd3)	LS ID	AP Notes
391	2006	13-24	Lwr Eel Rvr	Stitz	DS	Y	CV	50	130	5105	5	75	Y	1	NA	N	NA	NC	<10	630	25%	158	391	head & L lat reactivated, heli CC upslope of expanded RMZ no cut
392	2006	13-25	Lwr Eel Rvr	Stitz	DS	Y	SW	100	500	39270	4.4	150	Y	3	NA	N	NA	SK	>20	4266	5%	213	392	small reactivation in '03, whole slide react in '06
394	2006	13-24	Lwr Eel Rvr	Stitz	DFTT	Y	SW	75	150	8836	4.4	250	Y	3	AP	N	NA	RF	10-20	960	10%	96	394	reactivated in '03, remains bare and larger in '06
528	2006	14-24	Lwr Eel Rvr	Stitz	DS	Y	SW	75	100	5890	9	NP	Y	3	AA	N	NA	RF	10-20	1309	10%	131	528	retrogressing upslope
542	2006	13-25	Lwr Eel Rvr	Stitz	DS	Y	PL	25	25	491	4.4	NP	N	NA	NA	N	NA	PC	10-20	53	0%	0	542	on brush covered DSS
544	2006	13-25	Lwr Eel Rvr	Stitz	DS	Y	PL	25	25	491	4.4	NP	N	NA	NA	N	NA	PC	10-20	53	0%	0	544	on brush covered DSS
545	2006	13-25	Lwr Eel Rvr	Stitz	DFTT	Y	SW	20	50	785	4.4	50	Y	3	NA	N	NA	CC	10-20	85	5%	4	545	react @ lower lat margin, side suck
546	2006	13-25	Lwr Eel Rvr	Stitz	DS	Y	BL	25	25	491	4.4	20	N	NA	NA	N	NA	PC	10-20	53	0%	0	546	bluff toppel
547	2006	13-25	Lwr Eel Rvr	Stitz	DFTT	Y	SW	25	80	1571	4.4	100	N	NA	NA	N	NA	PC	10-20	171	0%	0	547	reactivation much smaller that initial event
557	2006	13-25	Lwr Eel Rvr	Stitz	TR	Y	PL	75	200	11781	4.4	100	N	NA	NA	N	NA	PC	10-20	1280	0%	0	557	react along L lat margin, bulk of slide mass did not move
601	2006	13-25	Lwr Eel Rvr	Stitz	DFTT	Y	SW	25	50	982	4.4	25	N	NA	NA	N	NA	PC	<10	107	0%	0	601	react at head much smaller than initial event
610	2006	13-24	Lwr Eel Rvr	Stitz	DS	Y	IG	75	75	4418	5	NP	Y	1	NA	N	NA	PC	>20	545	100%	545	610	3 small active areas add up to 75' x 75' w/in 610
624	2006	12-25	Lwr Eel Rvr	Stitz	DS	Y	BIS	50	50	1963	4.4	NP	N	NA	NA	N	NA	PC	10-20	213	0%	0	624	raveling scarp
629	2006	13-25	Lwr Eel Rvr	Stitz	DS	Y	SW	35	125	3436	4.4	50	N	NA	NA	N	NA	SK	10-20	373	0%	0	629	very hard to tell if 629 is same slide from '03 (630,632,627,628,?) veged over by
649	2006	14-24	Lwr Eel Rvr	Stitz	DFTT	Y	SW	50	200	7854	4.4	325	Y	3	NA	N	NA	PC	10-20	853	70%	597	649	react from 1997 (?)
1000	2006	13-24	Lwr Eel Rvr	Stitz	DS	N	SS	100	150	11781	4.4	75	Y	3	NA	N	NA	PC	10-20	1280	75%	960	1000	no reg. very high albedo
1001	2006	13-24	Lwr Eel Rvr	Stitz	DS	Y	SS	50	125	4909	4.4	NP	Y	3	NA	N	NA	PC	10-20	533	75%	400	1001	reactivation @ toe of larger DH, DS
1002	2006	13-25	Lwr Eel Rvr	Stitz	DS	Y	SW	25	50	982	4.4	40	N	NA	NA	N	NA	CC	<10	107	0%	0	1002	on brush covered DSS
536	2006	14-24	Lwr Eel Rvr	Stitz	TR	Y	SW	100	75	5890	5	600	Y	3	OP	Y	2000	RF	10-20	727	50%	364	1003	~50' NE of LS 536
1004	2006	14-24	Lwr Eel Rvr	Stitz	DS	N	SS	40	100	3142	4.4	150	Y	3	DC	N	NA	RF	10-20	341	60%	205	1004	back tilted tree down slope of head indicates not full evacuation
359	2006	14-24	Lwr Eel Rvr	Stitz	DFTT	Y	SW	100	300	23562	12	1000	Y	2	OP	Y	2000	RRF	10-20	6981	75%	5236	359	clearly fill related, huge runout
1006	2006	14-24	Lwr Eel Rvr	Stitz	DS	Y	SS	75	275	16199	4.4	150	Y	3	NA	N	NA	CC	10-20	1760	50%	880	1006	react from toe of older feature not ID in 2003
1007	2006	14-24	Lwr Eel Rvr	Stitz	DS	Y	SS	75	400	23562	5	NP	Y	3	OP	Y	2000	RF	10-20	2909	30%	873	1007	shallow raveling, react event did not affect initial slide
1008	2006	14-24	Lwr Eel Rvr	Stitz	DS	N	BL	25	150	2945	4.4	50	N	NA	NA	N	NA	CC	<10	320	0%	0	1008	bluff failure
1009	2006	14-24	Lwr Eel Rvr	Stitz	DS	N	BL	25	50	982	4.4	NP	N	NA	NA	N	NA	CC	<10	107	0%	0	1009	small bluff toppel
1010	2006	14-24	Lwr Eel Rvr	Stitz	DS	N	BL	25	50	982	4.4	NP	N	NA	NA	N	NA	CC	<10	107	0%	0	1010	small bluff toppel

LS ID	Photo Year	AP #	Watershed	Subbasin	Failure Mode	Reactivation	Geomorphic Assoc.	Width (ft)	Length (ft)	Slide Area (ft^2)	Depth (ft)	Runout (ft)	Del	Stream Class	Road Condition (@time of AP)	SPR Y/N (@ time of slide)	Landuse Association	AP Stand Age	AP Volume Displaced (yd^3)	% del est.	AP Volume Delivered (yd^3)	Notes
391	2010	15-23	Lwr Eel Rvr	Stitz	DS	Y	IG	50	40	1571	5	30	N	1	NA	N	NC	<10	194	0%	0	small react at head
392	2010	15-24	Lwr Eel Rvr	Stitz	DF	Y	ST	100	275	21598	10	950	Y	3	NA	N	SK	>20	5333	90%	4800	fresh in '07, full react of pre-existing LS, abandon mid-sloperd @ base of evac zone
551	2010	15-24	Lwr Eel Rvr	Stitz	DS	Y	IG	25	25	491	4.4	NP	Y	2	NA	N	PC	>20	53	100%	53	high albedo area in creek appears to corrolate w/551
571	2010	16-23	Lwr Eel Rvr	Stitz	DS	Y	SW	25	25	491	4.4	25	N	NA	NA	N	CC	10-20	53	0%	0	raveling of head scarp from 2003 event
610	2010	15-23	Lwr Eel Rvr	Stitz	DS	Y	IG	25	75	1473	4.4	NP	Y	1	NA	N	PC	>20	160	100%	160	persistant IG failure on outside bend Stitz
1011	2010	16-23	Lwr Eel Rvr	Stitz	DF	N	SW	25	75	1473	4.4	100	N	NA	NA	N	CC	>20	160	0%	0	initiated upslope of 649. Does not appear to be retrogression
359	2010	16-22	Lwr Eel Rvr	Stitz	DS	Y	SW	25	75	1473	4.4	50	N	NA	OP	Y	RF	>20	160	0%	0	initiated at head of LS 359
1010	2010	16-22	Lwr Eel Rvr	Stitz	DS	Y	SS	30	110	2592	4.4	NP	Y	3	NA	N	CC	>20	282	25%	70	initialed at toe, it's close to creek, del?

Appendix G: Landslides and Associated THPs

THP	THP Acres	# LS							
84-440	307.9	34	grnd-bsd str	392 393 550 - 558 617 - 639					
85-113	114.7	1		654					
85-616	117.2	12	cbl str	30 386 525 526 527 528 529 536 539 1000 1001 1004					
86EM-004	11.6	0							
86-086	50.2	4		360 643 644 1006					
86-198	39.2	1		562					
86-577	102.4	6		358 359 650 651 652 653					
86-644	54.9	18	cbl str	29 395 575 - 578 655 - 658 663 - 669 1007					
87-178	83.2	4		394 400 610 611					
87-342	117.4	22	cbl str	396 535 537 538 540 - 549 560 561 645 -649 1002 1011					
88-452	62.3	6		571 572 573 574 581 582					
89-826	99.6	2		384 563					
90-404	1.1	0							
92-378	92.7	3		548 606 607					
93-112	118.1	2		612 613					
94-138	100.7	7	grnd-bsd str, cbl cc	397 398 564 565 566 579 580 581					
95-150	60.5	5		530 531 532 533 534					
96-407	108.1	8		661 662 670 671 672 1008 1009 1010					
98-089	33.9	0	**#LS pre-hcp**	135	**pre-hcp acre**	1675.70	**ls/acre/yr pre-hcp**	0.0058	14 yr
00-415	27.1	0							
00-479	1.9	0							
01-141	56.6	0							
01-425	14.5	0							
01-152	87.6	2	heli shr, rcb	614 616					
02-244	1.6	0							
04-078	9.3	0							
04-139	73.1	3	heli thin, bluff	586 589 590					
04-235	20.8	0							
05-040	1.5	0							
07-161	158.4	0	**#LS post-hcp**	5	**post-hcp acre**	452.40	**ls/acre/yr post-hcp**	0.0014	8 yr
no thp	623.7	37	**#LS no cut/thp**	35	**no cut/thp acre**	623.70	**ls/acre/yr no cut/thp**	0.0026	22 yr
Total	2751.8	177							

Explanation for Mass Wasting Inventory Form

LS ID: Landslide Identification code corresponding to the landslide designation used in the geologic report and maps .

AP #: Aerial Photographic number corresponding to the flight-line and frame of the image in which the landslide was observed.

Failure Mode: Description of the failure mode of the mass-wasting feature or the geomorphic feature.

DS	Debris slide
DF	Debris flow
DFTT	Debris flow/Torrent track
TR	Translational/Rotational slide
EF	Earthflow
DG	Disturbed ground

Geomorphic Association: Observed geomorphology at the initiation point (upper-most point) of the mass-wasting feature.

DSS	Debris Slide Slope
HW	Headwall
SS	Stream Side
ST	Stream Channel
SW	Swale Channel
BIS	Major Break-In-Slope on hillslope, not inner gorge
PL	Planar
BL	Bluff
IG	Inner Gorge

Land Use Association:

CC	Clear Cut
NC	No Cut
NO	No Land Use Association
PC	Partial Cut
RC	Road Cut Slope

RF	Road Fill Slope
RX	Road Stream Crossing
SK	Skid Trail

Road Condition: The observed condition of the road at the time the aerial photograph was taken

AA	Abandon Actively
AP	Abandon Passively
DC	Decommissioned
OP	Open
UG	Upgraded

Other Abbreviations:

Y	Yes
N	No
NA	Not Applicable
% del est	Estimated Percent Delivery

Stitz Creek
Sediment Source Assessment and Sediment Reduction Recommendations

Prepared for

The Pacific Lumber Company

Prepared by

Natural Resources Management Corporation

December 16, 1998

STITZ CREEK SEDIMENT SOURCE ASSESSMENT AND SEDIMENT REDUCTION RECOMMENDATIONS

LIST OF TABLES

LIST OF FIGURES (Figures are located in Appendix A)

APPENDICES

Stitz Creek Sediment Source Assessment and Sediment Reduction Recommendations

INTRODUCTION

This report summarizes the methods and results of a sediment source investigation of the Stitz Creek watershed, northern California. This assessment was performed by Natural Resources Management Corporation, at the request of The Pacific Lumber Company. The report describes the effects of storms and erosional events that have occurred in the Stitz Creek watershed over the past 60 years.

Purpose

The purpose of this investigation was to:

1) Identify sources of erosion and sediment delivery in the Stitz Creek watershed,
2) Investigate the associations between land management activity and mass wasting, and
3) Inventory and identify sites with potential for future sediment production that may be amenable to prevention or control.

The Role of Mass Wasting in Watershed Dynamics

Mass wasting is defined as the downslope movement of soil or rock material under the influence of gravity and water without the direct aid of other media such as air or ice (Selby 1993). It is the most important process in developing the morphology of steep, mountainous terrain and provides the vital sediment link between hillslopes and stream channels. Mass wasting events are episodic in nature and deposit debris on hillslopes and stream channels. Mass wasting features that reach stream channels can alter stream environments. Changes may take the form of increased bed and suspended sediment loads, redistributed channel-bed sediments, introduced woody debris, changed channel geomorphology from accelerated bank erosion and undercutting, or in extreme cases, sediment dams and channel obstruction, and/or channel scour down to bedrock. Streams adjust to the alterations of individual mass wasting events in both the downstream and upstream directions. The magnitude of these geomorphic alterations are dependent on the intensity and frequency of mass wasting events, as well as the sediment processing capabilities of a particular stream. Larger streams and rivers adjust to mass wasting perturbations faster than smaller streams.

ENVIRONMENT

Study Area

Stitz Creek is located in Humboldt County on the north coast of California. The Stitz Creek watershed encompasses 4.0 square miles (2,587 acres) and is a third order tributary to the lower Eel River (see Figure 1). Its confluence with the Eel River is approximately 26 miles upstream from the mouth of the Eel River to the Pacific Ocean, and approximately five miles upstream of the town of Scotia. It is entirely owned by The Pacific Lumber Company (PALCO).

Geology

The Stitz Creek watershed is located in the North Coast Range geomorphic province and lies on the tectonically active plate margin of North America, approximately 17 miles east of the Mendocino Triple Junction at Cape Mendocino. The Mendocino Triple Junction is formed by the intersection of the North American, Gorda, and Pacific Plates. The geologic evolution of the plate margin from Late Jurassic to Paleogene time is dominated by subduction-related accretion of oceanic rocks of the Central and Coastal Belt Franciscan Formations, and Yager Formation (Manning and Ogle 1950, Ogle 1953, Irwin 1960, Bailey et al. 1964, Blake and Jones 1974 and 1981, McLaughlin et al. 1982, Blake et al. 1985). These rocks comprise the basement rocks of the region. Complex plate interactions associated with the northward migration of the Mendocino Triple Junction and continued subduction of the Gorda Plate (Jachens and Griscom 1983, Furlong 1993, and Furlong et al. 1998) throughout the late Cenozoic has resulted in coincident uplift, erosional stripping of basin deposits, and progressive northward migration of the locus of sedimentation (Nilsen and Clarke 1989).

Today, tectonism associated with the Mendocino Triple Junction region is dominated by north-west trending, north-east dipping thrust faults, and broad anticlinal folds (Carver et al. 1985, 1986; Carver 1987). Rapid uplift rates on these structures have continued throughout the late Quaternary (Kelsey and Carver 1988, Merritts and Bull 1989, Merritts 1996). One thrust system, the Little Salmon Fault Zone, has generated three large dip slip displacements, 3.6 to 4.5 meters per event, during the last 1700 years (Carver and Burke 1987, Clarke and Carver 1989). These rapid uplift rates result in ongoing erosional stripping of basin sediments and deposition and preservation of these sediments in local depocenters, including the Eel River Basin. Downcutting by streams in response to the uplift has resulted in steep V-shaped canyons and a high frequency of landslide occurrence.

The Stitz Creek watershed is underlain by Paleocene Yager Formation and Miocene-Pleistocene Wildcat Group sediments. The Wildcat Group is composed of a lower unit composed of deep marine mudstones and siltstones (Pullen Formation), marine mudstones, siltstones, and sandstones (Eel River Formation), marine massive mudstones with innerbedded thin sandstones, mudstones, and very fine sandstones (Rio Dell Formation); and an upper unit including shallow marine fossiliferous massive sandstones and pebbly conglomerates (Scotia Bluffs Sandstone), and non-marine conglomerates, sandstones, and claystones (Carlotta Formation) (Ogle 1953). Mudstone is the dominant rock type in the Wildcat sequence, but minor amounts of limestone, tuff, and lignite also exist. The Wildcat Group sediments were deposited unconformably on the underlying Yager and Franciscan basement rocks (Clarke 1992). The Yager formation consists of well-indurated marine mudstone, thin-bedded siltstone, lesser amounts of greywacke sandstone, and locally thick lenses of polymict conglomerate (Clarke 1992).

The Wildcat sediments in the watershed strike roughly east-west and have a moderate regional dip to the north. From geologic contacts identified on the Scotia Quadrangle by the California Department of Mines and Geology (DMG 1982), 54 percent of Stitz Creek watershed is characterized as Undifferentiated Wildcat, 30 percent as Scotia Bluffs Wildcat Formation, nine percent Carlotta Wildcat Formation, two percent Pullen Formation, and five percent Yager Formation. To more precisely characterize the Undifferentiated Wildcat Group in the Stitz Creek watershed, geologic contacts defined west of Stitz Creek were extrapolated along strike into the watershed. These contacts include the Rio Del Formation, Pullen Formation, and Eel River Formation. The resulting distribution of the underlying geology in the Stitz Creek watershed is

45 percent Rio Dell Formation, 30 percent Scotia Bluffs Formation, nine percent Carlotta Formation, seven percent Eel River Formation, four percent Pullen Formation, and five percent Yager Formation (see Figure 2).

Mass wasting processes acting on the Stitz Creek watershed are largely dependent on the underlying bedrock. The Rio Dell Formation (45% of watershed area) is the most extensive and erodable Wildcat unit in the Stitz Creek basin. Hillslopes underlain by the Rio Dell Formation characteristically have an intricate system of cross fracturing (Ogle 1953). The mudstones of the Rio Dell are generally softer than the mudstones of the Eel River and Pullen Formations, and thus have a higher incidence of shallow landslides. Landslides usually occur on dip plane surfaces where there is thin, rhythmic alternation of sandstone and mudstone bedding. Subsurface water accumulates above the less permeable mudstone layers that result in a decrease in effective normal stresses within the slide plane. A possible consequence of this subsurface water flux is slope instability. Often thin sandstone interbeds will fail as the rock glides on these slide planes. The occurrence of many thin rock glide failures led Ogle (1953) to describe the characteristic Rio Dell Formation hillside as "onion-skin" weathering.

Hillslopes underlain by the Scotia Bluffs Sandstone (30% of watershed area) and Carlotta Formation (9%) are characterized by rock fall; shallow landslides; steep, nearly vertical cliffs of 100 feet or greater; and thin, if any, colluvium. Scotia Bluffs Sandstone is able to form high relief cliffs due to its massive nature, compactness, and resistance to chemical decomposition of many of the grains (Ogle 1953). Cliff formation in the Carlotta Formation is the result of rapid weathering of claystone innerbeds which leads to undercutting and collapsing of masses of the loosely compacted conglomerate (Ogle 1953).

Hillslopes underlain by the Eel River Formation (7% of watershed area), Pullen Formation (4%), and Yager Formation (5%), found within the first mile or more of Stitz Creek, are generally not as steep as hillslopes further up in the watershed. Characteristic features of these formations include poorly exposed bedrock, frequent springs and seeps, and soft, plastic clayey materials. Large deep-seated slumps and earthflows commonly occur along watercourses where toe support is removed by fluvial erosion. Shallow landslides do occur in these formations, but are less frequent than in the Rio Dell, Scotia Bluffs, and Carlotta Formations.

A wide variety of geologic and hydrologic may influence the occurrence of mass wasting failures in the Stitz Creek watershed. Failure of a slope occurs when the driving forces are greater than the resisting forces. Driving force variables include cohesion, effective normal stress and the angle of internal friction. Resisting force variables include the weight of the landslide and the angle of the slope (Sidle 1995, Spittler 1998). Material strength is dependent on the composition of soil and bedrock materials, and depth and degree of weathering. At the soil and bedrock interface where subsurface water concentrates, slope failure may occur on dip slopes (where the bedding plane of the bedrock is parallel to the hillslope) due to changes in material hydraulic conductivities (Sidle 1985). Bedrock failures occur along discontinuities (e.g. bedding planes, fractures, faults, joints, etc.). Bedrock failure analysis includes an evaluation of several factors such as joint roughness coefficient (perturbation geometries of the discontinuity), strength values of the bedrock and discontinuity infilling, and geometry of the ground water regime (Hoek and Bray 1981, Goodman 1989). However, not all bedrock dip slopes are unstable nor all bedrock slopes dipping into the slope stable, and a licensed professional geologist may be needed to evaluate soil and bedrock stability.

Strong ground accelerations associated with earthquakes generated by the seismically active Mendocino Triple Junction can influence the occurrence of mass wasting. Seismic shaking has been documented to induce rock avalanches (Schuster et al. 1992) and lacustrine landslides (Jacoby et al. 1992) in the Puget Sound, Washington area. Liquefaction under a seismic load depends largely on the presence of groundwater in the soil, thus a well-drained soil has less exposure to seismically induced liquefaction and landslides (Hall et al. 1994). A summary of landslide data from 40 worldwide earthquakes indicates that the area affected by earthquake-induced landslides is directly proportional to earthquake magnitude (Keefer 1985).

Hydrologic factors that can influence the stability of hillslopes include intense and prolonged precipitation, the rate of water recharge into the soil mantle, the transmission rate of water within the soil mantle, and evapotranspiration (Sidle 1985). The relative rates of these processes determine the transient level of groundwater within hillslope soils. When infiltration rate of water is greater than the subsurface flow rate of water, increased pore water pressures, and thus landslide incidence, can result. Forest evapotranspiration rates, when compared to ground water recharge rates and ground water fluxes in pressure potentials, may be considered negligible to landslide occurrence. For example, typical evapotranspiration rates for coniferous forests are a few hundredths to a few tenths of an inch per day (Waring and Schlesinger 1985) whereas recharge and pressure potentials changes can be several inches per day (Kohler, personal communication).

Anthropogenic factors acting in conjunction with natural geologic and hydrologic factors can also influence the occurrence of landslides. Road, skid-trail, and landing construction can affect slope stability by mechanically steepening slopes, undercutting toe slopes, and concentrating runoff water onto the slope. Root decay (reduction in root strength) has been associated with a period of increased susceptibility to landsliding, which occurs approximately 3 to 10 years after clearcutting (Megahan et al. 1978).

Climate and Storm History

California's north coast region is subject to intense rainfall of long duration. The mean annual precipitation (1926 to 1997) at Scotia is 47 inches (DWR 1998), occurring predominately during the months of November through May (Appendix B). When high intensity precipitation events occur in the coastal mountains, localized and sometimes regional flooding is expected to follow. The amount of rainfall (magnitude) within a limited time (intensity) are critical factors that influence flooding and mass wasting on the landscape. For example, the 1964 storm is not associated with a high rainfall year, yet the intensity and magnitude of that rainfall event initiated mass wasting and flooding on a regional scale. From monthly rainfall data at Scotia, the largest monthly precipitation occurred in January 1995 (26.41 inches), December 1955 (22.88 inches), and December 1996 (22.58 inches). The respective December-January two-month totals for these years ('95, '55, '96) were equal to 32.73 inches, 37.31 inches, and 35.48 inches, respectively. The 1964 December-January two month total equaled 27.87 inches.

Daily precipitation records (1968 to 1998) for Casper Creek, Mendocino County, California, were analyzed in relation to the initiation of mass wasting features greater than 100 yd^3. Storm events capable of causing this mass wasting were called "stressing storms" and precipitation data were analyzed in 1-, 3-, 5-, and 10-day maximum rainfall totals. The analysis showed that landslide activity associated with high 3-day or 10-day precipitation totals in combination with moderately high 1-day amounts were more important than very high 1-day rainfall totals alone. In Caspar

Creek, stressing storms equated to a 1-day precipitation of 2.26 inches, a 3-day precipitation of 4.97 inches, a 5-day precipitation of 6.11 inches, or a 10-day precipitation of 8.32 inches (Cafferata and Spittler 1998). Preliminary rainfall data for the 1997 New Year's storm taken from the Bridgeville tipping gage (Appendix B), approximately 15 miles east of Stitz Creek, show a one day total on December 30, 1996 of 3.80 inches, a 3-day rainfall total of 10.60 inches, a 5-day total of 13.80 inches, and a 10-day total of 16.80 inches. An increase of landslide occurrence was noted throughout the region after this particular storm.

In the absence of site-specific rainfall data to evaluate rainfall intensities, the record of large flood events may be used as a guide for storm events that could potentially trigger landslide processes. Discharge records provide a good record for regional storms of significance, but they cannot take into account the variability and intensity of localized precipitation throughout a drainage area. Stitz Creek enters the Eel River approximately 5.5 miles above the USGS Gauging Station at Scotia (records from 1911-1995). The Scotia gage provides an indication of *regionally* intense storm events because its drainage area is over 3,000 square miles. The 1964 and 1955 storm events, which caused widespread regional flooding, hold the top discharge records for the Eel River drainage at Scotia. The discharges for these events were 752,000 cubic feet per second (cfs) and 541,000 cfs, respectively. The next 12 records are in the 300,000 to 387,000 cfs range, with the 1995 flood being the fourth largest discharge on record at 368,000 cfs.

However, due to rainfall variability that can occur over such a large area, the Eel River discharge is not completely representative of what occurs in Stitz Creek, a four square mile subset of that drainage area. The USGS gage at Bull Creek (drainage area of 28.1 sq. mi.), a tributary to the Eel River approximately 10 miles south (upstream) of Stitz Creek, is the nearest gage with a comparable drainage area to Stitz Creek. The Bull Creek gage (records from 1961-1995) recorded its highest discharge during the 1964 storm (6,520 cfs), followed closely by the 1995 storm (6,400 cfs) (Appendix B). The next highest discharges range between 4,280 cfs and 5,880 cfs for storms in 1966, 1970, 1974, 1982, and 1986. In comparison, the discharges for the water years between 1987 to 1994 rarely exceeded what would be considered as the average annual bankfull discharge (less than 1,500 cfs). Data are unavailable for the discharge peak of the 1997 storm at Bull Creek. However, judging by the rainfall records from Bridgeville, the discharge for January 1, 1997, would be of comparable magnitude to the top discharges on record for Bull Creek.

Land Use History

Initial land management in Stitz Creek occurred in the early 1900's. The old-growth in Stitz Creek was harvested at that time, primarily with steam donkey and oxen yarding techniques, apparently with the intent to convert it to pastureland. Historical rail tracks and ties were observed in the main channel of Stitz Creek. Review of the earliest available aerial photos (1947 and 1954) of Stitz Creek show no road network associated with the turn of the century timber harvesting. Stitz Creek was not re-entered for timber harvesting until the mid-1970's.

The role and influence of timber harvesting practices in the region have changed significantly over the last 30 years. Prior to the 1970's, there were virtually no regulations regarding management practices, silviculture, or size of timber harvest units. In the period between 1940 and 1973, road construction practices had few standards for proper compaction of fill materials. Side-casting of waste material was common. Roads commonly occurred on steep slopes, often adjacent to stream channels. Although Stitz Creek was not entered in this manner, many of the watersheds in northwestern California were heavily harvested utilizing tractor yarding and skidding, with little or no regard given to the watercourses. To compound matters, the 1964 flood event triggered tremendous amounts of mass wasting in the region due to a combination of natural landsliding and mass wasting exacerbated by the poor roading and yarding practices of the time. Channel aggradation resulting from that event can still be observed in northern California rivers today. In the Stitz Creek watershed, a debris flow (Slide #54, Figure 6) initiated during the 1964 storm deposited a terrace at the confluence of the tributary channel and the main stem of Stitz Creek. This terrace deposit was identified and published on a landslide map (DMG 1982), and was observable on the 1997 air photos and in the field.

Since the passage of the Z'berg-Nejedly Forest Practice Act of 1973, timber operations and road construction practices have improved. Among other measures, Watercourse and Lake Protection Zone (WLPZ) requirements add protection to watercourses and inner gorge locations. Roads are built further away from watercourses and avoid steep slopes, typically located on and near ridges to accommodate cable yarding practices. New roads are constructed to higher standards, minimizing side casting and installing culverts sized to withstand at least a 50-year flood event.

In the early 1970's approximately one mile of road was constructed from the Shively Road at the south end of the drainage. The first significant harvest to occur in Stitz Creek began in 1974 on 185 acres in the northern corner of the watershed in conjunction with the harvesting occurring in the Van Duzen River drainage. Between 1974 and 1981, approximately 12 miles of road were constructed and approximately 30 percent of the watershed had been re-entered for timber operations (see Figure 3). Road construction in Stitz Creek was located primarily on the ridges with several midslope spur roads. In some areas, skid trails were utilized for tractor yarding purposes. From 1981 to the present, an additional 7 miles of road were constructed. Approximately 1,250 acres (48% of the watershed) were re-entered for harvest operations by 1987. From 1988 to 1993, 360 acres were re-entered, and from 1994 to 1998, 344 acres had timber management with some acres overlapping the 1988 to 1993 areas for silvicultural steps (see Figure 4). By 1997, approximately 73 percent of the watershed had undergone timber management operations over the previous 23 years.

METHODS

Mass Wasting Inventory

Aerial photographs of Stitz Creek were obtained for the years of 1947, 1948, 1954, 1963, 1966, 1970, 1974, 1981, and 1997. However complete stereo coverage of the watershed were available only for the years of 1963, 1966, 1981, and 1997. All the photos were reviewed to provide an understanding of the spatial distribution, timing, and possible associations of mass wasting processes active in the Stitz Creek watershed, and the progression of land management occurring in the watershed. Mass wasting features from the Scotia Quadrangle map of Geology and Geomorphic Features Related to Landsliding (DMG 1982) and harvest history GIS maps provided by PALCO covering 1984 to the present were also incorporated in the analysis.

An initial tally was made of mass wasting features identified on the aerial photos in 1963, 1966, 1974, 1981, and 1997. Because the highest occurrence of mass wasting features occurred on the 1966 and 1997 photos, further analysis of the mass wasting features in those two years was conducted. Physical and geomorphic characteristics of the landslides were recorded including an identification number, type of landslide process, approximate failure date, approximate length, width, depth, area, volume, estimated sediment delivery range, geomorphic location (inner gorge, debris slide amphitheater, headwater swale, midslope, or ridge top), associated land use, slope form, aspect, and interpretation certainty (Appendix C). Landslide length and width were measured from the photo, and depths were determined from field measurements or estimated based on aerial photo interpretation and field calibration. Ocular estimates of sediment delivery were made in the field to validate estimates made from air photos. The percent of the landslide volume that reached a watercourse was estimated in four percentage volume ranges (1-25, 25-50, 50-75 and 75-100 percent), based on photo interpretation and field assessment. The minimum and maximum sediment delivery volumes were determined by multiplying the landslide volume by the low and high sediment delivery values in the percent range. The midpoint of the minimum and maximum sediment delivery range was reported in the following tables and text as the "estimated sediment delivery" in order to compare sediment delivery for different types of landslides and different time intervals.

Approximately 1.8 miles of the 4-mile main Stitz Creek channel were walked (from Shively Road bridge walking upstream) for a field reconnaissance of small inner gorge landslides. This was done to determine the significance of sediment delivered by inner gorge slides not observable on aerial photographs. Freshness of the scarp and the amount of revegetation on the scarp were the criteria used to determine approximate age of failure. Only slides considered to be less than 10 years old were included in the streamside analysis. Field measurements of landslide dimensions and sediment delivery were taken for the observed small inner gorge landslides. A sediment delivery index was determined by totaling the sediment volume and dividing by the miles walked (volume/river mile). This index was then extrapolated to the rest of Stitz Creek and to the larger Class II tributary streams from the USGS Scotia quadrangle.

Based on the assumption that landslide scars are visible on air photos for approximately 30 years, roughly two equivalent time intervals (1936-1966 and 1967-1997) were established in which to perform a detailed mass wasting inventory. Each interval ended with a significant storm event. The 1966 photos were the closest available photos following the 1964 storm event, and the 1997 photos were taken only eight months following the 1997 New Year's storm. To evaluate the effects of high intensity rainfall events on mass wasting in the Stitz Creek watershed, landslides associated with the 1964 and 1997 storm events were analyzed separately from the rest of the data set. Landslides that exhibit "fresh" scarp appearance on the 1966 and 1997 air photos were assumed to be a product of the aforementioned storms. Older landslides were dropped out of the storm event analysis. Sediment production determined for the 1964 and 1997 storm events were then compared to the overall sediment production for the time interval.

To assess the association of road construction with mass wasting occurrence, the landslides in Stitz Creek were divided into road related and non-road related categories. To assess the association of timber harvest with mass wasting occurrence, the landslides in Stitz Creek were classified by occurrence in areas harvested within the previous ten years, harvested prior to the previous ten years, or not harvested since the turn of the century. Landslides that were considered to be road related were excluded from the harvest association analysis.

Road Inventory

A detailed road inventory was used to evaluate the condition and erosion potential of the existing road network in Stitz Creek. The road inventory evaluated potential and present fluvial erosion and mass wasting erosion. An example of a road erosion data sheet is in Appendix D. The results obtained from the inventory provided field based data of sites that could contribute significant volumes of sediment to watercourses.

The primary haul and spur roads accessing the Stitz Creek watershed (H03 and H11 road networks) were inventoried for condition and potential sites or practices that could reduce future sediment production and delivery to the streams in the watershed. An aerial photo analysis provided a catalog of the road construction history in the watershed. The field based road inventory recorded the condition of roads, landings, and all the drainages crossed by the road. Potential future erosion, estimated future sediment delivery to watercourses, and approximate volume of past erosion were also quantified at drainage crossings, fill slopes, mass movement sites, and landings. General road maintenance sites, such as cutbank slumps, were not included in the survey if they were not likely to result in sediment delivery to a watercourse. Culvert condition and size were recorded and evaluated for storm discharge passage. The lengths and condition of inboard ditches were also evaluated and added to the drainage area of the stream culvert for flood risk, when relevant. Based on these data, road conditions were evaluated for opportunities to reduce future sediment inputs into a watercourse.

Road reaches and potential erosion sites were prioritized for repair as High, Moderate, and Low. Prioritization was based on potential volume of future erosion, potential sediment delivery to a watercourse, accessibility, and cost-effectiveness of the treatment to minimize the future sediment inputs. For example, if there was a single site that had a moderate to high sediment volume with a 50 percent sediment delivery probability, but was located at the end of an abandoned road reach that would require substantial road rebuilding to access, the priority of the site would drop to low as the cost in time and impact on the land would be greater than the potential sediment "saved". Likewise, the treatment of sediment source problems is limited to what is feasible.

All priority sites were divided into three categories for prevention and control of future road related erosion. Those categories were 1) hydrologic road decommissioning, 2) individual erosion sites, and 3) road upgrading. Hydrologic road decommissioning and treatment of individual erosion sites reduces future potential sediment production by utilizing heavy equipment to minimize volume of mass wasting sites and excavate stream crossings. Road upgrading work reduces fluvial erosion risk and minimizes chronic surface erosion source inputs, by eliminating diversion potentials, installing culverts sized for larger return interval discharge, and installing additional inboard ditch relief drains. Design criteria by PALCO for such work utilizes the standards described in the *Forest and Ranch Roads Handbook* (Weaver and Hagans 1994), unless otherwise specified and approved.

MASS WASTING BACKGROUND

Mass Wasting Types

The terminology used to describe individual landslides in this report closely follows the definitions of Varnes (1958, 1978), Cruden and Varnes (1996), and DMG (1997). Landslides were differentiated into three types: shallow landslides, debris flows, and deep-seated landslides.

Shallow Landslides: Shallow landslides, rock falls, and debris avalanches are the three kinds of mass wasting processes represented in this type. Shallow landslides are characterized as any mass-movement process involving sliding over a discrete failure surface that transports soil and rock downslope under gravitational stress. These landslides often occur on steep slopes (>65%), and areas with over-steepened road fill. Rock falls are characterized by rapid downslope movement of disaggregated rock and soil fragments by falling, rolling, and bounding. Debris avalanches are produced by the failure of the soil mantle, colluvium, and weathered bedrock, with a depth of failure less than 15 feet.

Shallow landslide headscarp widths range from about 5 feet to up to 500 feet in length. Shallow landslide debris moves rapidly downslope and sometimes transforms into debris flows upon entering confined steep-gradient channels. Often two or more shallow landslide features can coalesce into one larger complex feature. Deposits of shallow landslides can be recognized by the accumulation of an apron or fan of debris at the base of slopes and hummocky, irregular toe surfaces on hillslopes. The initial failure is usually followed by a few years of secondary erosion in the form of steep headscarp failures and rilling and gullying of the hummocky toe deposit and exposed slide face.

Movement or activation of shallow landslides is typically in response to elevated ground water conditions resulting from high intensity and/or long duration rainfall. Among the major factors influencing landslide incidence and susceptibility are soil mechanics properties, soil hydrologic properties (Hall et al. 1994), slope gradient, precipitation, rock type, faults, joints and bedding planes, soil type, and degree of weathering (Satterlund 1992). Additional naturally occurring factors that can contribute to the occurrence of landslides include removal of lateral support by stream erosion and undercutting, and changes in lateral stress, structure, cohesion, and pore water capacity due to seismic shaking in large earthquakes (Bishop and Stevens 1964, Alley and Thomson 1978). Land management practices that can increase the potential for shallow landslide activation include road construction or maintenance, which may remove lateral support as a result of road cuts, and/or add additional mass to the slope with fill material. Root decay following timber harvest can potentially weaken the soil cohesion as both the numbers of roots and the tensile strength of the remaining individual roots decrease with time (O'Loughlin 1974, Burroughs and Thomas 1977, O'Loughlin and Ziemer 1982, Greenway 1987). This can contribute to landslide incidence in unstable areas (Ziemer and Swanston 1977).

Debris Flows: Debris flows are characterized by a highly mobile slurry of soil, rock, vegetation, and water that can travel many miles down steep confined mountain channels (Benda and Cundy 1990). Debris flows are initiated in deep colluvial hollows along first order streams where ground and surface waters tend to concentrate. Debris flows can also initiate when oversaturated road fill material fails. Failure usually begins as a shallow landslide and becomes a debris flow as the moisture content of the material increases. Debris flows contain 70 to 80 percent solids and only 20 to 30 percent water (Selby 1993). Entrainment of additional sediment and organic debris can increase the volume of the original landslide by 100 percent or more (Swanston and Swanson 1976). Debris flows become more destructive as their volume increases with distance traveled. Large debris flows can travel down tributaries, scour a channel down to bedrock, and continue downslope to their confluence. Debris flow deposits are massive (not layered or stratified), coarse-grained, poorly sorted (large range in debris size), and are often preserved as in-channel debris fans. Once a colluvium-filled hollow (headwater swale) has been evacuated by a debris flow, it may take thousands of years of creep deposition to sufficiently load the resulting hollow for another debris flow (Dietrich et al. 1982, Reneau 1988).

<u>*Deep-Seated Landslides*</u>: Deep-seated landslides are generally large scale features that include translational/rotational landslides and earthflows. They are characterized by coherent movement (back rotation) of a blocky mass along a concave failure surface. Earthflows are deep-seated failures that move through a combination of slumping and plastic flow (Cruden and Varnes 1996). Deep-seated landslides typically include a steep, arcuate, poorly-vegetated headscarp, a back-tilted bench below the scarp, a lobate, hummocky body (which may be bounded on either side by a stream), and an oversteepened toe. However, one or more of these features may be absent or poorly expressed. Steep slopes at the toe of a deep-seated landslide commonly produce shallow landslides and earthflows. Deep-seated landslides can exceed five acres in area and are often associated with a failure surface that extends into bedrock.

Deep-seated landslides are natural features of the landscape that are characterized by intermittent periods of movement and dormancy. The movement or activation of deep-seated landslides is typically triggered by the build up of pore-water pressure in mechanically weak materials such as deep soils or clay rich rocks. Elevated pore-water pressures are usually caused by several consecutive extremely wet rain years followed by a high intensity rainfall event. Movement of deep-seated landslides may also be activated by stream incision of the landslide toe and strong ground shaking generated by large magnitude earthquakes. Land management activities and harvest operations generally are considered to have limited, if any, influence on deep-seated features. Deep-seated landslide features can be difficult to identify in aerial photographs due to the subdued attributes of the slide morphology and thick forest canopy.

Mass Wasting Geomorphic Zones

To evaluate landslide potential in the watershed, it is useful to describe the geomorphic zones where they are most prevalent. The geomorphic zones can be considered by land managers in making land use decisions that will minimize future mass wasting sediment input to watercourses. The physiographic and topographic features of each geomorphic zone in which landslides commonly occur in the Stitz Creek watershed have been modified from definitions outlined by DMG (1997) and are as follows:

<u>*Inner Gorge*</u>: An inner gorge is a geomorphic feature formed by fluvial downcutting and coalescing landslide scars. The most common mechanism of failure in this geomorphic zone is loss of toe support by active stream erosion and undercutting. The feature is identified as that area of the stream bank situated immediately adjacent to the stream channel, having smooth planar side slopes generally greater than 65 percent. The zone is situated below the first break in slope above the stream channel. Landslides initiating in this zone deliver between 75 to 100 percent of their mobilized material to the watercourse. This geomorphic zone applies to both perennial and ephemeral channels. The term ephemeral inner gorge was used to differentiate the inner gorge landslides occurring higher in the drainage network (i.e. Class II streams) from those occurring lower in the drainage. Ephemeral inner gorges are often located in or associated with debris slide amphitheaters.

<u>*Midslope*</u>: This geomorphic zone is characterized by moderate to steep side slopes with gradients generally 35 percent to more than 65 percent. This zone is commonly located upslope of the inner gorge and downslope of the ridge top geomorphic zones, and the slopes can exhibit planar, divergent, and locally convergent forms. Much of the debris generated from shallow landslides in this zone is deposited on the hillslope, but often up to 25 percent is deposited in watercourses. Midslope landslides often occur at a break in slope, a point where more gentle terrain drops

quickly to a steeper gradient in a downslope direction within the midslope location. Surface and ground waters can concentrate at the break in slope resulting in localized saturated soil conditions.

Headwater Swale: The headwater swale area is the basin above a Class III watercourse, commonly referred to in geomorphic literature as the zero order basin, or bedrock hollow. This is an area where colluvial deposits tend to be thickest and ground and surface waters concentrate due to strongly convergent slope form. The most common mass wasting processes acting in this zone are debris flows. Debris flow slides often scour the channel to bedrock and deliver 75 to 100 percent of the mobilized material to a watercourse.

Ridgetop: This geomorphic zone is characterized as the uppermost portion of the slope that climbs steeply towards the ridge. The zone includes the headwalls above headwater swales and along steep ridges located between tributary streams and watersheds. Shallow landslides generated in this zone rarely reach watercourses, but can contribute significant amounts of sediment to the loading of midslope areas.

Debris Slide Amphitheater: Debris slide amphitheater slopes are geomorphic features in which slopes have been sculpted by numerous debris slide events. These features are the site of chronic failure and have been active far longer than human involvement in the watershed. The amphitheaters are characterized by an aggregate of scars (old and recent) left by the movement of predominately unconsolidated rock, colluvium, and soil along relatively shallow failure planes. Slopes in debris slide amphitheaters generally exceed 65 percent. Sediment delivery volumes from individual landslide events in these zones are difficult to quantify because landslides often overlap each other over time.

RESULTS AND DISCUSSION

From the initial analyses of the aerial photograph coverage of Stitz Creek, it was apparent that large storms influenced the magnitude of mass wasting processes in the watershed. In a simple tally of mass wasting features observed in the years 1963, 1966, 1981, and 1997 (Table 1), the greatest number of features occurred in years following significant storm events (i.e., 1964 and 1997). The 1966 photos were taken two years after the 1964 storm event and the 1997 photos were taken 8 months after the 1997 storm event.

Table 1. Number of Mass Wasting Features Identified on Aerial Photos by photo year.

Year	Total
1963	69
1966	107
1981	69
1997	172

One reason for observing a greater occurrence of mass wasting in 1966 and 1997 compared to the other photo years is that vegetation had not yet established on landslides caused by the 1964 and 1997 storm events. These fresh scars made landslides more apparent on the air photos. The lesser number of landslides recognized on the other photos may be a result of longer periods between stressing storm events that caused mass wasting, which allowed for revegetation to obscure slide scars.

Landslide Characteristics in Stitz Creek Watershed

A total of 279 landslides were tallied in the Stitz Creek watershed from the 1966 and 1997 photo analysis combined (see Figure 5). Individual landslide data are listed in Appendix C. Landslide studies that use aerial photos in "mature" or "undisturbed" forests have been documented to underestimate the amount of landslides (Dent et al. 1997). Based on this observation the total number of landslides tallied in the Stitz Creek watershed is recognized as a minimum.

The majority of the inventoried landslides occurring in the two time intervals originated in planar topography (47%), where sub-surface water is evenly distributed across the slope, or convergent topography (33%), where surface and sub-surface waters concentrate. Few landslides originated in divergent topography (16%), where sub-surface water is diverted to the sides of topographic noses. Four percent could not be categorized.

The dominant mass wasting process in the Stitz Creek watershed was shallow landsliding (Table 2). Shallow landslides accounted for 74 percent of all landslides recognized, whereas debris flows and deep-seated landslides accounted for 24 percent and 3 percent, respectively. This percentage distribution of landslide type is similar to the distribution determined by the California Department of Mines and Geology (DMG 1982) on the Scotia Quadrangle. In the Stitz Creek watershed they identified 36 shallow landslides (84%), four debris flow/torrent tracks (9%), and three earthflows (7%).

Table 2. Distribution of the landslide type for mass wasting features (entire data set).

Type of Slide	Number of Landslides	Percent of Total Landslides	Percentage of Estimated Sediment Delivery
Debris Flow (DF)	65	24%	70%
Shallow Landslide (SL)	203	74%	24%
Deep-seated Landslide (DS)	8	3%	6%

Although shallow landslides were the most common mass wasting process, they did not produce the greatest sediment delivery. The mass wasting process responsible for the greatest percent of estimated sediment delivery was debris flows. Debris flows accounted for 71 percent of the estimated sediment delivery, whereas shallow landslides and deep-seated landslides accounted for 24 percent and 5 percent, respectively.

The combined landslides for the two time periods were then analyzed for their distribution in each geomorphic location, percent of total landslides per location, and percent of estimated sediment delivery per location (Table 3).

Table 3. Distribution of the landslides for each geomorphic location (entire data set).

Geomorphic Location	Number of Slides	Percent of Total Landslides	Percentage of Estimated Sediment Delivery
Inner Gorge	115	42%	36%
Midslope	92	33%	20%
Ridgetop	46	17%	13%
Headwater Swale	23	8%	31%

The inner gorge landslides represent the greatest percent of total landslides (42%) and the greatest percentage of the estimated sediment delivery (36%). In contrast, headwater swale landslides represent the smallest percent of the total landslides (8%) and the second greatest percentage of the estimated sediment delivery (31%). This is due to two massive debris flows (Slides #53 and #54 on the 1966 photos) that originated in headwater swale locations. While the sediment volume from these two landslides cannot be discounted for this study, it is recognized that landslides of this magnitude are a rare occurrence. As a result, the estimated sediment delivery from headwater swales determined in this study may be misrepresentative of sediment delivery from headwater swales in other watersheds in the region.

Observations from similar terrain in the California Coast Ranges show that shallow landslides and debris flows can occur anywhere from the ridge top to the stream channel (Louisiana-Pacific Corp. 1998). Steep slopes, slope form, geomorphic location, condition of the weathered Wildcat bedrock units, and the occurrence of high intensity rainfall events appear to be the major factors influencing the distribution and occurrence of landslides in the Stitz Creek watershed. Shallow landslides and debris flows occur in each geomorphic location, but are most commonly initiated in inner gorge and midslope areas. Deep-seated landslides tend to be initiated in inner gorge areas by erosion and loss of support at the toe of the slide. Due to their large size and nature, deep-seated landslides, can extend great distances upslope and include debris slides originating in midslope areas. Rock falls commonly occur along ridgetop zones and steep rock inner gorges.

Significance of Small Inner Gorge Landslides Not Observable on Photos

Forty-five percent of the mainstem of Stitz Creek was walked to identify and measure the dimensions of small inner gorge slides not visible on the aerial photos that are estimated to have occurred in the last two years. From these data, a sediment delivery volume of 2,002 cubic yards was calculated on 1.8 miles of stream reach, yielding a sediment delivery index of 1,112 cubic yards per mile. An additional sediment delivery volume of 3,336 cubic yards was calculated when the sediment delivery index was extrapolated to the major USGS blue-line tributaries. Assuming 100 percent sediment delivery, the total sediment volume delivered to the Stitz Creek drainage from small inner gorge landslides not observable on air photos was 5,338 cubic yards (Appendix E). This represents a maximum of three percent of the 1997 mass wasting sediment delivery volume. In some watersheds these small inner gorge landslides can contribute significant sediment volumes within the watershed's sediment budget (Louisiana-Pacific Corp. 1998); however, due to the relatively minor contribution these slides have to the overall mass wasting sediment contribution in Stitz Creek, they were dismissed from further analysis.

Detailed Mass Wasting Analysis occurring over 30-Year Time Intervals

Total mass wasting sediment production, and minimum, maximum, and estimated sediment delivery produced by each landslide type for the time intervals 1936-1966 and 1967-1997 is presented in Table 4.

Table 4. Total mass wasting volume and sediment delivery volumes (yd^3) for 30-year time intervals.

Time Interval	Landslide Type*	Total Mass Wasting (TMW) Volume	Minimum Sediment Delivery	Maximum Sediment Delivery	Estimated Sediment Delivery
1936 to 1966	DF	197,125 (74%)	129,082 (80%)	178,363 (80%)	153,723 (80%)
	SL	58,141 (22%)	28,182 (18%)	40,809 (18%)	34,496 (18%)
	DS	10,913 (4%)	2,728 (2%)	5,456 (2%)	4,092 (2%)
	Total	266,179 (100%)	159,992 (100%) (60% of TMW)	224,627 (100%) (80% of TMW)	192,310 (100%) (72% of TMW)
1967 to 1997	DF	144,611 (43%)	95,598 (66%)	131,725 (58%)	113,662 (60%)
	SL	134,959 (41%)	43,025 (29%)	73,424 (32%)	58,225 (31%)
	DS	53,022 (16%)	10,419 (7%)	23,341 (10%)	16,680 (9%)
	Total	332,592 (100%)	147,906 (100%) (44% of TMW)	228,490 (100%) (69% of TMW)	188,567 (100%) (57% of TMW)

* DF, Debris Flow; SL, Shallow Landslide; DS, Deep-Seated Landslide.

This table indicates several facts: first, the total mass wasting (TMW) volume mobilized in the 1967-1997 time interval was greater than in the 1936-1966 time interval; second, the volume of the estimated sediment delivery was approximately the same for both time intervals; third, the percent of the total mass wasting volume delivered to watercourses during the 1967-1997 time interval (57%) was less than the percent delivered in the 1936-1966 time interval (72%); and fourth, the shallow landslide volume and sediment delivery increased from the time interval 1936-1966 to the time interval 1966-1997.

The majority of sediment delivery in both time intervals was the result of debris flows. Debris flows may begin as small features, but have the potential to incorporate large volumes of debris into the slurry by scouring channels and sideslopes. Although debris flows contributed the majority of sediment volume to watercourses for each time period, the debris flows occurring in the 1936-1966 interval represented a greater percentage of the total mass wasting volume. The total volume of material mobilized in the 1967-1997 time interval by shallow landslides was comparable to the total volume mobilized by debris flows for that interval, the sediment volume delivered by shallow landslides was significantly less than the sediment volume delivered by debris flows. This can be attributed to the fact that material derived from shallow landslides occurring on the hillslopes may settle out on the hillside or become retained in the vegetation, limiting the amount of sediment delivery to the drainage network.

Sediment Production and Delivery Rates

A sediment mobilization rate and delivery rate was assessed for the Stitz Creek watershed based on the data presented in Table 4. Sediment delivery and mobilization rates are calculated by the following equation:

Rate = cubic yards of sediment / square area of watershed / time (Table 5).

Table 5. Sediment mobilization rates (yd^3/sq.mi./yr) for each time interval.

Time Interval	Rate of Sediment Mobilization	Minimum Sediment Delivery Rate	Maximum Sediment Delivery Rate	Estimated Sediment Delivery Rate
1936 – 1966	2,218	1,333	1,872	1,603
1967 – 1997	2,714	1,270	1,942	1,606

The mass wasting sediment mobilization rate was greater for the time interval 1967-1997 than the time interval 1936-1966, although the estimated sediment delivery rate for each time interval was similar. Three factors that can influence these rates are magnitude and frequency of large storms, occurrence of rare, large volume mass wasting features, and the land management activities occurring in the watershed within the time interval. While the time intervals have similar rates, different factors have occurred in the watershed to influence those rates. The large magnitude storm of 1964 produced two exceptionally large debris flows (Slides #53 and #54) that resulted in high sediment mobilization and delivery rates for the 1936-1966 time interval. The latter time interval incorporates a period of timber harvesting, as well as a several large magnitude rainfall events in 1995 and 1997.

Comparison of 1964 and 1997 Storm-Generated Mass Wasting

For each photo year, the storm generated landslides were identified by their fresh scars, and the landslides identified as being approximately five to 30 years old were dropped from the storm analysis. The distribution of each type of landslide produced by the 1964 and 1997 storms is presented in Table 6. The locations of individual landslides generated by these storms are in Figures 6 and 7, respectively.

Table 6. Landslide type and distribution resulting from the 1964 and 1997 storm events.

Storm Event	Type of Slide	Number of Slides	Percent of Total
1964	Debris Flow (DF)	17	19
	Shallow Landslide (SL)	69	77
	Deep-seated Landslide (DS)	1	1
	Rock Fall (RF)	3	3
	Total	90	100
1997	Debris Flow (DF)	15	15
	Shallow Landslide (SL)	75	77
	Deep-seated Landslide (DS)	3	3
	Rock Fall (RF)	4	4
	Total	97	100

The total number of mass wasting features associated with the 1964 storm (90) was remarkably similar to the number of features of the 1997 storm (97). Shallow landslides represented 77 percent of the total mass wasting features produced by each storm. Debris flows represented up to 19 percent of the features produced in the storms, while deep-seated landslides and rock falls each represented less than five percent of the storm related mass wasting. The distribution of landslide types generated by the two storms closely resembled the distribution found in the time interval analysis.

The total volume of sediment produced by each type of landslide in each storm as well as the minimum, maximum, and estimated sediment delivery are presented in Table 7.

Table 7. Total mass wasting volume and sediment delivery volumes (yd^3) for each storm event.

Storm Event	Landslide Type	Total Mass Wasting Volume (TMW)	Minimum Sediment Delivery	Maximum Sediment Delivery	Estimated Sediment Delivery
1964	DF	155,114 (72%)	110,146 (80%)	148,925 (78%)	129,536 (78%)
	SL	49,871 (23%)	25,411 (18%)	36,157 (19%)	30,784 (19%)
	DS	10,913 (5%)	2,728 (2%)	5,456 (3%)	4,092 (3%)
	RF	435 (0%)	1 (0%)	24 (0%)	13 (0%)
	Total	216,333 (100%)	138,286 (100%) (64% of TMW)	190,562 (100%) (88% of TMW)	164,446 (100%) (76% of TMW)
1997	DF	80,003 (55%)	56,987 (72%)	76,981 (68%)	66,984 (69%)
	SL	60,615 (42%)	20,889 (25%)	33,733 (29%)	27,311 (28%)
	DS	4,059 (3%)	2,252 (3%)	3,267 (3%)	2,760 (3%)
	RF	130 (0%)	1 (0%)	15 (0%)	15 (0%)
	Total	144,807 (100%)	80,129 (100%) (56% of TMW)	113,995 (100%) (79% of TMW)	97,070 (100%) (67% of TMW)

As in the analysis for the 30-year time intervals, debris flows were the dominant sediment producing feature and delivered the most sediment to watercourses in the analysis of individual storms. Two exceptionally large debris flows initiated in the 1964 storm (Slide #53, producing 69,403 yd^3, and Slide #54 producing 55,229 yd^3) represent 58 percent of the total sediment produced by the 1964 storm. The combined volume of these two slides approaches the volume produced by the 1997 storm. These two slides are of much greater size than the largest debris flow in the 1997 storm (Slide #4, producing 19,900 yd^3). If the two large 1964 debris flows were dropped from the analysis, the data would suggest that the smaller magnitude 1997 storm produced more mass wasting volume than the 1964 storm. However, the occurrence of these two slides, led us to conclude that the 1964 storm generated more mass wasting by volume than the 1997 storm. This illustrates how the variability of one or two large landslide volumes can influence the interpretation of mass wasting results. There were no contemporary land management activities occurring in the Stitz Creek watershed during the 1964 storm event. This shows that large intensity storms do cause large-scale landsliding and debris flows, independent of road and harvest influences.

The two storms produced approximately the same number of shallow landslides, with the 1997 storm producing a greater mass wasting volume. The volume produced by the 1997 storm may be attributed to greater accuracy in measuring slide dimensions. Slide dimensions were more accurately measured in the 1997 storm because the short time interval between the storm event and the photographs, and the open canopy created by timber harvest made the landslides more visible. Additionally, field measurements on the 1997 landslides allowed for calibration of the analysis. The 1964 storm analysis, in contrast, was conducted on photos taken approximately 1.5 years after the storm with much greater canopy closure, resulting in less accurate landslide dimension measurement. However, that the 1997 storm mobilized a greater total shallow landslide volume and delivered less volume than the 1964 storm, may also embody the 23 years of land management in the watershed. The lesser sediment delivery ratio of the 1997 shallow landslides may be the effect of the shallow slides being influenced by roads and/or harvesting, with more deposition occurring on the hillslope instead of in direct relation to the watercourses.

Road Construction and Mass Wasting Association

Construction of a road network can lead to accelerated erosion rates in a watershed (Beschta 1978, Reid and Dunne 1984). Several studies in the western Cascade Range in Oregon show that mass wasting associated with roads are 30 to more than 300 times greater than in undisturbed forests (Sidle et al. 1985). Road failures that occurred during the storms in 1955 and 1964 in numerous other watersheds in the region did not occur in the Stitz Creek watershed because the watershed had not yet been re-entered from its historic logging period, and therefore had no associated road network. As the road network in Stitz Creek expanded during in the 1980's, storms capable of triggering landslides were mostly absent. Only the 1997 aerial photographs captured the immediate effects of a regional landslide-triggering storm on road related landslides. For this analysis, it was assumed that any slide that initiated along a road or identifiable skid trail was produced directly or indirectly by that feature.

Slide #4 (Figure 7) was the largest debris flow by volume that initiated during the 1997 New Year's storm. The landslide scarp evacuated a section of road H03-0642, torrented down its channel to the mainstem of Stitz Creek, and delivered 75-100% of its material to the watercourse. The sandstone bedrock at the scarp has slope-parallel fractures and easily crumbles when touched. The stand in which the slide occurred had been selectively harvested in 1993, and the 1997 aerial photos show a full canopy of mature trees. It is unlikely that significant loss of root strength of the stand occurred as a result of the harvest, as a mature second growth redwood stand existed at the site. An additional field analysis was undertaken to more accurately identify the cause of the slide and estimate its volume.

The field investigation of Slide #4 revealed two gullies in the road at the scarp of the slide. The first gully originated on the road northeast of the slide and had undermined the culvert at the outer edge of the road to a depth of five feet. This gully appeared to have supplied water to the base of the slide. The other gully originated where the culvert was plugged near the back edge of the road and diverted water directly onto the crown of the slide. Because the road gullies diverted water to the base and top of the slide, we concluded that Slide #4 was influenced by the road. However we recognize that, in conjunction with the road runoff, a variety of natural causes also contributed to slope failure. A summary of field observations compiled by John Coyle, Certified Engineering Geologist, is in Appendix F.

Along the entire torrent track of Slide #4 it was noted that very little scour of the channel occurred and some of the material was deposited along the channel in debris flow levee bars. The material deposited along the channel was included in the delivery volume because it can be remobilized by high flows. Detailed field measurements of the dimensions of Slide #4 were used to calculate a sediment delivery volume of 19,900 yd^3 (Appendix G). This volume total was included in the road related category. The number of road related and non-road related landslides and their associated sediment delivery volumes are presented in Table 8.

Table 8. Road related vs. non-road related landslides that occurred in the 1997 storm.

Road Related	No. of Slides	Percent of Total	Minimum Sediment Delivery (yd^3)	Maximum Sediment Delivery (yd^3)	Estimated Sediment Delivery (yd^3)
Road Related	25	26%	52,842 (66%)	74,348 (65%)	63,595 (66%)
Not Associated	72	74%	27,287 (34%)	39,647 (35%)	33,467 (34%)
Total	97	100%	80,129 (100%)	113,995 (100%)	97,062 (100%)

Landslides assumed to be road related represent 26 percent of the total number of landslides, and 66 percent of the total estimated sediment volume delivered by the 1997 storm. Non-road related landslides represented 74 percent of the total number of landslides and only 34 percent of the estimated sediment delivery to Stitz Creek. These results are consistent with a similar analysis completed for Elk River, approximately 15 miles north of Stitz Creek (PWA 1998), which identified 24 percent of the landslides as road related and 76 percent as "hillslope landslides."

It is apparent from this analysis that the lower number of road related landslides contribute far more sediment volume than the greater number of hillslope landslides. This illustrates the fact that although road related landslides are less frequent than hillslope related slides, they tend to be responsible for a greater percentage of sediment delivery to watercourses. Therefore, when an effort is made to reduce sediment to watercourses, minimizing potential sediment volume from identified road sites will have a greater return in sediment reduction efforts.

Timber Harvest and Mass Wasting Association

Research has indicated that there tends to be an increase in landslide incidence five to 10 years following harvesting due to the decay of tree root systems (O'Loughlin and Ziemer 1982, Sidle et al. 1984). The effect of clearcutting on mass wasting processes has also been documented (Rood 1984, Ice 1985, Howes 1987). The trees in the Stitz Creek watershed are predominately redwoods, which sprout from their stumps rapidly after harvest. Root strength may be retained as the effect of the mother tree root decay is compensated for by the root development of the sprouts. Because of this "stump sprouting" the effect of loss of root strength on landslide occurrence in Stitz Creek may be less than in drainages with other vegetation types.

The effect of timber harvest on landslides was evaluated for all landslides not related to roads. The estimated sediment delivery volume from landslides not related to roads in Stitz Creek was 33,467 cubic yards, or 34 percent of the total estimated sediment delivery from the 1997 storm (from Table 7). The number of landslides and associated sediment volume that occurred in harvested areas as a function of time since harvest, and in areas not harvested, are presented in Table 9.

Table 9. Harvest age and sediment delivery volumes (yd^3) for the 1997 non-road related landslides.

Harvest History	Acres	Percent of landbase	No. of landslides	Minimum Sediment Delivery	Maximum Sediment Delivery	Estimated Sediment Delivery
Greater than 10 years ago (1974 – 1987)	1,249	48	50	23,289 (85%)	33,309 (84%)	28,229 (85%)
Less than 10 years ago (1988 – 1997)	628	24	13	1,845 (7%)	3,020 (8%)	2,433 (7%)
Not Harvested	710	27	10	2,153 (8%)	3,318 (8%)	2,736 (8%)
Total				27,287	39,647	33,467

Table 9 indicates that majority of the sediment volume from hillside landslides occurred on the landbase harvested more than 10 years ago and that more landslides have occurred in areas with timber harvest operations than in areas without harvest operations.

This analysis ignores several factors that could contribute to landslide incidence and size. The natural physiographic features of landscape (particularly slope), type of silviculture and yarding, revegetation characteristics, and storm history could all affect landslide differences not related to time since harvest. The analysis also encompasses a relatively small sample size, and individual large landslides may have skewed the results. One factor that may have contributed to the observed pattern is that areas harvested more than 10 years ago in Stitz Creek included a large proportion of the debris slide amphitheater area in the watershed; these areas are naturally prone to sliding.

Given the numerous variables affecting landslide occurrence and the limited data collected in the Stitz Creek watershed, results of this analysis may not adequately identify the effect of harvesting on mass wasting. However, in general terms, landslides associated with roads had a greater sediment contribution in the watershed (66 percent of the estimated sediment delivery), than non-road related landslides.

Road Inventory

A road inventory was conducted to identify treatable sites of potential future erosion for the existing roads in Stitz Creek. Roads that were not maintained and were not provided with no-maintenance erosion control measures associated with modern road decommissioning were termed abandoned. Road decommissioning measures include removal of watercourse crossing fills, removal of unstable road and landing fills, and providing for erosion-resistant drainage.

Approximately 16 miles of the nearly 20 miles of road construction in the Stitz Creek watershed were inventoried (Figure 8). All these roads were accessed from the south on roads H03 and H11. Two miles of historical road in the northwest corner of the drainage, accessed by crossing the Van Duzen River during low water conditions, were inaccessible for this inventory. During the inventory of the roads, several of the road reaches that were abandoned approximately a decade ago were not inventoried. These reaches were the terminal 20 percent of road H03.1606 (approximately 3,000 feet) and the abandoned portion of road H11.33 beyond the first 2,000 feet. These sections of road would require major rebuilds to access; either the road prism is entirely gone and/or the future sediment savings were too low to ensure a cost-effective treatment considering the rebuild needed to access the area. However, if these sections of road were to be rebuilt in the future, a subsequent erosion investigation would be warranted.

The primary roads accessing the drainage (H03 and H11) are generally located along the ridges and high in the drainage. They are typically surfaced with approximately 8 to 12 inches of rock and/or have had deep waterbars installed. The spur roads branching off of these roads have had varying degrees of maintenance, with some road reaches being abandoned over a decade ago. Figure 8 shows the current 1998 road network in Stitz Creek, with road and site labels. Several sections of the road, particularly those located in identified debris slide amphitheaters were completely obliterated by slides, isolating the more stable segments of the road prism beyond.

Recommendations for Roads in Stitz Creek

The erosion problems identified in the Stitz Creek watershed involved roads on slopes of greater than 50 percent, and insufficient drainage of the roads. A general overview of needed improvements follows.

Often a timber harvesting plan (THP) presents an opportunity to upgrade or decommission roads in an area. Road construction and reconstruction for THPs must comply with the California Forest Practice Rules (FPRs). PALCO has incorporated additional requirements in their *Truck Road and Landing Specifications and Construction Standards*, many of which were adopted from the *Handbook for Forest and Ranch Roads* (Weaver and Hagans 1994). Overall, the FPRs state the minimum standards required for road construction and reconstruction, and the *Handbook for Forest and Ranch Roads* provides more descriptive design criteria recommendations to achieve those standards. New road construction will occur in conformance to specified construction standards, which address erosion concerns and thereby minimize future sediment production potential.

Improvement of Existing Roads

In Wildcat geology, the road surface is easily rutted by vehicular traffic, especially on roads that are not rocked. In many cases, road outsloping would prove ineffective in this geology when the surface becomes rutted. Road improvements in the Stitz Creek watershed should minimize the surface water on roads by outsloping where appropriate, and maintaining inboard ditches and installing additional ditch relief culverts. Frequent drainage of the road system by rolling dips and relief drains is an important component of the strategy to minimize road surface water accumulation. Ditch relief culverts may need spacing as frequent as the waterbar spacing requirements, particularly on steep slopes. All headwall swales should have at least one drainage structure to minimize and drain the concentration of water that naturally occurs in those areas. Culvert sizing for at least a 50-year flood event appears appropriate. Armoring the outlets of culverts may be recommended to lessen the erosion potential that occurs if the culvert is overtopped.

Maintenance Recommendations

Wildcat geology is erosive and waterbars should be deep and spaced at a high frequency. Waterbars should be inspected and repaired as needed after storm events capable of triggering mass wasting or replaced each fall if the road has had vehicular traffic. Closed roads should exclude vehicular traffic, except possibly for quadrunner/ ATV access. Road maintenance in Stitz Creek should minimize outboard berms, keep inboard ditches clear, endhaul fill material rather than incorporating it into the road prism, and eliminate sidecasting.

Priority Sites from Road Inventory

High Priority

Table 10. High Priority road maintenance sites (Site locations in Figure 9).

Hydrologic road decommissioning	Estimated Erosion Potential (yd^3)
H11.67 (0.3 miles)	200
H11.33 (0.5 miles)	200
H11 (east) beyond H11.590 – X5 to terminal end (0.7 miles)	670
Individual erosion sites	
H11 – M1	1,800
H11.5974(W) – L3	500
H03.1606 – X4 and X5	445

3815

Road upgrading / preventative erosion measures	
H11	1,000+

Hydrologic road decommissioning: H11.67 is a spur road that has extensive diversions causing water concentration and fill failures. Hydrologically decommissioning road H11.33 would include removal of perched fill at the end landing as well as correcting the drainage problems exacerbated by an earthflow feature along the road. The end of road H11 (eastern end) is not actively maintained and the drainage crossings are eroding the fill prism, particularly crossings 1, 2, and 5.

Individual erosion sites: H11 – M1 is a site of deep-seated land movement and the material of the road and downslope of the road is at risk of large scale failure. As the feature is deep-seated, it is unlikely that all the potential future erosion can be eliminated from the site. Landing L3 on H11.5974(W) is actively failing, and concentrated water diverted from the road system feeds the site. H03.1606 – X4 and X5 are stream crossings that have failed or have no drainage structures and are eroding the road fill. However, to access these sites a temporary crossing would have to be installed in the channel that was "blown out" by a major debris torrent in the 1997 storm event. When these sites are repaired, there are several moderate priority sites further down the road that could also be treated (see below).

Road upgrading: H11 is the primary road accessing the watershed towards the east. It is well rocked, but needs inboard ditch clearing and additional ditch relief culverts. A high frequency spacing of relief culverts is necessary in this geology. Two headwall swales are chronic problem sites along this road and need additional drainage, and relief drains installed.

Moderate Priority

Table 11. Moderate priority sites for road maintenance (Site locations in Figure 10).

Hydrologic road decommissioning	Estimated Erosion Potential (yd³)
H11.55 (0.2 miles)	100
H11.5974 (W), first 800'	75
Individual erosion sites	
H11 (main) – X4, 6, 9, 11, 15, 18, 19, 20	420
H11.59 – S1	45
H11.8225 – X1	200
H03.1606 – X2, 3, 3a, M1	500
H03.06 – L1, X1	35
Road upgrading / Preventative erosion measures	
H03.06	300+

Hydrologic road decommissioning: H11.55 is a short spur road with perched fill at the end landing and outboard edge of the road. H11.5974(W) needs re-constructed waterbars/drainage and is the approach to a high priority site, L3.

Individual erosion sites: The crossings on H11 need clearing, elimination of diversion potential, upgrading, and/or additional ditch relief drains. H11.59 – S1 contains perched fill along the outboard edge of the road prism in an area prone to failures. H03.1606 X2, 3, 3a, and M1 are sites of fill susceptible to fluvial or mass wasting erosion (attending to both the high and moderate sites along this road would result in hydrologic decommissioning of this road reach). H03.06 – L1 has perched fill, and X1 is a headwall swale which needs relief drainage.

Road upgrading: Road H03.06 climbs a ridgeline, has steep road grades, and is rocked for the initial mile. However, the road needs upgrading with additional rock and improved waterbars and/or relief drains. Currently several of the waterbars have been eroded and need re-installation.

Low Priority:

Several low priority sites are worthy of mention in this section. These sites would become a higher priority only if work was to be completed in the area in which the roads to these sites were to be rebuilt. By themselves, the access limitation and minor future sediment delivery are not significant enough to warrant a higher rating.

Low priority sites: H03.0642 – X1. This crossing is on the opposite side of the debris torrent slide. If access were achieved, then this crossing should be excavated or upgraded because the culvert is plugged and there is also a road diversion feeding the erosion of the fill. The landing located at the end of H11.3317 has perched fill remaining, but would require a significant road rebuild to access. The long abandoned portion of H11.5974(W) has minor sediment potential existing at the crossings along the road. If this road were to be re-opened, crossing improvements would be required.

CONCLUSIONS AND MANAGEMENT RECOMENDATIONS

Mass Wasting Conclusions

Mass wasting naturally occurs in the Stitz Creek watershed due to the steep, uplifted terrain and the weathered, inherently weak structure of the bedrock. Shallow landslides represented 74 percent of the identified features. The mudstone dominated Rio Dell member of the Wildcat Formation was particularly susceptible to shallow landsliding. Shallow landslide features identified as debris flows produced the majority of the sediment volume in the watershed. The landslides typically initiated on steep slopes, most being associated with debris slide amphitheaters, inner gorges, and mid slope areas. Several deep-seated features were identified in Stitz Creek, but sediment production from these features was significantly less than the contribution from shallow landslides.

Higher numbers of landslides were observed in the 1966 and 1997 air photos compared to other photo years, which was attributed to the large storms of 1964 and 1997. The total mass wasting volume was higher in the time interval 1967-1997 than the volume determined for the 1936-1966 time interval. However sediment deliveries for the two time intervals are similar. In both the photo years, large debris flow features were the predominate source of sediment in our analysis of the mass wasting volume totals. From an analysis of the landslides generated by the 1997 storm event, 26 percent of the landslides were associated directly or indirectly to roads or skid trails and delivered up to 66 percent of the total sediment volume. Harvested areas, particularly those areas harvested over 10 years ago, tended to be associated with an increased incidence of landslides, although other contributing factors such as slope, geology, and location were not controlled for, and the variability of that data set was high.

Interim Aquatic Strategy

The Interim Aquatic Strategy (Appendix H) targets two of the most significant components of sediment yield in the watershed: 1) road and harvest activities on steep slopes, and 2) stream side buffers. As identified in this assessment, shallow landslides have the greatest occurrence on steep slopes, inner gorges, and midslope areas. Under the *Mass Wasting Avoidance Strategy*, a geologist's report and recommendations are required prior to harvesting or road construction in inner gorges, headwall swales, and unstable areas. Under the *Interim Aquatic Strategy*, restricted harvest requirements are set along the watercourses, which add protection to inner gorge slopes and headwalls, and create sediment buffers, which limit sediment delivery. In addition, under the *Interim Aquatic Strategy* new roads are constructed to a higher standard, and a goal of at least 500 miles per decade of restoration and storm-proofing of existing road is targeted.

Erosion Control and Sediment Reduction

Approximately 1.8 miles of road have high or moderate priority for hydrologic decommissioning. Twenty individual crossings, landings, and/or fill sites were identified as having a high or moderate priority need for erosion control work (fill excavation and/or elimination of diversion potential). General road upgrades, primarily the installation of additional relief culverts, are also needed on the two main system roads. Some sites may require a Certified Engineering Geologist (CEG) for final treatment prescriptions.

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Appendix A

Figures

Figure 1. Location of Stitz Creek Watershed, Humboldt Co., CA

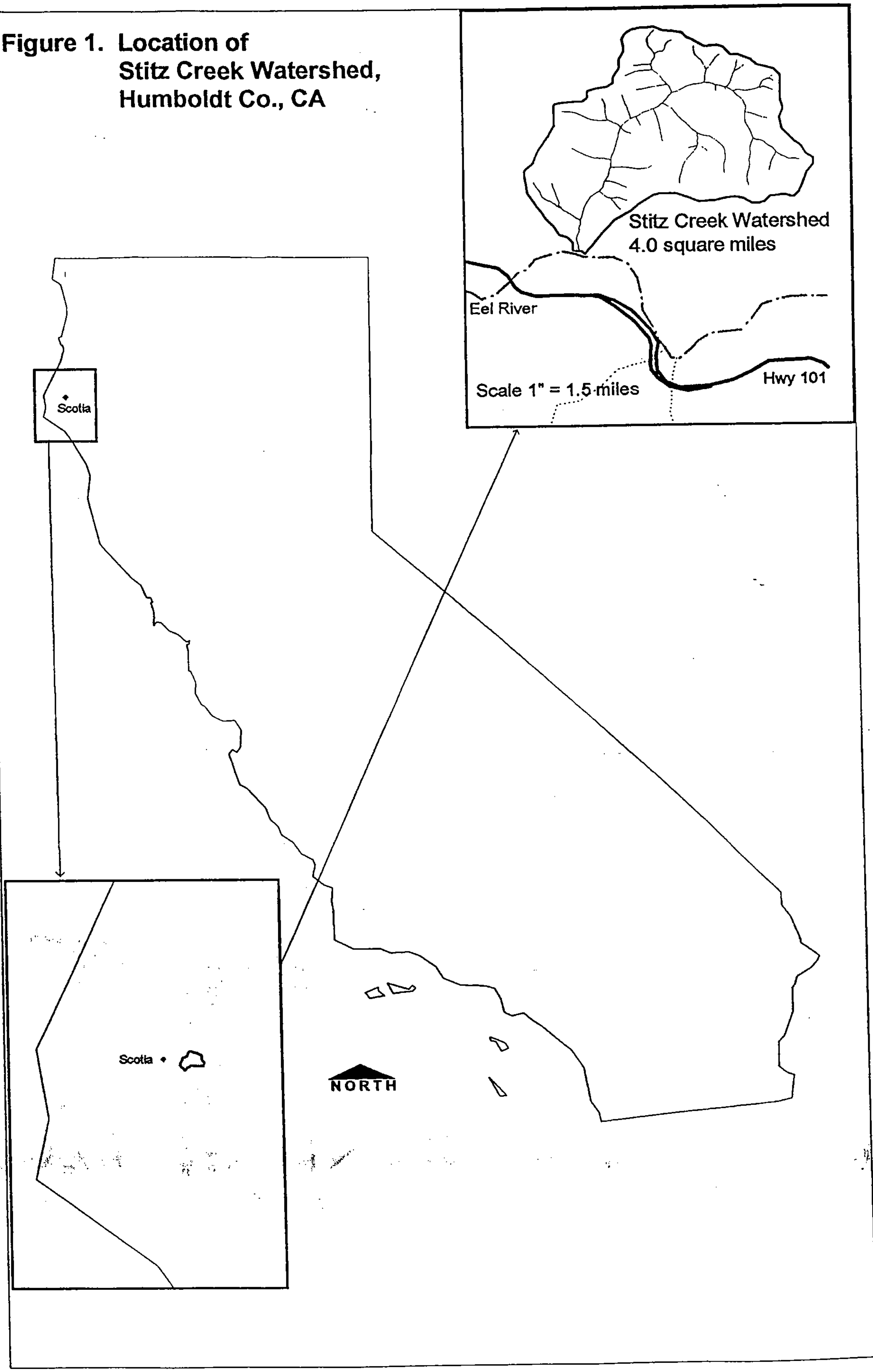


Figure 2. Stitz Creek Geologic Contact and Geomorphic Features Map

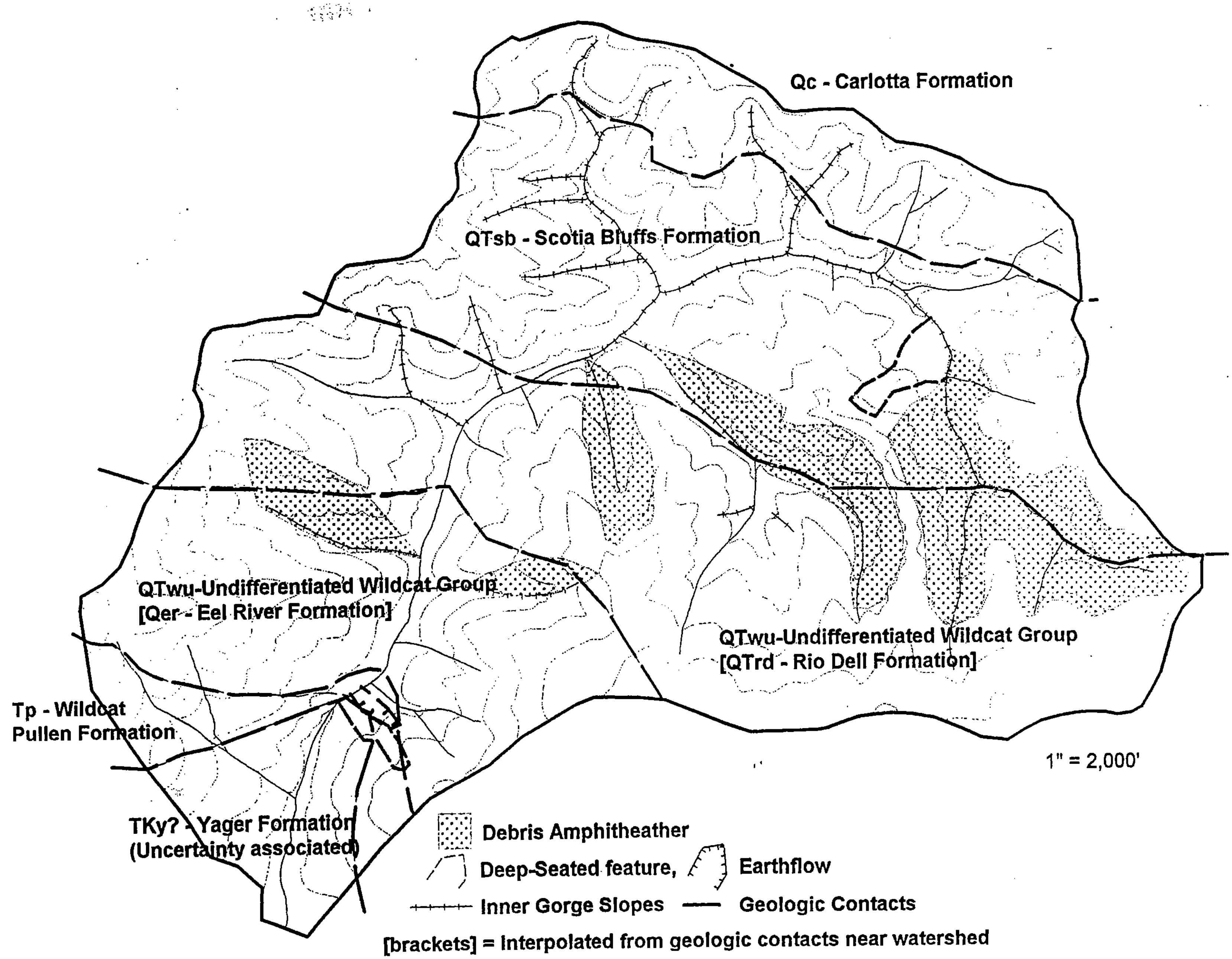


Figure 3. Land Use History from 1974 and 1981 aerial photographs

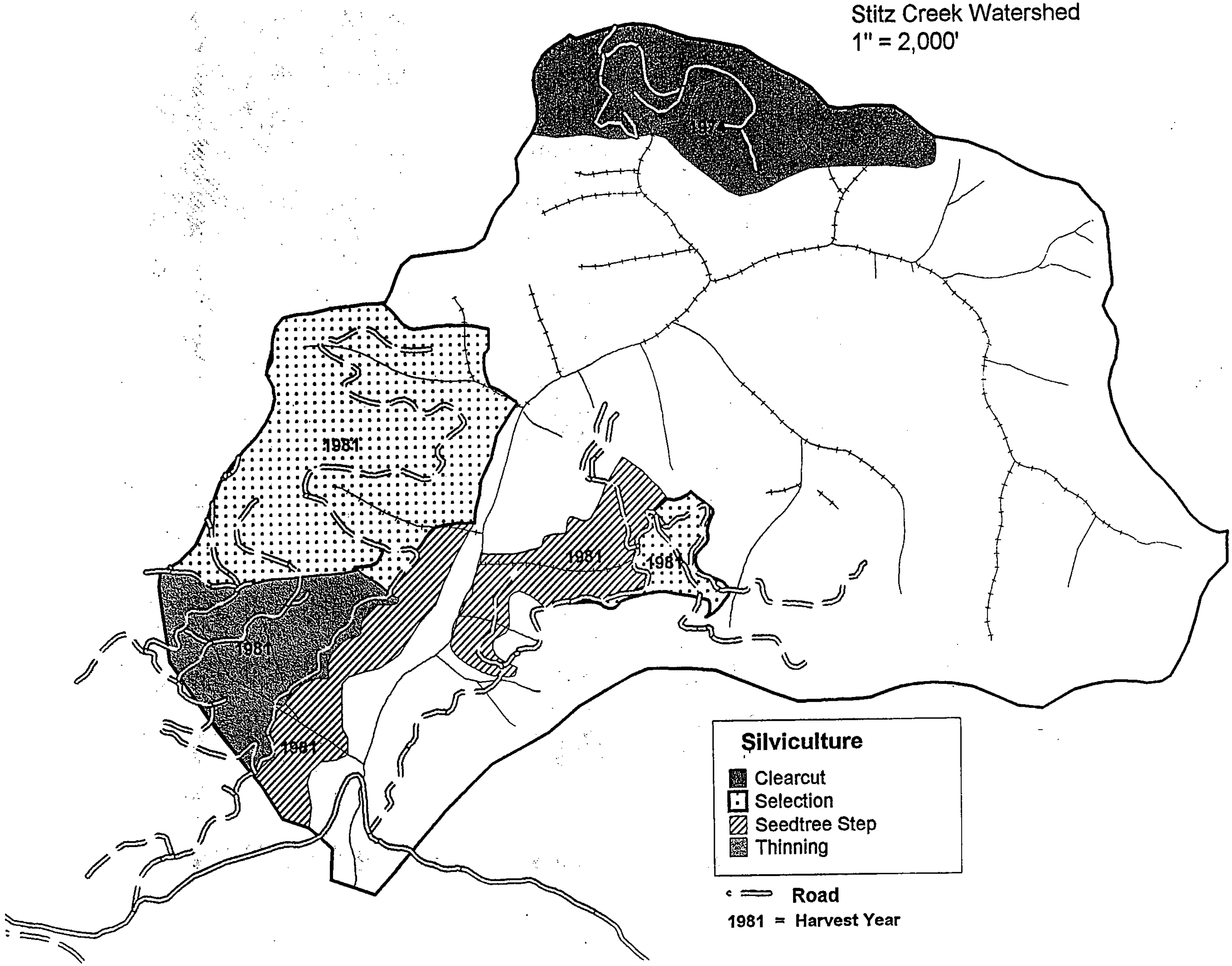
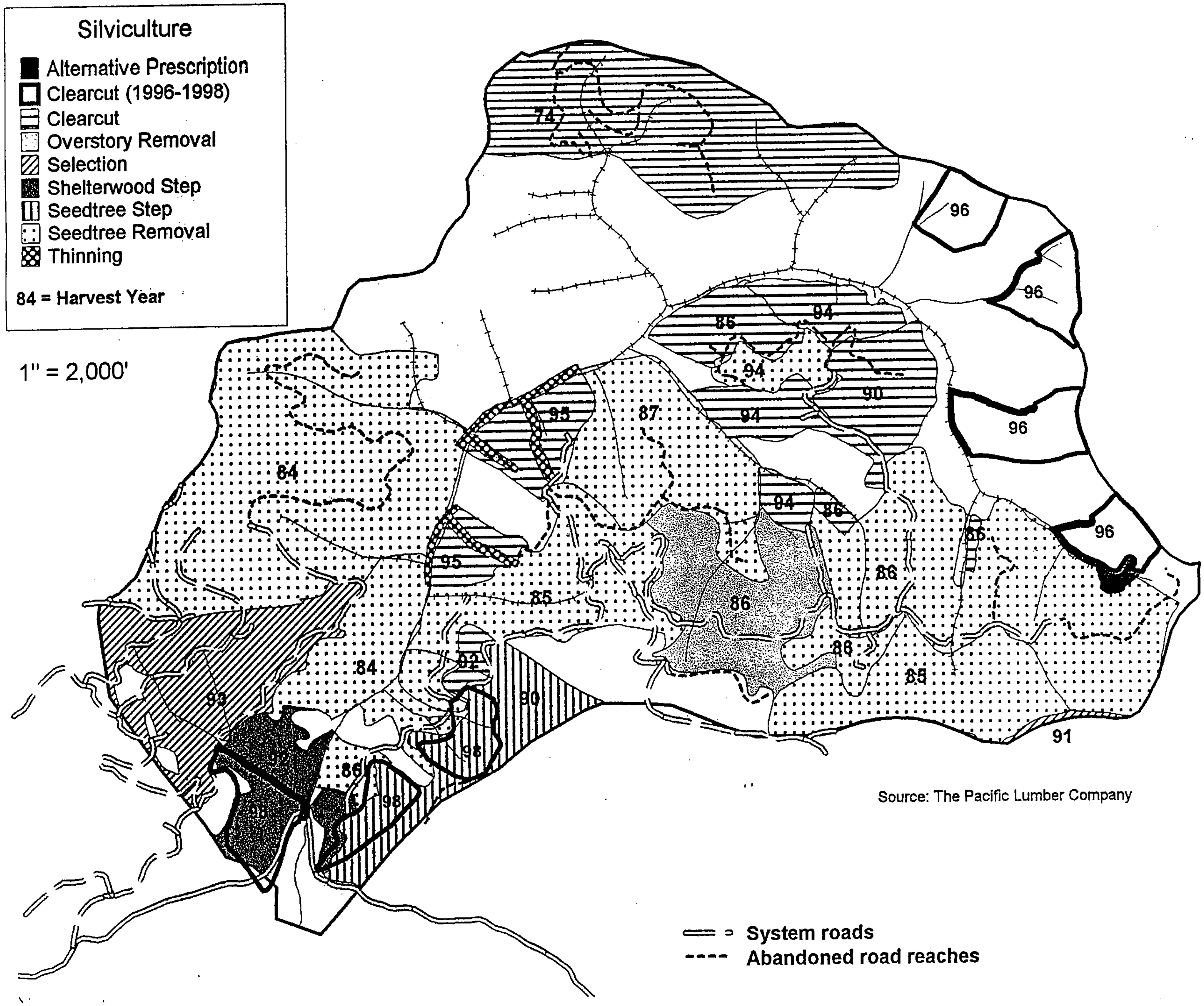


Figure 4. Land-Use History in Stitz Creek Watershed



Source: The Pacific Lumber Company

Figure 5. Locations of all landslides identified on the 1966 and 1997 photos

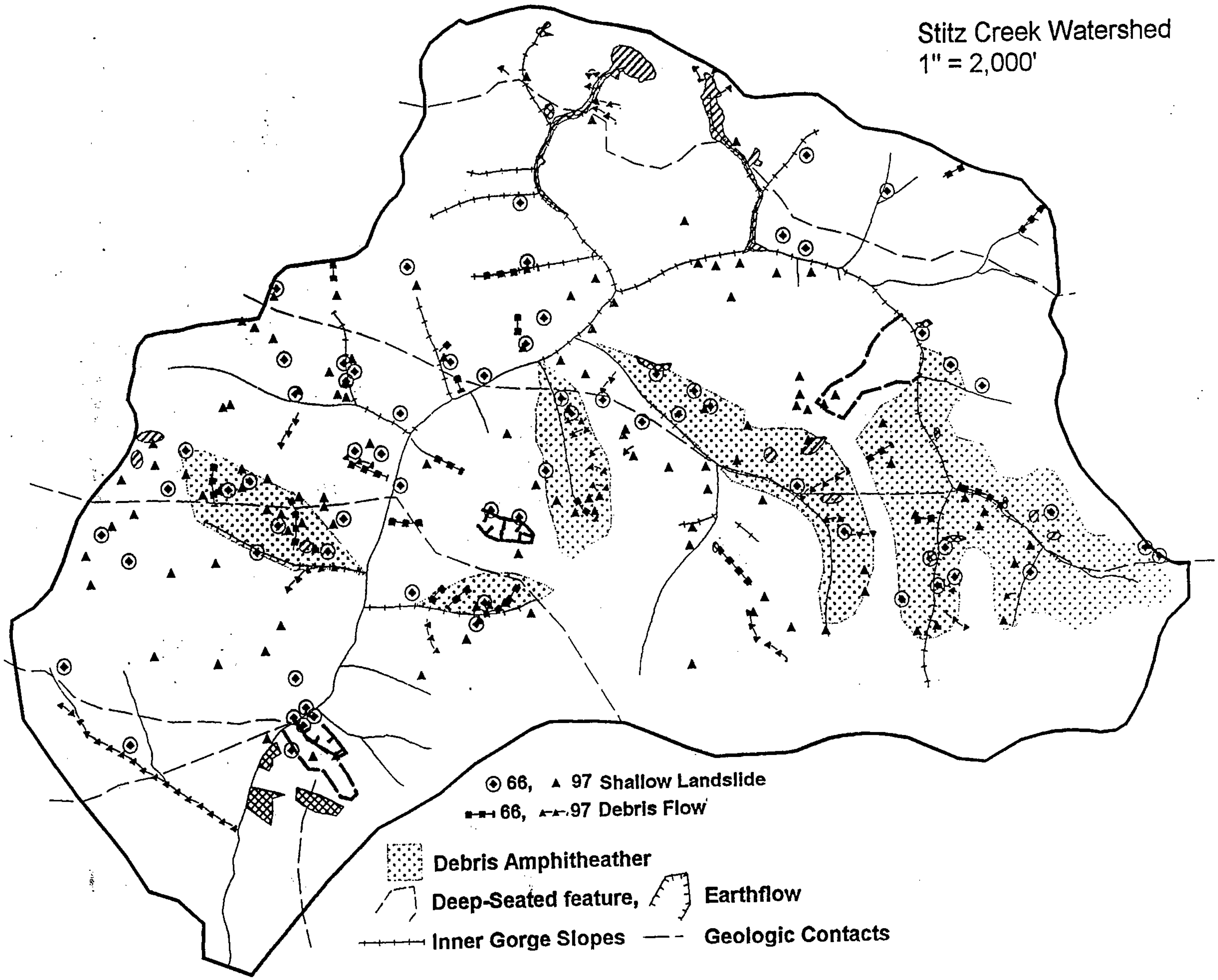


Figure 6. Locations of landslides generated by the 1964 storm event.

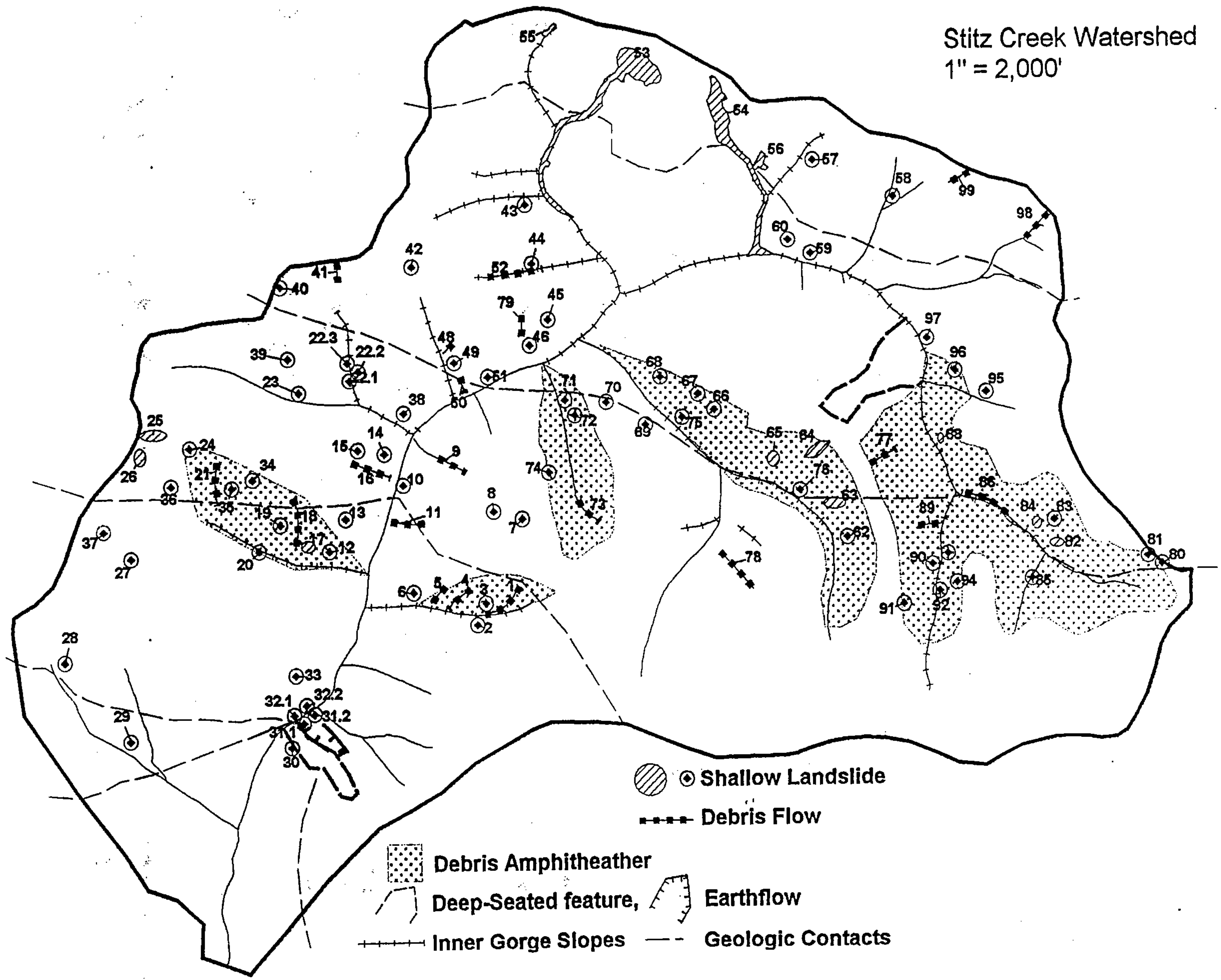


Figure 7. Locations of landslides generated by the 1997 storm event

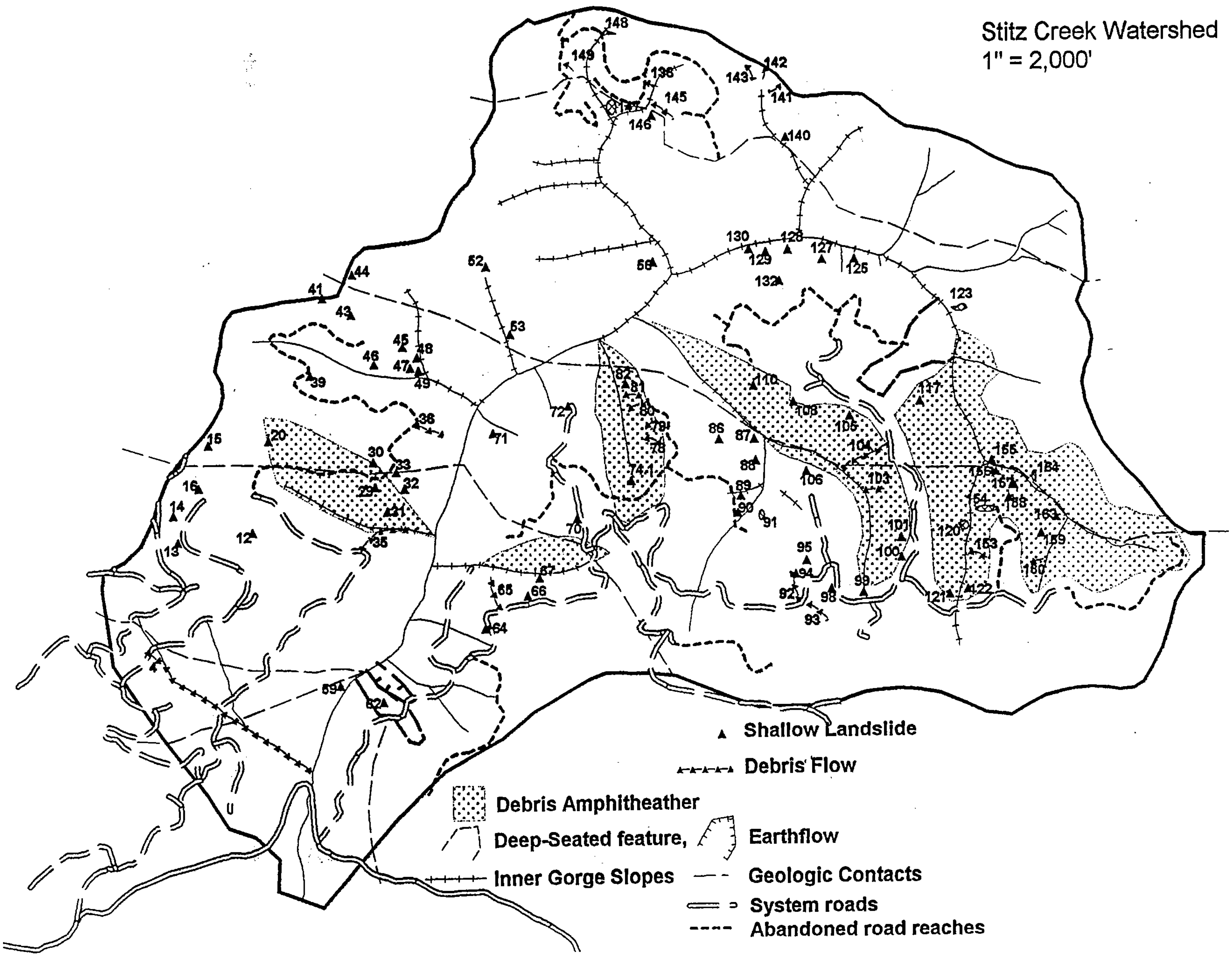


Figure 8. Road network in 1998.

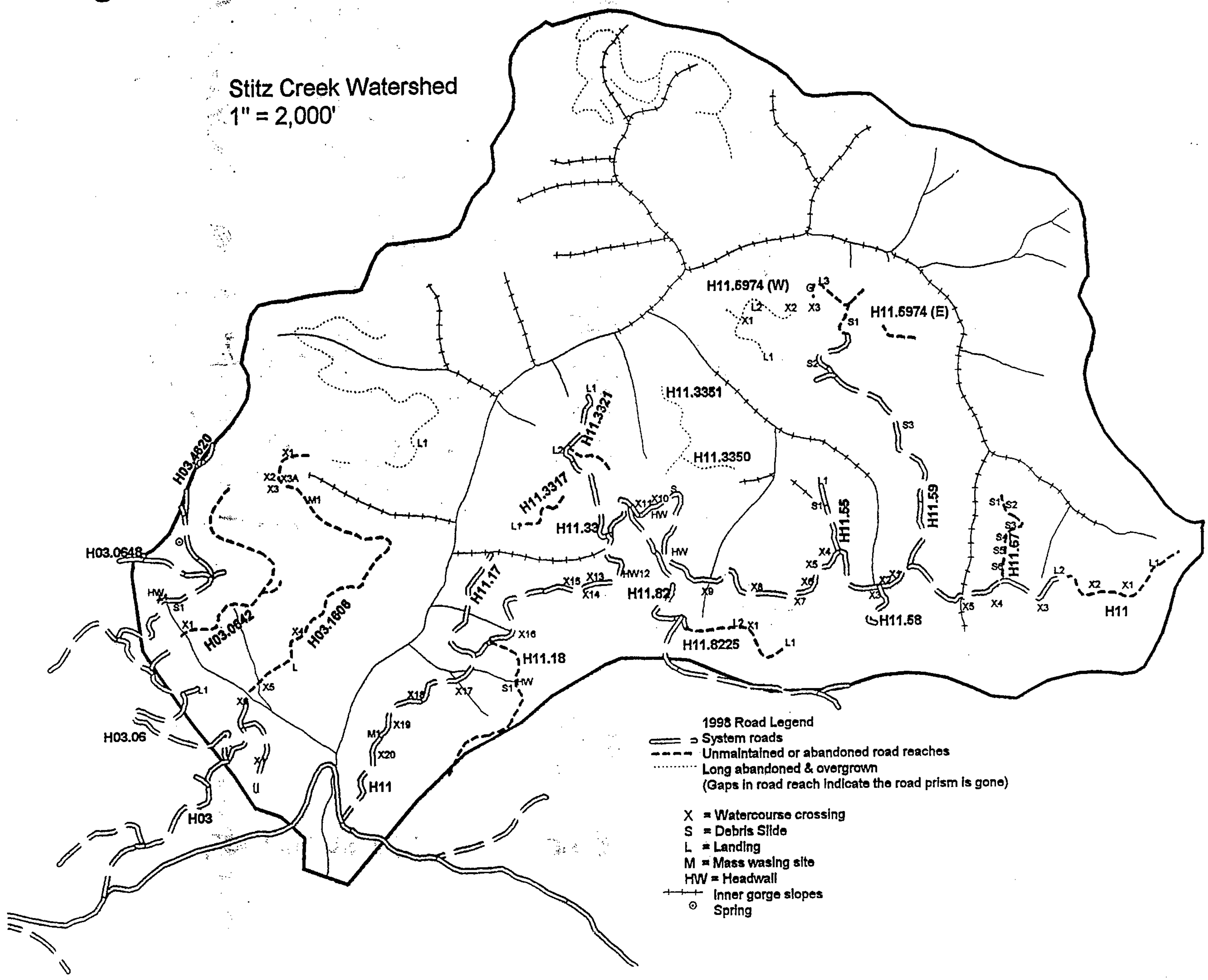


Figure 9. High priority sites identified in Stitz Creek road inventory

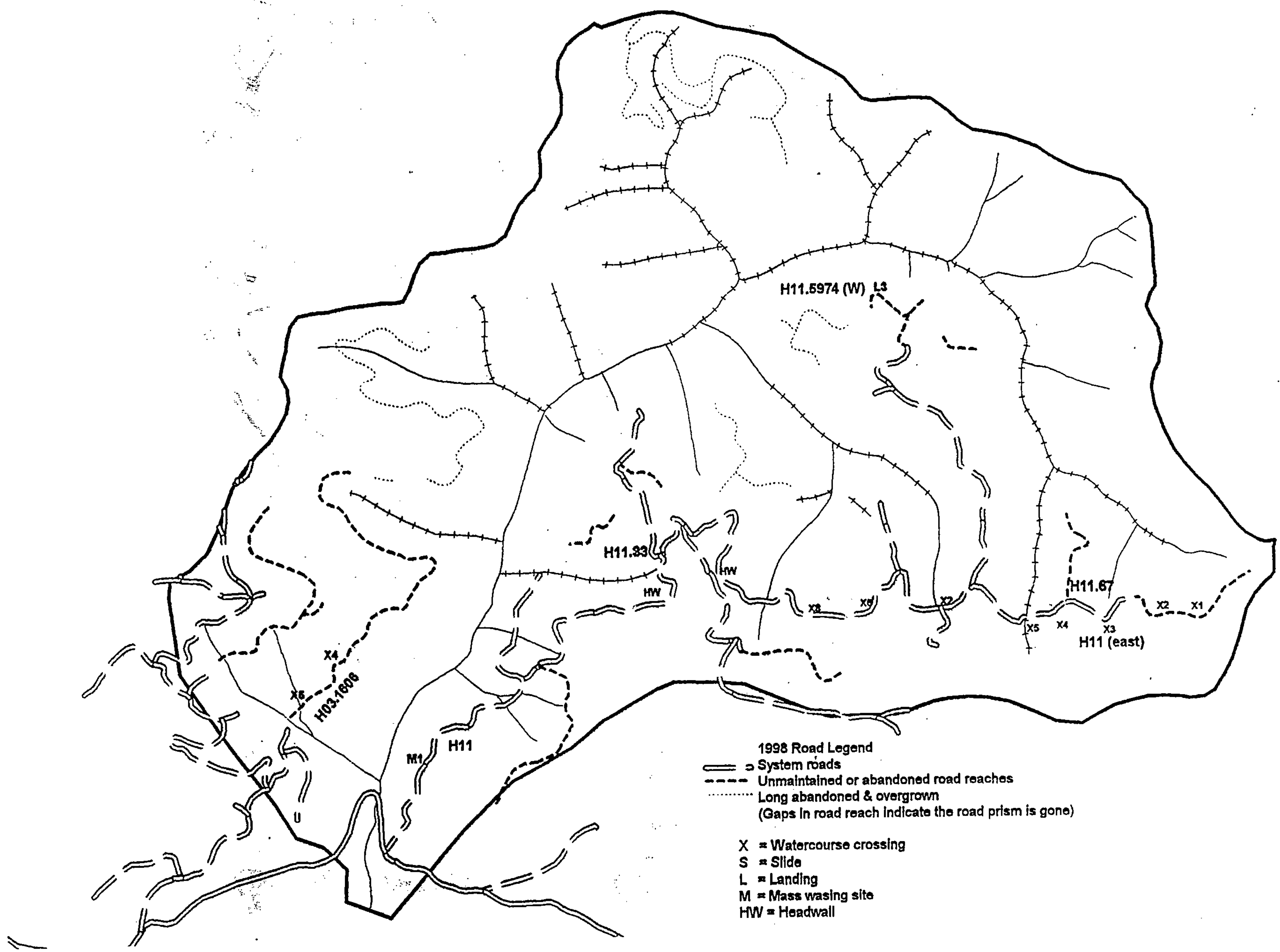
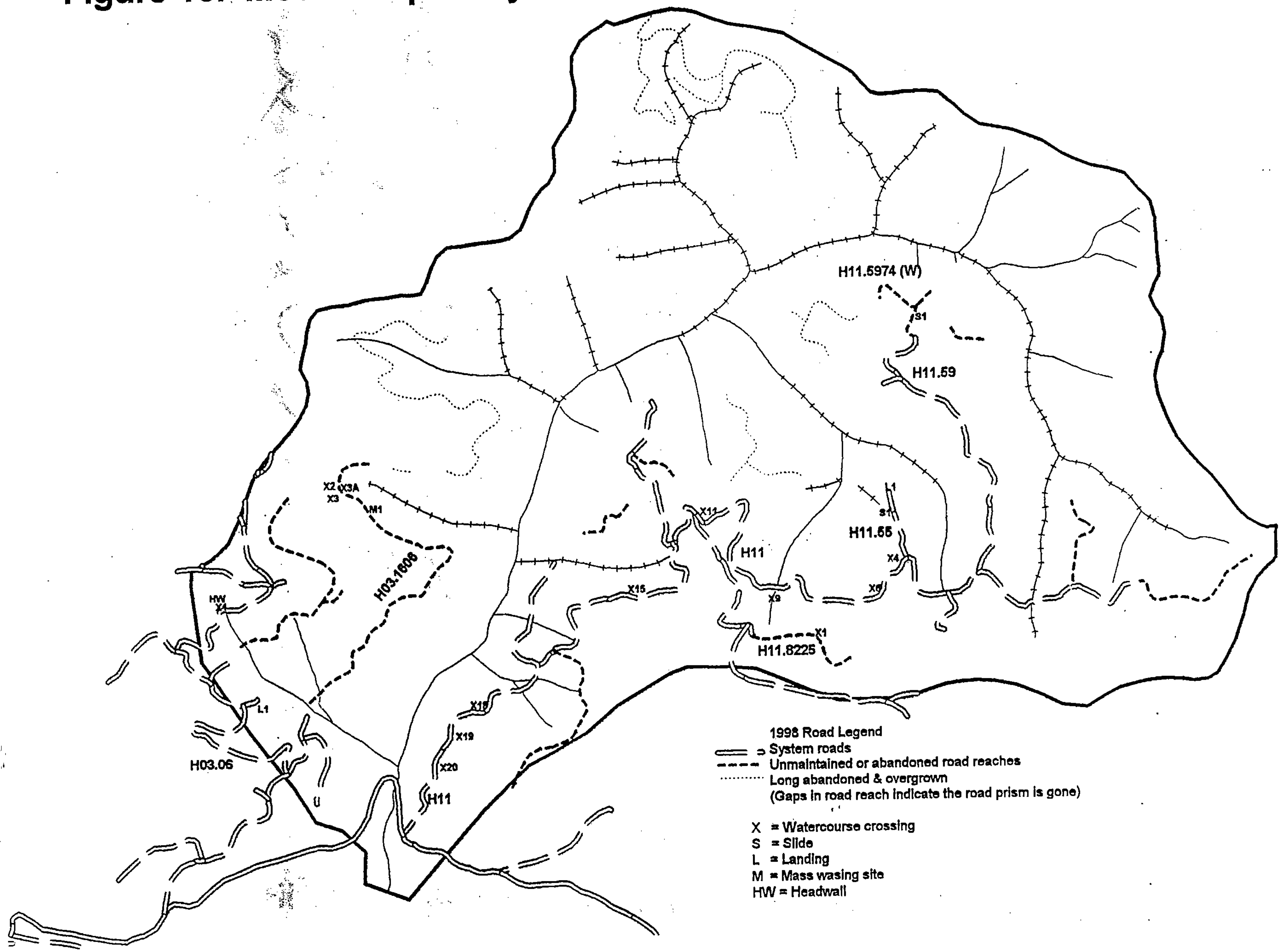


Figure 10. Moderate priority sites identified in Stitz Creek road inventory



Appendix B

Bull Creek Annual Maximum Discharges 1961-1995 and Bridgeville and Scotia Rainfall Data

US GEOLOGICAL SURVEY PEAK FLOW DATA
Peak flow data were retrieved from the National Water Data Storage and Retrieval System (WATSTORE).
Station name : Bull C Nr Weott Ca Station number: 11476600
drainage area (square miles).................. 28.1
base discharge (cubic ft/sec)................ 1700

Water Years Retrieved 1961-1995

Water Year	Date	Discharge (cfs)
1965	22-Dec-64	6520
1995	9-Jan-95	6400
1983	16-Dec-82	5880
1974	16-Jan-74	5830
1966	4-Jan-66	5000
1967	5-Dec-66	4800
1986	17-Feb-86	4780
1970	26-Jan-70	4280
1978	14-Dec-77	4260
1963	31-Jan-63	4120
1972	22-Jan-72	4000
1982	16-Nov-81	3840
1969	24-Dec-68	3550
1985	12-Nov-84	3500
1961	10-Feb-61	3400
1993	20-Jan-93	3300
1975	18-Mar-75	3290
1971	3-Dec-70	2970
1984	10-Nov-83	2810
1968	14-Jan-68	2710
1980	14-Jan-80	2540
1988	6-Dec-87	2310
1991	4-Mar-91	2040
1964	20-Jan-64	1930
1981	27-Jan-81	1770
1976	26-Feb-76	1590
1987	5-Mar-87	1460
1962	9-Feb-62	1380
1973	16-Jan-73	1370
1989	22-Nov-88	1150
1994	23-Jan-94	1110
1979	11-Jan-79	878
1990	8-Jan-90	806
1992	16-Feb-92	635
1977	19-Sep-77	173

BRIDGEVILLE *(BGV)*

Elevation: 646' · VAN DUZEN R basin · Operator: CA Dept of Water Resources

INCREMENTAL PRECIP (6524)

12/23/1996 00:00	0.08 inches
12/24/1996 00:00	0.00 inches
12/25/1996 00:00	0.28 inches
12/26/1996 00:00	1.16 inches
12/27/1996 00:00	0.88 inches
12/28/1996 00:00	0.52 inches
12/29/1996 00:00	3.04 inches
12/30/1996 00:00	3.80 inches
12/31/1996 00:00	3.76 inches
01/01/1997 00:00	1.96 inches
01/02/1997 00:00	1.24 inches
01/03/1997 00:00	0.16 inches
01/04/1997 00:00	0.00 inches
01/05/1997 00:00	0.00 inches

These data have not been reviewed for accuracy.

Highest Monthly Rainfall Totals at Scotia

Raw html Data		Date	Inches	2 month total over the new year		
01/01/1995	26.41 inches	1995	26.41	(12/01/1994	6.32 inches)	32.73
12/01/1955	22.88 inches	1955	22.88	(01/01/1956	14.43 inches)	37.31
12/01/1996	22.58 inches	1996	22.58	(01/01/1997	12.90 inches)	35.48
02/01/1958	21.54 inches	1958	21.54			
11/01/1973	21.53 inches	1973	21.53			
01/01/1959	19.75 inches	1959	19.75			
02/01/1938	19.39 inches	1938	19.39			
12/01/1941	18.94 inches	1941	18.94			
11/01/1984	18.70 inches	1984	18.70			
12/01/1952	18.66 inches	1952	18.66			
11/01/1926	18.65 inches	1926	18.65			
12/01/1964	18.37 inches	1964	18.37	(01/01/1965	9.50 inches)	27.87
12/01/1945	18.31 inches	1945	18.31			
12/01/1987	18.02 inches	1987	18.02			
12/01/1968	17.37 inches	1968	17.37			
01/01/1970	17.32 inches	1970	17.32			
12/01/1983	17.31 inches	1983	17.31			
01/01/1978	17.20 inches	1978	17.20			
12/01/1940	17.11 inches	1940	17.11			
03/01/1938	16.54 inches	1938	16.54			
01/01/1969	16.19 inches	1969	16.19			
02/01/1986	16.10 inches	1986	16.10			
01/01/1954	16.08 inches	1954	16.08			
03/01/1995	16.07 inches	1995	16.07			
11/01/1983	16.01 inches	1983	16.01			
02/01/1959	15.52 inches	1959	15.52			
12/01/1982	15.51 inches	1982	15.51			
01/01/1941	15.32 inches	1941	15.32			
01/01/1952	15.22 inches	1952	15.22			
11/01/1937	15.15 inches	1937	15.15			
12/01/1925	15.11 inches	1925	15.11			
12/01/1995	14.82 inches	1995	14.82			
03/01/1975	14.78 inches	1975	14.78			
12/01/1939	14.65 inches	1939	14.65			
02/01/1940	14.60 inches	1940	14.60			
10/01/1950	14.55 inches	1950	14.55			
12/01/1969	14.45 inches	1969	14.45			
01/01/1956	14.43 inches	1956	14.43			
01/01/1966	14.24 inches	1966	14.24			
01/01/1936	14.11 inches	1936	14.11			
03/01/1949	14.05 inches	1949	14.05			
12/01/1931	13.81 inches	1931	13.81			
02/01/1983	13.76 inches	1983	13.76			
02/01/1969	13.52 inches	1969	13.52			
12/01/1933	13.49 inches	1933	13.49			
01/01/1983	13.34 inches	1983	13.34			
03/01/1991	13.33 inches	1991	13.33			
12/01/1970	13.32 inches	1970	13.32			
12/01/1992	13.27 inches	1992	13.27			
01/01/1953	13.23 inches	1953	13.23			

Scotia Monthly Preciptation Data from CA Dept. of Water Resources
Elevation 139' Eel River Basin - Operator: National Weather Service

Raw html Data

Date	Inches
1997 Total	41.13
1996 Total	64.87
1995 Total	70.57
1994 Total	39.01
1993 Total	46.33
1992 Total	44.95
1991 Total	33.24
1990 Total	33.03
1989 Total	31.11
1988 Total	36.40
1987 Total	50.34
1986 Total	48.13
1985 Total	24.33
1984 Total	44.16
1983 Total	73.23
1982 Total	30.45
1981 Total	0.00
1980 Total	33.82
1979 Total	52.56
1978 Total	47.70
1977 Total	36.58
1976 Total	24.97
1975 Total	55.11
1974 Total	52.23
1973 Total	66.82
1972 Total	43.62
1971 Total	49.30
1970 Total	56.34
1969 Total	56.69
1968 Total	49.65
1967 Total	45.35
1966 Total	49.85
1965 Total	40.29
1964 Total	51.89
1963 Total	52.08
1962 Total	47.83
1961 Total	41.03
1960 Total	47.97
1959 Total	46.23
1958 Total	59.39
1957 Total	54.81
1956 Total	42.99
1955 Total	52.25
1954 Total	56.42
1953 Total	53.34
1952 Total	55.90
1951 Total	52.47
1950 Total	58.60

Scotia Monthly Preciptation Data from CA Dept. of Water Resources
Elevation 139' Eel River Basin - Operator: National Weather Service

Raw html Data

Date	Inches
1949 Total	34.16
1948 Total	49.60
1947 Total	33.34
1946 Total	29.70
1945 Total	62.85
1944 Total	43.54
1943 Total	39.35
1942 Total	49.76
1941 Total	67.49
1940 Total	56.86
1939 Total	36.88
1938 Total	66.65
1937 Total	60.69
1936 Total	36.79
1935 Total	42.15
1934 Total	40.56
1933 Total	47.62
1932 Total	35.09
1931 Total	41.43
1930 Total	30.09
1929 Total	23.15
1928 Total	38.10
1927 Total	46.58
1926 Total	53.04
1925 Total	15.11
Grand Total	3325.94

Average Annual Rainfall = 46.84 inches
(no rainfall data for 1981)

Appendix C

Landslide Data Form Descriptions and Individual Landslide Data

Description of the Parameters used to describe mass wasting in the mass wasting inventory

I.D. Number: Each landslide is numbered in the order invertoried.

Slide Type: The landslide type is recorded at each site by SL, shallow landslide; DS, deep-seated landslide; DF, debris flow; SL/DF, shallow landslide and debris flow; RF, rock fall.

Certainty: The certainty of identification is recorded at each site by D, definite; P, probable; Q, questionable.

Age/approximate failure date: Minimum failure date is assumed to be the photo year that the slide first appears on. Degree of revegetation, scarp morphology, and review of older air photos were used to better constrain the age.

Slope Form: The shape of the slope in which each slide originates is recorded by P, planar; C, convergent; D, divergent.

Aspect: The direction that each slide failed is recorded by E, east; W, west; N, north; S, south

Location: The geomorphic location where each slide occurs is recorded by IG, inner gorge; EIG, ephemeral inner gorge; MS, mid slope; HW, headwater swale; RT, ridge top.

Physical Characteristics: Include length, width, depth, area, and volume

Sediment Delivery: A range of sediment delivery (0-25, 25-50, 50-75, 75-100) was applied to each slide to determine minimum and maximum sediment delivery.

All Slides Identified on the 1966 Aerial Photos

ID	TYPE	LENGTH	WIDTH	AREA	DEPTH	CY_VOLUME	SED_DEL	MIN_DEL	MAX_DEL	SLOPE_FORM	ASPECT	AGE	LOCATION	ROAD	CERTAINTY
1	SL/DF	182	109	19,838	8	5,878	75-100	4,408	5,878	C	SW	< 66	IG	0	D
1.1	DF	218	36	7,848	4	1,163	75-100	872	1,163	C	SW	< 66	IG	0	D
2	SL	55	36	1,980	4	293	25-50	73	147	C	W	< 66	IG	0	D
3	SL	10	36	360	4	53	50-75	27	40	P	S	< 66	MS	0	P
4	SL/DF	109	109	11,881	4	1,760	25-50	440	880	P	S	< 66	MS	0	D
5	SL/DF	255	55	14,025	4	2,078	75-100	1,558	2,078	P	S	< 66	IG	0	D
6	SL	72	36	2,592	4	384	50-75	192	288	P	W	< 66	IG	0	D
7	SL	72	36	2,592	3	288	0	0	0	C	W	< 66	MS	0	Q
8	SL	72	72	5,184	3	576	0	0	0	P	W	< 66	MS	0	Q
9	SL/DF	328	50	16,400	6	3,644	25-50	911	1,822	C	W	< 66	MS	0	D
10	SL	72	90	6,480	4	960	50-75	480	720	P	W	< 66	IG	0	D
11	SL/DF	72	109	7,848	8	2,325	50-75	1,163	1,744	P	W	< 66	IG	0	D
11.1	DF	182	55	10,010	4	1,483	50-75	741	1,112	P	W	< 66	IG	0	D
12	SL	90	72	6,480	4	960	25-50	240	480	D	S	< 66	IG	0	D
13	SL	72	36	2,592	3	288	1-25	3	72	D	E	< 66	MS	0	D
14	SL	36	36	1,296	3	144	0	0	0	P	E	< 66	MS	0	D
15	SL	145	36	5,220	4	773	0	0	0	P	E	< 66	MS	0	D
16	SL/DF	360	20	7,200	3	800	25-50	200	400	P	E	10+	MS	0	D
16.1	DF	36	72	2,592	6	576	25-50	144	288	P	E	10+	MS	0	D
17	SL	146	72	10,512	4	1,557	50-75	779	1,168	P	S	< 66	IG	0	D
18	SL/DF	360	54	19,440	4	2,880	50-75	1,440	2,160	D	S	< 66	MS	0	D
19	SL/DF	145	40	5,800	4	859	50-75	430	644	P	S	5+	MS	0	D
20	SL	54	36	1,944	4	288	75-100	216	288	P	N	< 66	IG	0	D
21	SL/DF	182	72	13,104	8	3,883	75-100	2,912	3,883	P	S	1966	MS	0	D
21.1	DF	291	18	5,238	3	582	75-100	437	582	P	S	1966	MS	0	D
22.1	SL	30	30	900	3	100	50-75	50	75	C	S	1966	IG	0	D
22.2	SL	72	27	1,944	4	288	75-100	216	288	P	E	1966	IG	0	D
22.3	SL	18	18	324	3	36	75-100	27	36	P	E	1966	IG	0	D
23	SL	182	40	7,280	4	1,079	75-100	809	1,079	P	S	< 66	IG	0	D
24	SL	36	18	648	3	72	0	0	0	C	SE	< 66	HW	0	P
25	SL	72	36	2,592	3	288	0	0	0	C	S	< 66	RT	0	Q
26	SL	36	182	6,552	3	728	1-25	7	182	P	S	< 66	MS	0	Q

All Slides Identified on the 1966 Aerial Photos

ID	TYPE	LENGTH	WIDTH	AREA	DEPTH	CY_VOLUME	SED_DEL	MIN_DEL	MAX_DEL	SLOPE_FORM	ASPECT	AGE	LOCATION	ROAD	CERTAINTY
27	SL	54	25	1,350	3	150	0	0	0	P	SE	< 66	MS	0	D
28	SL	72	36	2,592	4	384	1-25	4	96	C	SW	< 66	HW	0	D
29	SL	36	18	648	3	72	1-25	1	18	P	S	< 66	IG	0	D
30	DS	254	145	36,830	8	10,913	25-50	2,728	5,456		NW	< 66	IG	0	D
31.1	SL	145	36	5,220	4	773	75-100	580	773	P	NW	< 66	IG	0	D
31.2	SL	145	72	10,440	4	1,547	50-75	773	1,160	P	NW	< 66	IG	0	D
32.1	SL	145	36	5,220	4	773	75-100	580	773	P	SE	< 66	IG	0	D
32.2	SL	54	36	1,944	4	288	75-100	216	288	P	SE	< 66	IG	0	D
33	SL	72	18	1,296	3	144	0	0	0	D	SE	< 66	MS	0	D
34	SL/DF	436	109	47,524	6	10,561	25-50	2,640	5,280	P	S	20+	RT	0	Q
35	SL/DF	290	72	20,880	6	4,640	25-50	1,160	2,320	P	S	20+	MS	0	Q
36	SL	70	36	2,520	3	280	1-25	3	70	P	S	< 66	EIG	0	D
37	SL	36	18	648	3	72	0	0	0	D	SE	< 66	MS	0	D
38	SL/RF	36	36	1,296	2	96	1-25	1	24	D	S	< 66	IG	0	D
39	SL	32	18	576	3	64	0	0	0	P	S	< 66	MS	0	P
40	RF	36	18	648	2	48	0	0	0	P	S	< 66	RT	0	D
41	RF	109	36	3,924	2	291	0	0	0	C	S	1966	RT	0	D
42	SL	36	36	1,296	3	144	1-25	1	36	C	SE	< 66	HW	0	D
43	SL/DF	182	54	9,828	4	1,456	25-50	364	728	D	NE	20+	IG	0	P
44	SL	36	253	9,108	3	1,012	25-50	253	506	P	SE	< 66	IG	0	D
45	SL	46	36	1,656	3	184	0	0	0	P	S	< 66	MS	0	D
46	SL	55	27	1,485	4	220	1-25	2	55	P	S	< 66	IG	0	D
48	SL	182	36	6,552	4	971	75-100	728	971	P	SW	5-10	MS	0	P
49	SL	54	36	1,944	4	288	50-75	144	216	P	SW	< 66	IG	0	D
50	SL	182	18	3,276	4	485	75-100	364	485	D	SE	< 66	IG	0	D
51	SL	18	18	324	3	36	75-100	27	36	P	SE	< 66	IG	0	P
52	SL/DF	473	72	34,056	8	10,091	75-100	7,568	10,091	C	E	20+	MS	0	P
53	SL/DF	546	200	109,200	15	60,667	75-100	45,500	60,667	C	SW	< 66	HW	0	D
53.1	DF	1092	36	39,312	6	8,736	75-100	6,552	8,736	C	SW	< 66	HW	0	D
54	SL/DF	546	182	99,372	12	44,165	75-100	33,124	44,165	C	S	< 66	HW	0	D
54.1	DF	1383	36	49,788	6	11,064	75-100	8,298	11,064	C	S	< 66	HW	0	D
55	SL	290	54	15,660	12	6,960	75-100	5,220	6,960	C	SW	< 66	MS	0	D

11/30/98

All Slides Identified on the 1966 Aerial Photos

ID	TYPE	LENGTH	WIDTH	AREA	DEPTH	CY_VOLUME	SED_DEL	MIN_DEL	MAX_DEL	SLOPE_FORM	ASPECT	AGE	LOCATION	ROAD	CERTAINTY
56	SL/DF	76	54	4,104	4	608	50-75	304	456	C	W	< 66	IG	0	D
56.1	DF	54	218	11,772	4	1,744	50-75	872	1,308	C	W	< 66	IG	0	D
57	SL	109	73	7,957	4	1,179	75-100	884	1,179	C	W	< 66	HW	0	D
58	SL	127	36	4,572	4	677	75-100	508	677	C	SW	< 66	HW	0	D
59	SL	145	76	11,020	4	1,633	50-75	816	1,224	P	S	< 66	IG	0	D
60	SL	145	36	5,220	4	773	50-75	387	580	P	S	1966	IG	0	D
62	SL	182	36	6,552	4	971	50-75	485	728	P	W	< 66	IG	0	D
63	SL	182	36	6,552	4	971	50-75	485	728	P	W	1966	IG	0	D
64	SL/DF	145	76	11,020	4	1,633	50-75	816	1,224	C	S	10-20	MS	0	P
65	SL/DF	182	109	19,838	4	2,939	75-100	2,204	2,939	P	S	5-10	IG	0	D
66	SL	18	18	324	3	36	0	0	0	C	S	< 66	MS	0	D
67	SL	91	36	3,276	4	485	0	0	0	P	W	< 66	MS	0	D
68	SL	76	27	2,052	3	228	1-25	2	57	P	SW	1966	MS	0	D
69	SL	182	36	6,552	4	971	50-75	485	728	P	E	< 66	IG	0	D
70	SL	218	109	23,762	6	5,280	25-50	1,320	2,640	P	NE	10-20	RT	0	D
71	SL	109	20	2,180	4	323	25-50	81	161	P	W	5-10	IG	0	P
72	SL	109	54	5,886	4	872	50-75	436	654	P	W	< 66	IG	0	D
73	SL/DF	290	54	15,660	4	2,320	50-75	1,160	1,740	C	W	5-10	HW	0	D
74	SL	76	36	2,736	4	405	0	0	0	P	E	< 66	RT	0	D
75	SL	76	40	3,040	4	450	25-50	113	225	P	SW	< 66	IG	0	D
76	SL	54	54	2,916	4	432	75-100	324	432	P	SW	< 66	IG	0	D
77	SL	218	18	3,924	4	581	0	0	0	P	NE	< 66	MS	0	D
78	SL/DF	291	76	22,116	4	3,276	25-50	819	1,638	P	NW	10-20	MS	0	P
79	SL	109	36	3,924	4	581	50-75	436	436	P	S	1966	IG	0	D
80	SL	25	25	625	3	69	0	0	0	P	W	< 66	RT	0	D
81	SL	36	25	900	3	100	0	0	0	P	W	< 66	RT	0	D
82	SL	146	146	21,316	4	3,158	50-75	1,579	2,368	P	SW	< 66	IG	0	D
83	SL	36	54	1,944	4	288	1-25	3	72	C	SW	< 66	IG	0	D
84	SL	109	109	11,881	4	1,760	75-100	1,320	1,760	D	SW	< 66	IG	0	D
85	SL	76	36	2,736	4	405	75-100	304	405	P	NW	< 66	IG	0	D
86	SL	76	509	38,684	4	5,731	75-100	4,298	5,731	D	SW	< 66	IG	0	D
88	SL	109	109	11,881	4	1,760	50-75	880	1,320	P	W	< 66	IG	0	D

All Slides Identified on the 1966 Aerial Photos

ID	TYPE	LENGTH	WIDTH	AREA	DEPTH	CY_VOLUME	SED_DEL	MIN_DEL	MAX_DEL	SLOPE_FORM	ASPECT	AGE	LOCATION	ROAD	CERTAINTY
89	SL/DF	254	76	19,304	4	2,860	50-75	1,430	2,145	P	E	5-10	IG	0	D
90	SL	76	76	5,776	4	856	75-100	642	856	P	E	5-10	IG	0	D
91	SL	76	36	2,736	4	405	0	0	0	P	E	20+	MS	0	Q
92	SL	25	25	625	3	69	75-100	52	69	P	W	< 66	IG	0	D
93	SL	65	20	1,300	3	144	50-75	72	108	P	W	1966	IG	0	D
94	SL	36	36	1,296	3	144	0	0	0	P	W	< 66	MS	0	D
95	SL	30	30	900	3	100	0	0	0	C	W	1966	MS	0	D
96	SL	25	25	625	3	69	0	0	0	P	W	1966	MS	0	D
97	SL	30	76	2,280	4	338	75-100	253	338	P	W	1966	IG	0	D
98	SL/DF	218	76	16,568	4	2,455	25-50	614	1,227	C	SW	< 66	HW	SKID	D
99	SL	182	54	9,828	4	1,456	0	0	0	D	SW	< 66	RT	SKID	D

All Slides Identified on the 1997 Aerial Photos

ID	TYPE	LENGTH	WIDTH	AREA	DEPTH	CY_VOLUME	SED_DEL	MIN_DEL	MAX_DEL	SLOPE_FORM	ASPECT	AGE	LOCATION	ROAD	CERTAINTY
4	SL/DF	from field measurements				19,900	75-100	14,925	19,900	C		1997	IG	1	D
7	SL	40	30	1,200	4	178	0	0	0	D	E	5-10	MS	1	Q
8	SL	40	20	800	0	0	0	0	0	D	SE	5-10	MS	2	D
9	SL	0	0	0	0	0	0	0	0	C	SE	5-10	MS	1	Q
10	DS	360	250	90,000	10	33,333	1-25	333	8,333	C	E	5-20	MS	3	D
11	SL/DF	120	100	12,000	5	2,222	50-75	1,111	1,667	C	N	5	MS	1	D
12	SL	30	120	3,600	4	533	1-25	5	133	C	N	1997	MS	0	D
13	SL	100	30	3,000	3	333	0	0	0	C	NE	1997	HW	0	P
14	SL	60	30	1,800	3	200	0	0	0	D	NE	1997	HW	0	D
15	SL	140	40	5,600	4	830	0	0	0	C	E	1997	HW	0	D
16	SL	80	80	6,400	3	711	0	0	0	D	E	1997	MS	0	D
17	SL	320	60	19,200	8	5,689	25-50	1,422	2,844	D	E	5-20	MS	2	D
18	SL	240	60	14,400	4	2,133	75-100	1,600	2,133	D	E	5-20	IG	0	D
18	SL	80	40	3,200	4	474	75-100	356	474	D	E	5-20	IG	0	D
19	SL	80	40	3,200	3	356	50-75	178	267	C	E	5-20	HW	0	D
20	SL	80	40	3,200	4	474	25-50	119	237	D	S	1997	MS	0	D
21	SL	20	20	400	3	44	0	0	0	D	S	5-20	MS	2	Q
22	SL	100	20	2,000	3	222	0	0	0	P	S	5-20	MS	2	Q
23	SL	120	40	4,800	3	533	0	0	0	P	S	5-20	RT	0	P
24	SL	240	40	9,600	4	1,422	1-25	14	356	C	S	5-20	RT	0	D
25	SL	240	80	19,200	4	2,844	1-25	28	711	C	S	5-20	RT	0	D
26	SL	240	70	16,800	4	2,489	50-75	1,244	1,867	P	S	5-20	IG	1	P
27	SL/DF	280	70	19,600	4	2,904	50-75	1,452	2,178	P	S	5-20	IG	1	D
28	SL/DF	320	50	16,000	5	2,963	25-50	741	1,481	P	S	5-20	IG	1	D
29	SL/DF	160	50	8,000	4	1,185	50-75	593	889	P	S	1997	IG	1	D
30	SL	80	80	6,400	4	948	0	0	0	P	S	1997	MS	2	D
31	SL	280	40	11,200	5	2,074	75-100	1,556	2,074	D	S	1997	IG	3	P
32	SL	150	20	3,000	4	444	1-25	4	111	D	S	1997	IG	3	P
33	SL	120	20	2,400	4	356	1-25	4	89	D	SE	1997	MS	1	D
34	SL/DF	360	120	43,200	5	8,000	25-50	2,000	4,000	C	SE	5-20	MS	1	D
35	SL/DF	480	140	67,200	8	19,911	75-100	14,933	19,911	D	N	1997	IG	1	D
36	SL	60	20	1,200	3	133	0	0	0	D	SE	1997	MS	1	Q
37	SL	160	60	9,600	4	1,422	1-25	14	356	D	NE	5-20	MS	0	D
38	SL/DF	400	100	40,000	8	11,852	75-100	8,889	11,852	C	N	5-20	MS	2	D
39	SL	20	20	400	3	44	25-50	11	22	P	S	1997	EIG	1	D
40	SL	80	40	3,200	3	356	50-75	178	267	P	S	5-20	EIG	1	P
41	SL	80	300	24,000	8	7,111	1-25	71	1,778	C	S	1997	RT	3	D

All Slides Identified on the 1997 Aerial Photos

ID	TYPE	LENGTH	WIDTH	AREA	DEPTH	CY_VOLUME	SED_DEL	MIN_DEL	MAX_DEL	SLOPE_FORM	ASPECT	AGE	LOCATION	ROAD	CERTAINTY
42	SL	80	60	4,800	3	533	0	0	0	C	S	5-20	RT	0	Q
43	SL	160	40	6,400	4	948	25-50	237	474	D	S	1997	MS	0	D
44	SL	240	40	9,600	4	1,422	0	0	0	D	SE	1997	RT	0	D
45	SL	30	30	900	4	133	1-25	1	33	P	E	1997	IG	0	D
46	SL	120	40	4,800	4	711	25-50	178	356	P	S	1997	IG	0	D
47	SL	80	40	3,200	4	474	75-100	356	474	C	S	1997	IG	0	D
48	SL	20	20	400	3	44	75-100	33	44	P	E	1997	IG	0	D
49	SL	30	40	1,200	3	133	75-100	100	133	D	S	1997	IG	0	D
50	SL	40	30	1,200	3	133	1-25	1	33	C	S	5-20	IG	0	Q
52	SL	30	30	900	3	100	1-25	1	25	C	S	1997	EIG	0	P
53	SL	20	20	400	3	44	1-25	0	11	P	SW	1997	IG	0	Q
54	SL	20	30	600	3	67	1-25	1	17	P	S	5-20	IG	0	Q
55	SL	120	20	2,400	4	356	1-25	4	89	C	S	5-20	MS	3	P
56	SL	20	10	200	3	22	0	0	0	P	S	1997	MS	0	Q
57	DS	350	120	42,000	10	15,556	50-75	7,778	11,667	C	W	20+	IG	0	D
57	SL	60	35	2,100	1	78	75-100	58	78	C	W	1997	IG	0	D
58	DS	200	280	56,000	0	0	75-100	0	0	P	NW	20+	IG	0	D
58	SL/DS	80	75	6,000	4	889	75-100	667	889	P	NW	1997	IG	0	D
58	SL/DS	40	50	2,000	1	74	75-100	56	74	P	NW	5-10	IG	0	D
58	SL/DS	100	200	20,000	3	2,222	50-75	1,111	1,667	P	NW	1997	IG	0	D
59	SL	80	60	4,800	8	1,422	75-100	1,067	1,422	P	SE	1997	IG	0	D
61	SL	80	50	4,000	5	741	75-100	556	741	P	N	5-10	IG	1	D
62	SL	20	20	400	4	59	0	0	0	C	N	1997	IG	1	Q
63	SL	400	120	48,000	8	14,222	1-25	142	3,556		W	20+	MS	0	P
64	SL	80	60	4,800	5	889	1-25	9	222	C	N	1997	MS	1	D
65	SL/DF	200	100	20,000	7	5,185	75-100	3,889	5,185	D	N	1997	MS	1	D
66	SL	15	10	150	3	17	0	0	0	P	N	1997	MS	0	Q
67	SL	80	10	800	4	119	1-25	0	0	P	N	1997	IG	0	D
68	SL	80	10	800	4	119	75-100	89	119	D	SW	5-20	IG	1	P
69	SL/DF	240	40	9,600	4	1,422	75-100	1,067	1,422	P	S	20+	IG	0	D
69	SL/DF	200	30	6,000	4	889	75-100	667	889	P	S	20+	IG	0	D
69	SL/DF	240	40	9,600	8	2,844	75-100	2,133	2,844	P	S	20+	IG	0	D
70	SL	80	95	7,600	8	2,252	1-25	23	563	D	W	1997	MS	1	D
71	SL	40	40	1,600	3	178	0	0	0	P	SW	1997	MS	0	Q
72	SL	240	30	7,200	4	1,067	50-75	533	800	P	W	1997	RT	1	D
73	SL/DF	320	80	25,600	8	7,585	75-100	5,689	7,585	P	NE	5-20	MS	0	D
74	SL/DF	100	120	12,000	10	4,444	75-100	3,333	4,444	P	NE	5-20	RT	0	D

All Slides Identified on the 1997 Aerial Photos

ID	TYPE	LENGTH	WIDTH	AREA	DEPTH	CY_VOLUME	SED_DEL	MIN_DEL	MAX_DEL	SLOPE_FORM	ASPECT	AGE	LOCATION	ROAD	CERTAINTY
74	DF	220	60	13,200	6	2,933	75-100	2,200	2,933	P	NE	1997	HW	0	D
75	SL	600	120	72,000	8	21,333	50-75	10,667	16,000	C	N	5-20	RT	1	D
75	SL/DF	200	50	10,000	4	1,481	25-50	370	741	P	W	5-20	MS	0	D
76	SL	80	80	6,400	1	237	0	0	0				MS-	0	D
77	SL	160	20	3,200	1	119	50-75	59	89	P	W	5-20	MS	0	D
78	SL/DF	300	60	18,000	4	2,667	50-75	1,333	2,000	P	W	1997	RT	0	D
79	SL	80	10	800	3	89	1-25	1	22	P	W	1997	RT	0	D
80	SL/DF	400	40	16,000	8	4,741	75-100	3,556	4,741	P	W	1997	RT	0	D
81	SL/DF	200	20	4,000	4	593	50-75	296	444	P	W	1997	RT	0	D
82	SL/DF	180	20	3,600	4	533	50-75	267	400	P	W	1997	RT	0	D
83	SL	150	50	7,500	4	1,111	75-100	556	833	C	N	5-10	IG	0	D
84	SL	80	80	6,400	4	948	1-25	9	237	P	E	5-20	RT	0	P
85	SL/DF	120	40	4,800	8	1,422	75-100	1,067	1,422	P	E	5-20	RT	0	D
86	SL	60	20	1,200	3	133	0	0	0	D	NW	1997	MS	0	D
87	SL	20	20	400	3	44	1-25	0	11	P	E	1997	IG	0	Q
88	SL	20	20	400	3	44	1-25	0	11	D	E	1997	IG	0	Q
89	SL	60	60	3,600	2	267	1-25	3	67	P	E	1997	MS	0	D
90	SL	200	80	16,000	4	2,370	50-75	1,185	1,778	D	E	1997	MS	1	D
91	SL	320	80	25,600	4	3,793	75-100	2,844	3,793	P	NW	1997	IG	0	D
92	SL/DF	80	120	9,600	10	3,556	75-100	2,667	3,556	D	N	1997	IG	3	D
92	DF	600	40	24,000	6	5,333	75-100	4,000	5,333	D	N	1997	IG	3	D
93	SL/DF	240	40	9,600	4	1,422	75-100	1,067	1,422	C	N	1997	IG	2	D
93	DF	200	20	4,000	6	889	75-100	667	889	C	N	1997	IG	2	D
94	SL/DF	80	120	9,600	10	3,556	50-75	1,778	2,667	P	W	1997	IG	0	D
94	DF	160	40	6,400	6	1,422	50-75	711	1,067	P	W	1997	IG	0	D
95	SL	50	30	1,500	3	167	0	0	0	D	W	1997	MS	0	Q
96	SL	120	75	9,000	7	2,333	50-75	1,167	1,750	P	W	1997	RT	3	D
97	SL	40	60	2,400	3	267	0	0	0	C	N	5-20	MS	0	D
98	SL	30	30	900	3	100	0	0	0	P	NW	1997	MS	0	P
99	SL	40	30	1,200	3	133	75-100	100	133	C	N	1997	HW	3	D
100	SL	80	42	3,360	6	747	1-25	7	187	D	W	1997	RT	3	D
101	SL	100	40	4,000	4	593	0	0	0	C	W	1997	MS	0	D
102	SL/DF	0	0	0	0	0	75-100	0	0	P	W	5-20	RT	1	D
103	SL	200	40	8,000	4	1,185	75-100	889	1,185	P	W	1997	IG	0	D
104	SL/DF	120	90	10,800	3	1,200	75-100	900	1,200	C	W	1997	RT	3	D
104	DF	200	40	8,000	3	889	75-100	667	889	C	W	1997	RT	3	D
105	SL	60	40	2,400	4	356	0	0	0	C	W	1997	RT	0	D

All Slides Identified on the 1997 Aerial Photos

ID	TYPE	LENGTH	WIDTH	AREA	DEPTH	CY_VOLUME	SED_DEL	MIN_DEL	MAX_DEL	SLOPE_FORM	ASPECT	AGE	LOCATION	ROAD	CERTAINTY
106	SL	50	40	2,000	2	148	1-25	1	37	C	N	1997	MS	0	D
107	SL	160	120	19,200	3	2,133	25-50	533	1,067	C	SW	5-20	MS	0	P
108	SL	30	20	600	3	67	1-25	1	17	P	NW	1997	MS	0	P
109	SL	80	30	2,400	4	356	25-50	89	178	C	W	1997	HW	0	D
110	SL	30	30	900	3	100	0	0	0	C	S	1997	RT	0	Q
111	RF	40	40	1,600	1	59	0	0	0	C	NE	5-20	RT	0	D
112	RF	40	40	1,600	1	59	0	0	0	C	E	5-20	RT	0	P
113	SL/DF	70	40	2,800	4	415	1-25	4	104	C	N	5-20	RT	3	D
113	DF	110	90	9,900	4	1,467	1-25	15	367	C	N	5-20	RT	3	D
114	SL	120	80	9,600	4	1,422	1-25	14	356	P	N	5-20	RT	0	P
115	SL	50	40	2,000	4	296	0	0	0	P	N	5-20	MS	0	P
116	SL	60	40	2,400	4	356	0	0	0	C	N	5-20	MS	0	P
117	SL	120	80	9,600	6	2,133	25-50	533	1,067	C	E	1997	MS	0	D
118	SL	160	40	6,400	4	948	25-50	237	474	C	NE	5-20	RT	0	D
119	SL	160	20	3,200	3	356	25-50	89	178	C	E	5-20	MS	0	P
120	SL	120	120	14,400	2	1,067	75-100	800	1,067	C	N	1997	HW	0	D
121	SL	20	10	200	3	22	1-25	0	6	P	N	1997	HW	0	P
122	SL	30	30	900	3	100	25-50	25	50	P	N	1997	HW	0	P
123	SL	200	60	12,000	4	1,778	50-75	889	1,333	P	SW	1997	IG	0	D
125	SL	60	40	2,400	4	356	25-50	89	178	P	SE	1997	RT	4	D
127	SL	200	40	8,000	6	1,778	1-25	18	444	C	N	1997	MS	3	D
128	SL	60	30	1,800	4	267	0	0	0	D	W	1997	MS	0	D
129	SL	30	20	600	4	89	25-50	22	44	C	N	1997	IG	0	D
130	SL/DS	160	40	6,400	4	948	50-75	474	711	C	N	1997	IG	0	D
131	SL	120	20	2,400	4	356	1-25	4	89	C	SW	5-10	EIG	0	P
132	SL	40	60	2,400	4	356	0	0	0	P	W	1997	MS	0	D
134	SL	20	20	400	3	44		0	0	P	SW	5-10	RT	0	Q
135	SL	40	40	1,600	4	237	0	0	0	P	SW	5-10	RT	0	Q
136	SL	240	60	14,400	6	3,200	75-100	2,400	3,200	C	SE	1997	MS	1	D
137	SL	120	40	4,800	4	711	1-25	7	178	P	NE	5-10	MS	0	D
137	SL	60	40	2,400	3	267	25-50	67	133	C	NE	5-10	MS	0	D
138	SL	50	40	2,000	4	296	1-25	3	74	P	E	5-10	MS	0	D
138	SL	40	60	2,400	3	267	1-25	3	67	C	E	5-10	MS	0	D
139	SL/DF	160	80	12,800	4	1,896	25-50	474	948	C	N	5-10	IG	0	D
140	RF	80	10	800	2	59	1-25	1	15	C	S	1997	IG	0	D
141	RF	30	10	300	1	11	0	0	0	P	S	1997	RT	0	D
142	RF	80	10	800	1	30	0	0	0	P	S	1997	RT	0	D

All Slides Identified on the 1997 Aerial Photos

ID	TYPE	LENGTH	WIDTH	AREA	DEPTH	CY_VOLUME	SED_DEL	MIN_DEL	MAX_DEL	SLOPE_FORM	ASPECT	AGE	LOCATION	ROAD	CERTAINTY
143	RF	40	20	800	1	30	0	0	0	P	S	1997	RT	0	D
144	SL/DF	240	160	38,400	6	8,533	75-100	6,400	8,533	C	NW	5-10	RT	0	D
145	SL/DF	60	40	2,400	6	533	75-100	400	533	C	NW	1997	MS	0	D
145	DF	240	80	19,200	4	2,844	75-100	2,133	2,844	C	NW	1997	MS	0	D
146	SL	60	60	3,600	4	533	0	0	0	P	SW	1997	EIG	0	D
147	SL	240	160	38,400	4	5,689	75-100	4,267	5,689	D	SW	1997	IG	4	D
148	SL	160	40	6,400	3	711	0	0	0	D	SW	1997	RT	0	D
149	SL/DF	120	30	3,600	4	533	1-25	5	133		S	1997	IG	1	D
149	DF	80	20	1,600	3	178	1-25	2	44		S	1997	IG	1	D
150	SL/DF	320	60	19,200	6	4,267	75-100	3,200	4,267	C	E	5-10	HW	1	D
151	SL	40	80	3,200	4	474	75-100	356	474	D	W	5-10	IG	0	D
152	SL	100	100	10,000	20	7,407	50-75	3,704	5,556	C	W	5-10	RT-	1	D
153	SL	240	40	9,600	4	1,422	25-50	356	711	C	NW	1997	MS	0	D
154	SL	80	120	9,600	4	1,422	1-25	14	356	D	W	1997	RT	1	D
155	SL	20	20	400	3	44	75-100	33	44	C	S	1997	IG	0	D
156	SL	40	20	800	3	89	1-25	1	22	C	N	1997	IG	0	D
157	SL	70	30	2,100	3	233	1-25	2	58	C	NE	1997	IG	0	D
158	SL	40	40	1,600	3	178	0	0	0	C	E	1997	MS	4	D
159	SL	30	30	900	3	100	0	0	0	C	W	1997	MS	4	P
160	SL	120	30	3,600	4	533	25-50	133	267	C	W	1997	IG	0	D
161	SL	40	40	1,600	3	178	1-25	2	44		NW	5-10	IG	3	P
163	SL	60	80	4,800	4	711	75-100	533	711			1997	IG	0	D
164	SL	80	40	3,200	4	474	25-50	119	237			1997	MS	0	D

Appendix D

Example Road Erosion Data Form

Road Name ____________________ Page _____ of _____

Potential Sed. Yield: H M L

Road Inventory Form
NRM 4/20/98

Date____________ Surveyors______________ Creek________________ Watershed_______________ Air Photo#, date___________

Quads_________________________________ Township / Range / Sections T_______ R_______ S_______

ROAD INFORMATION / SUMMARY

Abandoned per CDF Standards? T F Drivable? T F Maintained? T F Major Rebuild? T F Has ≥1000' over 12% T F

Year Built:______ **Condition**: Stable__ Maintenance problems__ Upgrades needed__ Failures__ **Cross Drains**: Adequate Inadequate

Summary / Comments

Road: Addnl. Ditch relief sites/lengths:______________________________________; Outslope ___ Inslope ____

Remove Berm___ Rock Rd___ Tx.immed: H M L Complexity: H M L ; Hrs for: b/hoe___; grader___; excavator___; dozer___; dump tr.___; loader___

Est. Volume moved_________ yds^3: stockpiled_____% incorporated_____% endhauled_____% Production Rate (yds^3/hr)____

DRAINAGE CROSSING RECORD - Tx #s: (0) none; (1) add rolling/ critical dip; (2) install /upgrade CMP; (3) repair/clean CMP; (4) add IBD relief drains; (5) clean/ cut ditch; (6) add downspout; (7) reconst. fill; (8) remove berm; (9) rock road; (10) outslope rd; (11) inslope rd; (12) add trash rack; (13) pull fill / excavate

Site #	Ford, None Humboldt or ?	Xing Obsvs.– %plug, +IBD, o/l erosion...	CMP Dia. (in.)	Head-wall ht (inches)	Drainage Area (ac)	DP/ DV	Future EP L x (ch.)W x D ft or yd	Est. Vol. (cy)	Past Erosion (cy)	% Fut. Delivery	Tx. #s	Immed H M L
							__ x __ x __			___%		
							__ x __ x __			___%		
							__ x __ x __			___%		
							__ x __ x __			___%		
							__ x __ x __			___%		
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							__ x __ x __			___%		
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							__ x __ x __			___%		
							__ x __ x __			___%		
							__ x __ x __			___%		

MASS MOVEMENT SITES -- Tx.#s: (0) none; excavate: (1) soil, (2) logs/debris; (3) rock armor/ buttress; (4) protect base of slope w/ logs; (5) reveg; (6) other:

Feature & ID (Landing, rd.fill, rd.cutbank, swale, inner gorge, Hillslope)	Process (Debis slide, fill failure, channelTorrent)	Origination (Rd, IBD, Skid tr., Cut, Spring, Natural)	Erosion (Future, Past, Both)	Existing Volume L x W x D (ft or yd)	Active Perched, Undercut	Failure into Class I, II or III	Distance (ft)	% Slope	% Sed Yld.	Tx. #s
1.				x x						
2.				x x						
3.				x x						
4.				x x						
5.				x x						

Tx.immed. Site 1: H M L Complexity: H M L Access: G M P ; Hrs for: excavator___; dozer___; dump tr.___; labor___; b/hoe___

Tx.immed. Site 2: H M L Complexity: H M L Access: G M P ; Hrs for: excavator___; dozer___; dump tr.___; labor___; b/hoe___

Tx.immed. Site 3: H M L Complexity: H M L Access: G M P ; Hrs for: excavator___; dozer___; dump tr.___; labor___; b/hoe___

Tx.immed. Site 4: H M L Complexity: H M L Access: G M P ; Hrs for: excavator___; dozer___; dump tr.___; labor___; b/hoe___

Tx.immed. Site 5: H M L Complexity: H M L Access: G M P ; Hrs for: excavator___; dozer___; dump tr.___; labor___; b/hoe___

PAST EROSION VOLUMES

Site # or ID	Type: Mass Mvmt, Fillslope, Gully, Torrent, etc.	Past Erosion Volume LxWxD	Age -recent/old	% Delivery to Channel

ROAD DECOMMISSIONING: EXCAVATION VOLUME MEASUREMENTS

	(PROFILE MEASUREMENTS)						(X-SEC MEASUREMENTS)							
Site #	CMP Dia. (in.)	inlet slope % or °	inlet fill length	Road length	outlet slope % or °	outlet length	Inlet valley Width	Outlet valley Wid.	Ch. Wid.	DP / DV	Future EP L x (ch.)W x D ft or yd	Est. Vol. (cy)	Past Eros. (cy)	RNP (cy)
											x x			
											x x			
											x x			
											x x			
											x x			
											x x			
											x x			

Site________________ Volume Caluculation from RNP Program _________cubic yards

Profile Notes:

% ANGLE arctan (%/100) = °	ANGLE (degrees)	LENGTH (ft)	FLAGS
	_		(opti.) Abv Inlet
	_		TOP UES
	0	0	TRN XS1 IBR
(ROAD)	0		TRN XS2 OBR
	_		BOT

Cross Section Notes:

ANGLE (degrees)	Inlet WIDTH (XS1)	FLAGS	ANGLE (degrees)	Outlet WIDTH (XS2)	FLAGS
0	_	LRP (ref pt)	0	_	LRP
0	_	LEC (edge cut)	0	_	LEC
0		TRN CLP	0		TRN CLP
0		REC	0		REC
0		RRP	0		RRP

Appendix E.

Sample Distances and Volume of Sediment Delivered by Small Inner Gorge Landslides not Observable on Air Photos

Sample distances (miles) and volume of sediment delivered by small inner gorge landslides that were not observable on air photos.

Location	Distance (miles)	Delivery Rate (cubic yards/mile)	Volume (cubic yards)
Stitz Creek (field)	1.8	1,112	2,002
Stitz Creek extrapolation	1.4	1,112	1,557
Blue-line tributary extrapolation	1.6	1,112	1,779
Total	4.8		5,338

Appendix F

Site Observations and Preliminary Conclusions on Slide #4 by John Coyle, CEG

JOHN COYLE &
ASSOCIATES, INC
Engineering Geologists

November 30, 1998

DEC 0 3 1998

TO: Tom Koler
Staff Geologist
Scotia Pacific Company LLC

SUBJECT: STITZ CREEK DEBRIS SLIDE
Site Observations and Preliminary Conclusions

Dear Mr. Koler:

We have completed a preliminary field review of the Stitz Creek slide. The purpose of our field review was to attempt to form an opinion as to whether the slide was a road related failure or an "in unit" failure that migrated up slope to include the road now at the crown of the failure. The scope of work included review of portions of a report prepared by Oscar Huber (CEG) specifically addressing the slide and portions of the watershed analysis for Stitz Creek prepared by Natural Resources Management (NRM) Corporation that specifically address the Stitz Creek slide. Rick Koehler of NRM accompanied us in the field.

The slide is located on a southeast-facing slope characterized by slopes up to 65%. A southeast-trending ridge through which the road was cut creating some high, steep cut slopes opposite the slide scar. A drainage swale delivers run off to the road from the hillside area just to the east of the ridge noted above. A road further up the hillside crosses this swale. The site is underlain by rocks of the Wildcat Group. Geologic mapping by CDMG for the Scotia Quadrangle suggests that a general east-west strike and a moderately steep dip to the north characterize bedrock in the area of the slide. The rocks exposed in the scarp are generally highly fractured sandstone. Soils exposed in the slide scar are locally thick. A logging road crosses the crown of the slide. Another road about mid-way down slope between the scar and Stitz Creek was crossed by the torrent tract related to the failure. The head of the slide is at an elevation of about 1250 feet; the scar extends down slope about 250 to 300 feet (slope distance).

Color aerial photographs taken in 1994, before the failure, and 1997, after the failure, were reviewed. On the 1994 photographs the road (now at the crown of the slide) exhibits a light grayish-white color, probably do to the rocked surface. However, in the area of the failure light yellow-brown colors (similar to the color of the bedrock) are observed along the inside and outside margins of the road. We interpret the different color to be due to rock debris that has fallen on to the road from the adjacent cut slope, some of which was cleared and placed on the out side margin of the road.

334 State Street, Suite 106
Los Altos, California 94022
650-948-4279

SITE OBSERVATIONS

The following briefly summarizes our site observations:

- The slide involved both the overlying soil cover and the underlying bedrock.
- Prior to undertaking our field review, it was explained to us that the road was built as a full-bench road. Our field review the northeastern margin of the scarp showed about 4 feet of fill at the outside edge of the road.
- The remnants of the road form the crown of the scarp.
- At the crown of the slide (along the road) the scarp is about 150 feet wide and the scarp is about 70 to 80 feet high.
- There was slide debris due to cut slope failures on the remnants of the road surface.
- The remaining road section that extends to the northeast of the slide scarp slopes toward the slide scar.
- Drainage from the swale just east of the ridge delivers water to the road and to the eastern margin of the slide scarp.
- There is a culvert just to the east of the slide scarp; the inlet is plugged.
- Just east of the slide scarp, a gully has been eroded across the road down to the top of the culvert; locally to a depth of about 5 feet.
- Weak and highly fractured and jointed rocks are exposed in the slide scarp.
- A set of moderately steep to steep southward-dipping joints was observed. This system appears to control the general orientation and development of the scarp.
- Thick soils are locally exposed.
- Weak soils are probably present, but this has not been confirmed.
- Steep hillside slopes are present, especially down slope of the road adjacent to lateral margins of the slide.
- It appears that relatively smaller parts of the scarp have continued to fail subsequent to the initial failure.

- Though it is thought that the road was built using full-bench methods; based on our review of aerial photographs and field observations it appears that some fill may have been present along the out-side margin of the road, placed either during construction or side cast during times of cleanup of cut-slope failures, or both.

DISCUSSION

The exact location and cause or origin of the slide is difficult to ascertain. It is possible that the slide initially began as an "in unit" failure that migrated up slope to include the road. Such a failure could have been initiated by erosion and down-cutting along the drainage that borders the northeastern margin of the slide scar. It could also have begun on the slope below the road due to weak soils and bedrock and high pore pressures (maybe influenced by the road) in the soils and rock fractures. However, the topography, the generally the planar nature of the slope prior to failure (as seen on 1994 aerial photographs) and the ridge through which the road was cut, argue somewhat against concentration of subsurface water.

It could be possible that the presence of the road was the causative factor. Though it appears the road was built using full-bench methods, it is likely that some fill was present along the outer margin of the road. The fill could have been place during initial construction or later maintenance that resulted in placement of side-cast fill, particularly from clean up of nearby cut-slope failures, or both. Other factors that might have influenced failure could have been related to the possibility that the culvert was plugged, directing run off from the road, along with runoff from the small drainage just to the northeast of the failure, on to the road toward the area of the slide scar. From there run off could have either flowed over the edge of the road and on to the slopes below the road, or it might have been ponded, to some extent, on the road, due to the presence of the side cast fill from maintenance and cut slope clean up, or both. In any event, the water would have added to the saturation of the slope and the already weak rocks and soil, leading subsequently to failure of the slope. Failure of the adjacent cut slope and redirection of run off just prior to the catastrophic failure of the slope might also have influenced failure of the slope and road.

Placement of fill, even a small amount, on already weak and steep slopes and later saturated soils and bedrock could have finally, over time, resulted in failure of the road and slope. Also sudden placement of slide debris from the nearby cut slope on the road could have surcharged the weak earth materials that underlie the road section enough to cause or at least influence failure.

PRELIMINARY CONCLUSIONS

In short, the specific cause of failure of the slope and whether the failure was road-related or "in unit" is difficult to pin down definitively. Based on our observations several failure scenarios are possible, some somewhat more plausible that others. Because of the presence of the road and some observations related to the road, the influence of the road can not be ruled out and it maybe likely it did have some influence; however, that the road was the primary cause can not be positively demonstrated. It is possible that the slide was an "in unit" failure but, with the information available, this can not be determined for certain either.

If you have any questions, please call.

Sincerely,
JOHN COYLE & ASSOCIATES, INC.

John M. Coyle

John M. Coyle
Chief Engineering Geologist
CEG 1263

Appendix G

Volume Calculations and Assumptions for Slide #4

Slide #4 is broken up into five pieces (B, C, D, E, and debris torrent) in order to calculate volume.

The volume of piece A (not part of the slide) is used with geometric relations to calculate the volume of B. The pieces A, B, and C are treated as pyramids and the pieces D and E are treated as trapezoids. We assume that the debris torrent only scoured for the first 500 ft below the slide with a depth of 3 ft and a width of 10 ft. The volume of the debris torrent is treated as a rectangle.

Volume of landslide = vol. B + vol. C + vol. D + vol. E + vol. of debris torrent.

Volume of B = vol. (A + B) – vol. A = (1/2)*66*75*140 – (1/2)*26*75*140

= 346,500 – 136,500 = 210,000 ft^3

Volume of C = (1/2)*20*17*120 = 20,400 ft^3

Volume of D = (1/2)*(120 + 80)*20*92 = 184,000 ft^3

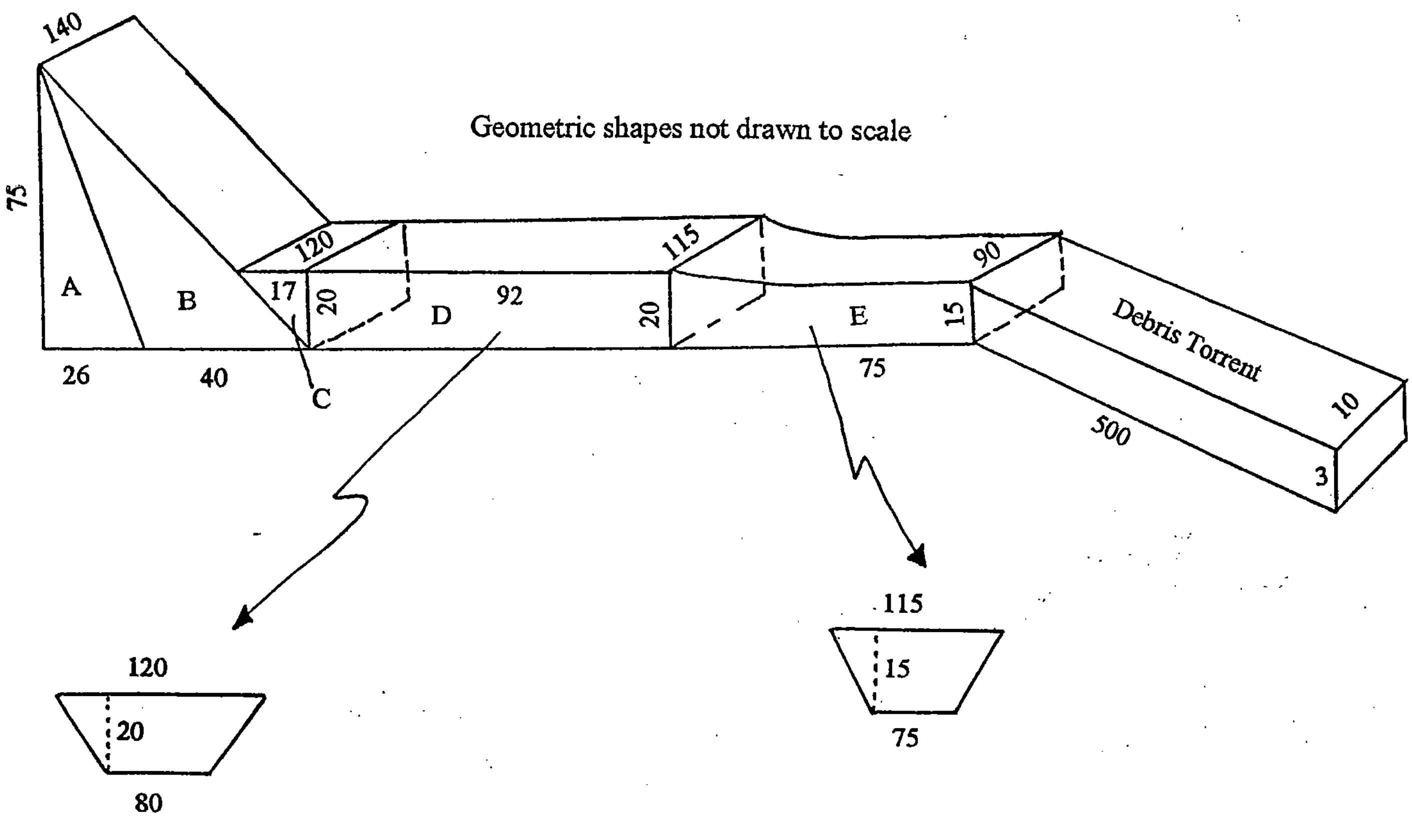
Volume of E = (1/2)*(115 +75)*15*75 = 106,875 ft^3

Volume of debris torrent = 500*10*3 = 15,000 ft^3

Volume of landslide = 210,000 ft^3 + 20,400 ft^3 + 184,000 ft^3 + 106,875 ft^3 + 15,000 ft^3

= 536,275 ft^3 / 27ft^3/yd^3

= 19,900 yd^3



Appendix H

Interim Aquatic Strategy and Mass Wasting Avoidance Strategy

INTERIM
(July 24, 1998)
AQUATIC STRATEGY
for Timber Harvest & Roads
for the
PACIFIC LUMBER CO. HCP

Management Zone	Prescription	Related Function/Indicator
Channel Migration Zone [CMZ] evaluations will be conducted as part of the DNR Watershed Assessments that are planned for each basin on the ownership. All segments of Class I and Class II streams that have a Rosgen type C, D or E channel morphology will be examined to identify the current boundaries of the bankfull channel and the remaining portion of the floodplain that is likely to become part of the active channel during the 50 years covered by the Incidental Take Permit (ITP) as evidenced by past channel migration and other field indicators. Areas not evaluated in a watershed analysis must be analyzed separately by PL using a qualified fluvial geomorphologist before any THP that includes CMZ areas can be approved. Additionally NMFS, CDF&G, USFWS, and EPA or NCRWQCB will be consulted regarding any such mapping.	The following measures will apply to Channel Migration Zones: • Management within the CMZ will be allowed under two cases. The first case will be to enhance and facilitate riparian functions based upon a completed Watershed Analysis, and Riparian Management Plan as agreed upon by the permitting agencies. The second will be in cases of emergencies which could result in the loss of life or property, and in cases of emergencies as per agreement with NMFS, USFWS, and CDF&G. Loss of property is defined as a demonstrated high risk of loss of capital improvements such as bridges, roads, culverts, and houses, however it does not include loss of vegetation. • No herbicides or pesticides will be used in the CMZ. Fertilizers can be used, ground application only, for erosion control purposes. Aerial application of fertilizers is not allowed. • No sanitation salvage or exemption harvest, including emergency exemption harvest, (as defined and allowed in the California Forest Practice Rules (CFPRs)) will be allowed in the RMZ, except as per agreement with NMFS, FWS, and CDF&G in accordance with the approved HCP.	Bank Stability, LWD protection, Off-channel habitat protection, Channel migration protection, microclimate protection, pools, etc.

CLASS I All fish bearing (or restorable) Class I watercourses as defined in the CFPRs will have a Riparian Management Zone (RMZ). The RMZ will measure 170 ft (slope distance) from the watercourse transition line as defined in the CFPRs or CMZ edge (if a CMZ is present), on each side of the watercourse. Willows will not be considered permanent vegetation for the purposes of determining the location of the watercourse transition line. The RMZ for Class I watercourses is divided into three management bands, the Restricted Harvest Band (RHB), the Limited Entry Band (LEB) and the Outer Band (OB). The bands are	Prescriptions that apply to the entire Class I RMZ	• After each entry, PALCO will retain an additional 10 trees greater than 40 inches DBH per acre on each side of the watercourse. The trees can be counted entirely or partially within the RHB. If trees of this size are not available, the 10 largest trees in the RMZ will be retained. • No sanitation salvage or exemption harvest, including emergency exemption harvest, (as defined and allowed in the California Forest Practice Rules (CFPRs)) will be allowed in the RMZ, except as per agreement with NMFS, FWS, and CDF&G in accordance with the approved HCP. • All portions of down wood (i.e., LWD) except as defined as slash in the FPA, or within Class I outer bands as specified below will be retained. • Trees felled during current harvesting operations and THP approved roads construction are not considered down wood for purposes of retention. • Felled hazard trees or snags not associated with a THP are considered down wood and are to be retained in the general vicinity. • Trees that fall naturally onto roads, landings, or harvest units within the RMZ are considered down wood and are to be retained in the general vicinity. • All non-hazard snags will be retained, as per the snag policy in Volume II Part M. • The RMZ is an equipment exclusion zone (EEZ) for timber operations, except for roads and permitted equipment crossings. • No herbicides or pesticides will be used within the RMZ. Fertilizers will be used for ground application for erosion control only. Aerially-applied fertilizers will not be directly applied to Class I RMZs. • Full suspension yarding will be used when feasible. Full suspension is not feasible on flat ground, in other sites with limited deflection, where an adjacent landowner will not provide permission to secure a cable, or where a full suspension yarding system would jeopardize the safety of field personnel. For these conditions, yarding will be conducted in a manner that avoids ground disturbance that may deliver sediment to a watercourse to the maximum extent practicable. Where ground disturbance occurs PALCO will treat (e.g., through seeding, mulching, etc.) all sites with exposed mineral soil that can reasonably be expected to deliver sediment to a watercourse (e.g., gullies, ruts). • Trees may be felled within RMZs to provide clearance for cable yarding corridors. Such felling will be done only as needed to ensure worker safety. In such cases, to the extent feasible given site conditions and the CFPRs, trees will be felled toward the watercourses to provide LWD. Regardless, trees felled within the WLPZ for safety purposes will be retained as down wood. • Trees not marked for harvest which are damaged in the	Bank Stability, LWD protection and recruitment, temperature, sediment filtration, microclimate, soil compaction

measured 0 ft to 30 ft, 30 ft to 100 ft, and 100 ft to 170 ft from the watercourse transition line as defined in the CFPRs or CMZ edge (if a CMZ is present), respectively.		cable yarding corridors must be retained in place, either standing or as down wood. • There will be a maximum of 1 entry every 20 years.	
<u>CLASS I</u>	Prescriptions that apply to Class I Restricted Harvest Band (Edge of watercourse transition line or CMZ if present to 30')	• Harvest to enhance and facilitate riparian functions such as canopy or LWD levels, may be allowed within the RHB based upon a completed watershed analysis and Riparian Management Plan as agreed upon (both processes) by the permitting agencies. • Watershed analysis and/or PWA protocol (see section on watershed analysis) will be used to determine the priorities and road storm proofing standards to be used on all existing haul roads and stream crossings. • Road segments within the RHB must be mitigated by extending the RHB on the opposite side of the watercourse from the existing road an equivalent distance of that portion of the road prism within the RHB. In the case of RMZ road crossings, the first 50 ft of road extending inland from the watercourse transition line as defined in the CFPRs (14 CCR 895.1) is exempt from this mitigation.	Bank Stability, LWD protection and recruitment, temperature, sediment filtration, microclimate, soil compaction
<u>CLASS I</u>	Prescriptions that apply to Class I Restricted Limited Entry Band [LEB] (30' to 100' from the watercourse transition line or channel migration zone if present) PL's Late Seral Prescriptions	• Only single tree selection harvest will occur within the LEB. Harvest will only occur if there is a preharvest conifer basal area of 345 sq ft per acre or greater within the LEB. • A minimum 300 sq ft post harvest conifer basal area per acre will be retained within the LEB. • Basal area measurements will be made for conformance every 200 ft lineal segment of RMZ. • No more than 40 percent of the conifer basal area may be harvested in a single entry. • Tree sizes and quantity distribution will be retained as per Table 4. If replacement size classes must be used to obtain the stated size distributions, the replacement size class must come from higher size classes if such trees are available; provided, however, that the largest trees in the stand must be left and harvesting conducted in a manner that facilitates and expedites development of stand conditions stated in Table 4. • Watershed analysis and/or the PWA road storm-proofing protocol will be used to determine the priorities and road storm proofing standards to be used on all roads inside the LEB. Surface area covered in roads will be included in all calculations of basal area.	Bank Stability, LWD protection and recruitment, temperature, sediment filtration, microclimate, soil compaction

<u>CLASS I</u>	PL's Late Seral Prescriptions will apply to Class I Outer Band [OB] (100' to 170' from the channel migration zone [CMZ])	• Only single tree selection harvest will occur within the OB. • Harvest will only occur in the OB if there is a preharvest conifer basal area of 276 sq ft per acre or greater within the OB on each side of the watercourse. • A minimum 240 sq ft post harvest conifer basal area per acre of OB will be retained. • No more than 40 percent of the conifer basal area may be harvested in a single entry. • Tree sizes and quantity distribution will be retained as per Table 4. If replacement size classes must be used to obtain the stated size distributions, the replacement size class must come from higher size classes if such trees are available; provided, however, that the largest trees in the stand must be left and harvesting conducted in a manner that facilitates and expedites development of stand conditions stated in Table 4. • Basal area measurements will be made for conformance no less than every 200 ft lineal segment of RMZ. • In areas with slopes <50 percent portions of downed wood (i.e., LWD) can be removed from the OB. That is, if a tree originating in any of the 3 Bands falls, portions in the RHB and LEB must be retained onsite in place, but the portions in the OB can be removed for slopes <50%. • In areas with slopes 50 percent or greater, all down wood (i.e., LWD) except as defined as slash in the FPA must be retained.	Bank Stability, LWD protection and recruitment, temperature, sediment filtration, microclimate, soil compaction
<u>CLASS II</u> Non-fish bearing streams (Class II watercourses as defined in the CFPRs) will have a Riparian Management Zone (RMZ). The RMZ of Class II streams will measure 100 ft (slope distance) from the watercourse transition line as defined in the CFPRs or CMZ edge (if	Prescriptions that apply to the entire Class II RMZ are as follows:	• No sanitation salvage or exemption harvest, including emergency exemption harvest, (as defined and allowed in the CFPRs) will be allowed in the RMZ, except as per agreement with NMFS, FWS, and CDF&G in accordance with the approved HCP. • All portions of down wood (i.e., LWD) will be retained, except as defined as slash in the CFPRs. • Full suspension yarding will be used when feasible. Full suspension is not feasible on flat ground, in other sites with limited deflection, where an adjacent landowner will not provide permission to secure a cable, or where a full suspension yarding system would jeopardize the safety of field personnel. For these conditions, yarding will be conducted in a manner that avoids ground disturbance that may deliver sediment to a watercourse to the maximum extent practicable. Where ground disturbance occurs PALCO will treat (e.g., through seeding, mulching, etc.) all sites with exposed mineral soil that can reasonably be expected to deliver sediment to a watercourse (e.g., gullies, ruts). • Trees felled during current harvesting and approved THP roads construction are not considered down wood for purposes of retention. • Felled hazard trees not associated with a THP are	Bank Stability, LWD protection and recruitment, temperature, sediment filtration, microclimate, soil compaction

a CMZ is present), on each side of the watercourse. Willows will not be considered permanent vegetation for the purpose of determining the location of the watercourse transition line. The RMZ is divided into two management bands, the Restricted Harvest Band (RHB), and the Selective Entry Band (SEB), which are measured from the watercourse transition line as defined in the CFPRs or CMZ (if a CMZ is present), 0 ft to 10 ft, and 10 ft to 100 ft, respectively.		considered down wood and are to be retained in the general vicinity. • Trees that fall naturally onto roads, landings or harvest units are considered down wood and are to be retained in the general vicinity. • Trees not marked for harvest may be felled within WLPZs to provide clearance for cable yarding corridors. Such felling will be done only as needed to ensure worker safety. In such cases, to the extent feasible given site conditions and the CFPRs, trees will be felled toward the watercourses to provide LWD. Regardless, trees felled within the WLPZ for safety purposes will be retained as down wood. • Trees damaged in the cable yarding corridors must be retained in place. • The RMZ is an EEZ for timber operations, except for roads and permitted equipment crossings. • No herbicides or pesticides will be used within the RMZ. Fertilizers will be used for ground application for erosion control only. Aerial fertization will be excluded from Class II RMZs.	
CLASS II	Prescriptions that will apply to the Class II Restricted Harvest Band [RHB] (Edge of watercourse transition line or CMZ if present to10')	• Management to enhance and facilitate riparian functions such as canopy or LWD levels may be allowed within the RHB based upon a completed watershed analysis and Riparian Management Plan as agreed upon (both processes) by the permitting agencies. • If the 10 ft line falls anywhere on a tree bole, the tree is to be retained as part of the Restricted Harvest Band. • Watershed analysis and/or the PWA road storm-proofing protocol will determine the priorities and road storm proofing standards to be used on all existing haul roads and stream crossings. • Road segments within the RHB, must be mitigated by extending the RHB on the opposite side of the watercourse as the existing road an equivalent distance of	LWD protection and recruitment, temperature, sediment filtration, microclimate, soil compaction

		that portion of the road prism within the RHB. In the case of RMZ road crossings, the first 15 ft of road extending inland from the watercourse transaction line as defined in the CFPRs (14 CCR 895.1) is exempt from this mitigation.	
<u>CLASS II</u>	Prescriptions that will apply to the Class II Selective Entry Band [SEB] (10-100' from the watercourse transition line or CMZ if present) PL's Late Seral Prescriptions	• Only single tree selection harvest will occur within the SEB. • Harvest will only occur in the SEB if there is a preharvest conifer basal area of 276 sq ft per acre or greater within the SEB. • A minimum 240 sq ft post harvest conifer basal area per acre of SEB will be retained. • No more than 40 percent of the conifer basal area may be harvested in a single entry. • Tree sizes and quantity distribution will be retained as per Table 4. If replacement size classes must be used to obtain the stated size distributions, the replacement size class must come from higher size classes if such trees are available; provided, however, that the largest trees in the stand must be left and harvesting conducted in a manner that facilitates and expedites development of stand conditions stated in Table 4. • Basal area measurements will be made for conformance every 200 ft lineal segment of RMZ. • There will be a maximum of 1 entry every 20 years. • Watershed analysis and/or PWA protocol will be used to determine the priorities and road storm proofing standards to be used on all roads inside the LEB. Surface area covered in roads will be included in all calculations of basal area.	Sediment Metering, LWD delivery to Class I and II watercourses.
<u>CLASS III</u>	Prescriptions that apply to all Class III watercourses: Class III streams will have three management categories based on percent slope, <30%, 30% - 50%, and >50%.	• There will be no removal of any portion of down wood within the Equipment Limitation Zone/Equipment Exclusion Zone (ELZ/EEZ) except for emergencies as per agreement with NMFS, USFWS and CDFG in accordance with the approved HCP. • Trees felled during current harvesting and approved THP road construction are not considered down wood for purposes of retention. • Felled hazard trees not associated with a harvesting operation or road construction are considered down wood and are to be retained in the general vicinity. • Trees that fall naturally onto roads, landings, or harvest units are considered down wood and are to be retained in the general vicinity. • No fire will be ignited within the equipment limitation zones (ELZs) or EEZs.	
<u>CLASS III</u>	Prescriptions that apply to Class III streams with	• Equipment Limitation Zone (ELZ) extending 25 ft from the stream edge, or to the drainage divide, or ridgeline of the Class III stream whichever is less. • Stabilize skid trails as per the CFPRs (Section 916.7) or	

	slopes <30 percent:	as per an approved THP. • Ground based equipment in the ELZ is acceptable if less resource damage will occur by operating in the ELZ, as per an approved THP. Where the above measure applies, all tractor road watercourse crossings must be flagged on the ground prior to the preharvest inspection and shown on the THP map in order to be adequately evaluated for the potential to generate sediment.	
CLASS III	Prescriptions that apply to Class III streams with slopes of 30 - 50 percent:	• ELZ extending 50 ft from the stream edge, or to the drainage divide, or ridgeline of the Class III stream whichever is less. • Stabilize skid trails as per the CFPRs (Section 916.7) or as per an approved THP. • Ground based equipment in the ELZ is acceptable if less resource damage will occur by operating in the ELZ, as per an approved THP. • Where the above measure applies, all tractor road watercourse crossings must be flagged on the ground prior to preharvest inspection and shown on the THP map in order to be adequately evaluated for the potential to generate sediment.	
CLASS III	Prescriptions that apply to Class III streams with slopes >50 percent:	• EEZ (Equipment Exclusion Zone) extending 100 ft from the stream edge, or to the drainage divide, or ridgeline of the Class III stream whichever is less. • Ground based equipment in the EEZ is acceptable if less resource damage will occur by operating in the EEZ, as per an approved THP. • Where the above measure applies, all tractor road watercourse crossings must be flagged on the ground prior to preharvest inspection and shown on the THP map in order to be adequately evaluated for the potential to generate sediment.	

ROAD NETWORK	Assessment of existing road network and sediment sources	PALCO will assess the road network and associated sediment sources on its lands either as part of the watershed assessment or the road storm-proofing program protocols (see below). Given the accelerated schedule being proposed for watershed analysis, most of this assessment is likely to occur within the first few years after issuance of the ITPs. However, at a minimum, the assessments must be completed as follows: • Elk River, Freshwater Creek, Lawrence Creek, and Yager Creek will be evaluated within the first decade of Plan implementation; • Van Duzen and Middle Eel rivers will be evaluated during the second decade; and • Larabee Creek, Salmon Creek, and Mattole and Bear rivers will be evaluated during the third decade. It is anticipated that all sites assigned a high or medium priority rating based on the audit of potential sediment sources will be storm-proofed over the first 30 years of Plan	Sediment Control

		implementation.	
	Restoration of sediment delivery sites for non-THP related roads	<u>Prior to issuance of the ITP:</u> - Based on PWA analysis, complete recommended road storm proofing on high and medium risk sites, on at least 50 miles per year. <u>After issuance of the ITP:</u> - Based on watershed analysis, complete recommended work on high and medium risk sites, on a planning watershed basis, within the prioritized hydrologic units and schedule listed above. Variations from this schedule will be conducted only upon approval of the agencies.	
	Storm-proofing or upgrading THP related roads	- All THP related roads and landings shall comply with specifications described in Handbook for Forest and Ranch Roads (Weaver 1994) • For purposes of this Plan, a road will be considered upgraded when it is well drained and shows no signs of imminent failure (e.g., as evidenced by slumping, scarps or cracks in the road fill) which would deliver sediment to a watercourse. Actions necessary to upgrade a road include the installation of ditch relief culverts and/or rolling dips where significant downcutting of the ditch is noted and removal or stabilization of unstable fill material at sites showing signs of imminent failure which could impact a watercourse. An upgraded road, as described above meets the definition used in the Plan of "complying with the specifications described in the Handbook for Forest and Ranch Roads (Weaver and Hagans 1994.)" • In each decade of HCP implementation, or until all active roads have been storm-proofed, at least 500 miles of existing roads will be improved to meet the storm-proofing standards identified in the PWA guidelines (Volume II Part N). PL will work closely with agencies to identify priority areas for this work. Additionally, unless otherwise agreed to by the agencies pursuant to prioritization discussions, storm-proofing will proceed according to the schedule by decade for hydrologic units provided in the January 7, 1998 Interagency Aquatic Strategy on page 10 thereof (see Section 3). Storm-proofing conducted as part of THPs will count towards the per-decade objective. When used in this Plan, the term storm-proofing describes a process which involves the following elements: 1. An audit of potential sediment sources along a road is conducted. A trained observer walks the road segment looking for actual or potential occurrences of erosion, slippage, mass wasting, blocked or perched culverts, or other potential sediment sources. The audits document instances of Humboldt crossings, unstable fill slopes for roads and landings, stream crossings that have high	

		potential for culvert blockage and diversion of stream flows onto the road bed, sufficient drainage and diversion of road drainage directly into watercourses. 2. The likelihood that each identified feature will deliver sediment to watercourses is also evaluated as part of the road audit, as is the total volume of sediment that could be prevented from delivery if remedial action is taken. 3. Based on the volume of sediment saved and likelihood of delivery, sediment sites are assigned a rating of high, medium or low priority. 4. All high and medium priority sites are then scheduled for corrective action. Corrective action typically requires an excavator, bulldozer, and one or more dump trucks to dig up and replace stream crossings, install drainage structures, remove unstable fill, alter the road bed to reduce the potential for diversion of flows onto the road surface, and the installation of rolling dips and/or water bars to route water and sediment. 5. Storm-proofing is considered complete when the specified corrective actions are complete, and the roads database and GIS system are updated to show that the subject road has been storm-proofed.	
	Construction of new roads	• All new roads will be built to site-specific storm-proof specifications. (See previous storm proofing discussion.) • New roads will not be constructed in RMZs except for crossings or when feasible alternatives that would have less environmental impact are clearly not available as determined through consultation with the appropriate agencies, and will be designed to minimize the number of stream crossings and avoid mass wasting risk areas. Road layout will attempt to follow natural grades to help limit sedimentation, will be constructed on slopes primarily under 50%, and will be single lane (between 12 to 14 feet wide). In addition, bridges, culverts, or fords at stream crossings will provide for adequate passage of water during storm events. • Structures over fish-bearing streams and restorable fish-bearing streams for all new roads will be designed to provide for unimpeded fish passage. This could involve use of bottomless or baffled culverts, bridges, or other such structures. Where culverts are used they will be installed at an appropriate gradient, be sized to permit passage of a 100 year recurrence interval flood, and will contain downstream storm proofing of the stream bed to ensure that they are passable, and to prevent culvert "perching." Fish passage will be ensured by adhering to guidelines for culvert installation by NMFS, or by agency review of alternate installation measures. • Road or landing construction or reconstruction shall comply with applicable state and federal laws and shall not occur during periods of measurable precipitation (excluding fog drizzle or drip) and shall not resume	

		thereafter until and unless soil moisture conditions are not in excess of that which occurs from normal road watering or light rainfall such that the construction or reconstruction activities will result in the loss of soil materials in amounts that will cause a visible increase in the turbidity in a Class I, II, or III watercourse, or in any drainage facility or road surface that drains directly to a Class I, II, or III watercourse (not applicable to standing water that is not draining directly to a watercourse). During each winter period (which for these purposes shall be between November first of each year and April first of the following year) no more than 2.5 miles of new road construction and 5 miles of reconstruction or storm-proofing shall occur on the Plan Area unless such additional work is approved after consultation with NMFS, USFWS, and CDFG. PALCO and the agencies shall reevaluate these winter mileage limitations during the first three years of plan implementation to determine their effectiveness. If modifications are deemed appropriate, PALCO and the agencies shall meet and agree on any necessary changes.	
	Maintenance and Use of existing roads	Truck hauling, road grading, road rocking, or other non-emergency road use activities shall comply with applicable federal and state laws and shall cease when the activities result in a visible increase in the turbidity in a Class I, II, or III watercourse, or in any drainage facility or road surface that drains directly to a Class I, II, or III watercourse (not applicable to standing water that is not draining directly to a watercourse). Once these activities have ceased due to the foregoing conditions, these activities shall not resume until and unless soil moisture conditions are not in excess of that which occurs from normal road watering or light rainfall such that use will result in the loss of surface materials from the road in amounts that will cause a visible increase in the turbidity in a Class I, II, or III watercourse, or in any drainage facility or road surface that drains directly to a Class I, II, or III watercourse (not applicable to standing water that is not draining directly to a watercourse).	
	Monitoring Road Network	1. All open (i.e., non-abandoned) roads will be inspected at least yearly. 2. Roads will be inspected during the winter period incidental to normal operations and note all occurrences of road slippage, erosion or impending mass failure, blocked culverts, and failures or erosion control measures. 3. Any maintenance needs identified by inspections will be performed by the end of the field season following the inspection.	

HILLSLOPE MANAGE-MENT	Mass Wasting Extreme, Very High and High Mass Wasting Potential Zones (including Inner Gorges, Headwall Swales & Unstable Areas)	The Hillslope Management-Mass Wasting process applies to all portions of PL's ownership, including inside the RMZs. The prescriptions in the RMZs for mass wasting will not be less restrictive than the riparian prescriptions developed as part of the interim or default strategies or through watershed analysis as appropriate and applicable to this Plan. PL will not harvest or construct new roads in portions of its ownership with an "extreme" mass wasting potential, in inner gorges, headwall swales, or unstable areas without a geologist's report recommending alternative prescriptions that are approved by CDF. The professional registered PL geologist shall assess the influence of the proposed operation on the risk of hillslope failure. In areas where the potential for mass wasting is rated as "very high" or "high," PL will not operate heavy equipment off of existing roads or construct new roads, without a geologist's report recommending alternative prescriptions that are approved by CDF. The geologist's written report must accompany the THP when submitted for review. For portions of the ownership lacking geology and soils maps necessary to make a determination of risk, PL is responsible for providing site specific risk ratings based on review by a geologist. In most cases such determinations will be done as part of the THP approval process. NMFS, CDFG and EPA or Regional Water Quality Control Board shall be notified of all THPs that are being submitted on areas of extreme, very high and high mass wasting potential in addition to inner gorges, headwall swales, and unstable areas, if the proposed operation goes beyond the default prescriptions. A registered geologist shall assess the influence of the proposed operation on the risk of hillslope failure and prepare a written report. If required (i.e., if prescriptions other than the defaults are being proposed), the geologist's report along with the THP will be sent to NMFS, CDF&G and either EPA, or the Regional Water Control Quality Board upon THP submission. If the notified agencies have concerns regarding the harvest proposal related to the risk of mass wasting, they may communicate such concerns to the RPF and CDF within 30 days of receipt of materials from PALCO or until the close of the public comment period, whichever is longer. As mandated under the FPA, CDF, as lead agency for THP review, will consider all input and determine whether the mass wasting mitigation measures contained in the THP will avoid significant impacts.	
	Surface Erosion	PL will treat all sites of exposed mineral soils, resulting from forestry activities within watercourses protection zones that are equal to or greater than 100 sq ft, or areas less than 100 sq ft which are on slopes greater than 30 percent if the site can deliver fine sediment to watercourses. Exposed mineral soil treatments can include revegetation or other erosion control measures including, but not limited to, seeding and mulching. Watercourse crossings will also be treated to avoid or minimize sediment delivery, using watershed analysis and/or road storm proofing protocols and road armoring standards to	

		be used on all such crossings. Cable corridors (cable roads) that divert or carry water away from natural drainage patterns or channelize run-off that reaches watercourses will have waterbreaks installed at intervals as per the CFPRs (14 CCR 914.6).	

BURNING		PL will continue to manage prescribed burns (including brush piling, fire breaks, ignition techniques, prescriptions for environmental conditions permitting ignition, etc.) to minimize adverse effects. Mitigation may be required for fire management, including suppression and rehabilitation efforts, if PL or its agents are found in violation of, or out of compliance with, their burning permit. Additional prescribed burning practices may be identified during the watershed assessment process.	Sediment Control and slope stability

Table 4. Tree size and quantity necessary to meet two different residual basal area requirements.

Residual Basal Area Requirement	DBH Class	Basal Area Percent	# of Trees Per Acre*
300 sq ft/acre	6 to 12"	5%	34
	12 to 18"	10%	24
	18 to 24"	15%	19
	24 to 30"	15%	11
	30 to 36"	15%	8
	36 to 42"	20%	7
	42 to 48"	20%	5
	Over 48"	0%	0
240 sq ft/acre	4 to 8"	3%	37
	8 to 12"	4%	18
	12 to 16"	8%	18
	18 to 20"	10%	14
	20 to 24"	12%	11
	24 to 28"	12%	9
	28 to 32"	15%	7
	32 to 36"	18%	7
	36 to 40"	18%	5
	Over 40"	0%	0

* Retention requirements are based on basal area not tree number. Number of trees/acre provided for information purposes only.

Inner gorge, as used here, is defined as that area of the watercourse bank situated immediately adjacent to the watercourse channel, having a sideslope of 65% or greater, and extending from the edge of the channel upslope until the slope becomes less than 65% or for a distance of 400 ft., (slope distance) whichever is less.

Headwall swale is defined here as a concave depression, with convergent slopes > 65%;—that is connected to a watercourse via a continuous linear depression (a linear depression interrupted by a landslide deposit is considered continuous for this definition).

Unstable areas are characterized by slide areas or by some or all of the following: hummocky topography consisting of rolling bumpy ground, frequent benches, and depressions; short, irregular surface drainages which begin and end on the slope; tension cracks and head wall scarps; slopes are irregular and may be slightly concave in upper half and convex in lower half from previous slope failure; evidence of impaired ground water movement resulting in local zones of saturation within the soil mass which is indicated at the surface by sag ponds with standing water, springs, or patches of wet ground. Some or all of the following may be present: hydrophytic vegetation prevalent; leaning, jackstrawed or split trees are common; pistol butted trees with excessive sweep may occur in areas of hummocky topography (leaning and pistol butted trees should be used as indicators of unstable areas only in the presence of other indicators

Appendix C
Stitz Creek Road Sites Scheduled for Repair in 2019

WorkOrderID	Site	Road #	Priority	Road Class	Stream Class	Problem	Solution	Comments	Yards Soil	% Delivery	SedSiteID	Schedule
-1054872800	RJ801	H03.0616	High	Abandoned	III	Landslide - Shallow	Excavate Soil	Recommend not completely excavating crossing. Excavate over steepened material provide drainage and rip-rap outfall and as needed. Conduct additional GEO review of site prior to any treatment. Site is beyond other pulled crossing. Site will need treat	20.4	100	11725	15-Oct-20
-1058705481	RJ800	H03.0616	Low	Abandoned		Cut Bank Failure	Excavate Soil	If road is opened to access sites beyond this site excavate failed material on road. End haul or drift excavated material within road bed. Do not sidecast failed material.	0	NA	11726	15-Oct-20
1368778554	RJ898	H03.0616	Low	Abandoned		Fill - Landing	Excavate Soil	If road is opened excavate over steepened edge of landing.	0	NA	11727	15-Oct-20
-1519186644	RJ807	H03.061608	Low	Open		Culv.-Ditch Relief	Culv. Maintenance	Clean out outlet. Hand work is fine. Additional work would be to excavate slope below outlet to allow better drainage of outlet.	0	NA	11718	15-Oct-20
-502343491	RJ808	H03.061608	Low	Open	II	Culv.	Culv. Maintenance	Jack open culvert outlet	0	NA	11719	15-Oct-20
1775943714	RJ870	H03.0634	Low	Abandoned		Cut Bank Failure	Excavate Soil	Excavated failed material and either drift material along road or endhaul no sidecasting of excavated material.	0	NA	11789	15-Oct-20
1349904566	RJ864	H03.0634	High	Abandoned	III	Fill - NO Culvert	Temporary Crossing	Prior to excavation further inspection down slope should occur to insure that drainage from excavated channel is continues to be within drainage further down slope. Excavate TOP to Bot. Excavate channel wider than natural channel width. Layback slopes	11.8	100	11795	15-Oct-20
860711935	RJ865	H03.0634	Low	Abandoned		Landslide - Shallow	Excavate Soil	Prior to treatment to gain access to sites beyond this site further GEO review and input will be required. Minimize excavation and ramp up onto and over material on road.	0	NA	11794	15-Oct-20
1611091525	RJ867	H03.0634	Low	Abandoned		Cut Bank Failure	Excavate Soil	Excavated failed material from road. No sidecasting of excavated material. Material may be drifted within road prism or endhauled.	0	NA	11792	15-Oct-20
43143675	RJ871	H03.0634	High	Abandoned		Landslide - Shallow	Other	Any treatment proposal will require additional GEO review and input. Over steepened banks on the right edge could be laid back through excavation.	100	100	11787	15-Oct-20
-941943647	RJ862	H03.0634	Low	Abandoned		Cut Bank Failure	Excavate Soil	Excavated failed material from road surface no sidecasting of material.	0	NA	11797	15-Oct-20
-1186249138	RJ863	H03.0634	High	Abandoned	III	Fill - NO Culvert	Temporary Crossing	Excavate TOP to BOT. Excavate channel wider than natural channel width. Layback slopes to 50% or natural angle whichever is steeper.	0.7	100	11796	15-Oct-20
-664594988	RJ866	H03.0634	Low	Abandoned		Cut Bank Failure	Excavate Soil	Excavated failed material from road and excavated failed material that made it over the road. No sidecasting of excavated material.	0	NA	11793	15-Oct-20
-1686677252	RJ897	H03.064620	Other	Rocked (Perm)	--	Other	Other	LARGE AMOUNT OF LANDING SLASH WITHIN HEAD OF SWALE. MOST MATERIAL NOT REACHABLE WITH EXCAVATOR. BEST TREATMENT WOULD BE TO BURN MATERIAL. BEST ACCESS FRO EXCAVATION APPEARS TO BE FROM THE RIGHT OFF POINT EXCAVATING DOWN INTO MATERIAL IF SLOPE IS STABLE	0	NA		15-Oct-20
1885707463	RJ896	H03.064620	Other	Rocked (Perm)	--	Other	Other	UNTREATED LANDING SLASH LOCATED ABOVE 80% SLOPES. EXCAVATE SLAH THAT CAN BE REACHED OR TREAT BY BURNING	0	NA		15-Oct-20
-906389992	RJ821	H11	Other	Rocked (Perm)	III	Culv.	Culv. Maintenance	OUTLET SLIGHTLY OBSTRUCTED WITH ROCK. CLEAN OUT BY HAND. A DIVERSION POTENTIAL EXIST TO THE RIGHT. IMPROVE EXISTING CRITICAL DIP TO A MORE DEFINED CONDITION TO ELEMENATE DIVERSIOIN POTENTIAL.	0	NA		15-Oct-20
1096661971	RJ820	H11	Other	Rocked (Perm)	--	Other	Other	MINOR HEADCUTTING CONTINUES AT DISCHARGE POINT OF ROAD DRAINAGE OUT. INSTALL DISSIPATOR.	0	NA		15-Oct-20
1259475034	RJ819	H11	Other	Rocked (Perm)	--	Fill - Landing	Excavate Soil	RECENT SMALL FAILURE LEFT SIDE OF LANDING. ALSO OBSERVED CRACKS IN THIS AREA. NO SIGN OF CRACKS ON RIGHT SIDE OF LANDING BUT LARGE AMOUNT OF STEEP FILL WITH SIGNS OF BURIED WOODY DEBRIS. EXCAVATE ENTIRE LANDING FILL	0	NA		15-Oct-20

Appendix C
Stitz Creek Road Sites Scheduled for Repair in 2019

WorkOrderID	Site	Road #	Priority	Road Class	Stream Class	Problem	Solution	Comments	Yards Soil	% Delivery	SedSiteID	Schedule
924940893	RJ818	H11	Other	Rocked (Perm)	III	Culv.-Ditch Relief	Culv. Maintenance	MINOR HEADCUTTING AT OUTLET. INSTALL DISSIPATOR BELOW OUTLET	0	NA		15-Oct-20
-1525014441	RJ816	H11	Other	Rocked (Perm)	--	Fill - Landing	Excavate Soil	ON GOING FAILURE. EXCAVATE FAILING MATRA FROM TOP OF SLIDE	0	NA		15-Oct-20
842131215	RJ824	H11	Other	Rocked (Perm)	III	Culv.	Culv. Maintenance	DOWNSPOUT DAMAGED AT CULVERT OUTLET AND WATER FLOWS UNDER DOWNSPOUT. CORRECT PROBLEM SO WATER FLOWS IN DOWNSPOUT.	0	NA		15-Oct-20
-1352090258	RJ815	H11	Other	Rocked (Perm)	--	Fill - Road	Excavate Soil	SMALL FILL FAILUR 30W X 20L X 8D. EXCAVATE FAILED MATERIAL THAT CAN BE REACHED AND LAY BACK OVER STEEPENED BANK. ALSO EXCAVATE OVER STEEPENED SIDECAST MATERIAL TO RIGHT APPROX 30 FT WIDE ALONG RD	0	NA		15-Oct-20
1761803329	RJ814	H11	Other	Rocked (Perm)	III	Culv.	Culv. Maintenance	HEADCUTTING OCCURRING BELOW OUTLET INSTALL DISSIPATOR OR DOWNSPOUT TO STABEL DISCHARGE AREA	0	NA		15-Oct-20
538891584	RJ813	H11	Other	Rocked (Perm)	--	Culv.	Other	IT APPEARS THAT 18 INCH CPP WAS INSTALLED AS DRC DRAINING A WET PORTOIN OF BANK AND DITCH. HRC MAP SHOW CROSSING AS CLASS III ENDING JUST ABOVE CULVERT INLET. THERE IS SIGN OF SMALL DEFINED CHANNEL COMING INTO CULVERT OFF SLOPE. CURRENTLY SOME MONOR FL	0	NA		15-Oct-20
939808923	RJ812	H11	Other	Rocked (Perm)	DR	Culv.-Ditch Relief	Other	12 INCH CMP DRC INLET & OUTLET CRUSHED & PARTIALLY PLUGGED. EITHER OPEN PU AND CLEAN OUTOR REPLACE WITH 18 INCH CULVERT	0	NA		15-Oct-20
1667671362	RJ811	H11	Other	Rocked (Perm)	III	Culv.-Ditch Relief	Culv. Maintenance	PLUGGED DRC DUE TO BANK FAILURE. CLEAN OUT DRC	0	NA		15-Oct-20
-1080419355	RJ810	H11	Other	Rocked (Perm)	--	Inside ditch	Ditch - Clean	BANK FAILURE HAS DITCH BLOCKED. CLEAN DITCH	0	NA		15-Oct-20
560322892	RJ817	H11	Other	Rocked (Perm)	--	Fill - NO Culvert	Excavate Soil	OVERSTEEPENED SLOPE DUE TO PAST FAILURE. SOME PERCHED MATERIAL STILL EXIST. EXCAVATE SLOPE AND LAY BACK APPROX 75 FEET WIDE.	0	NA		15-Oct-20
711051782	RJ823	H11	Other	Rocked (Perm)	III	Culv.-HDP	Other	DIVERSION POTENTIAL TO LEFT DOWN INSIDE DITCH. BLOCK OFF DITCH TO LEFT.	0	NA		15-Oct-20
1629296548	RJ825	H11	Other	Rocked (Perm)	III	Culv.	Other	MINOR HEADCUTTING OCCURRING AT OUTLET. INSTALL DISSIPATOR	0	NA		15-Oct-20
1346256372	RJ809	H11	Storm Damage	Rocked (Perm)	--	Landslide - Deep	Other	LARGE OLD HILLSLOPE LANDSLIDE THAT HAS AFFECT ROAD. TO OPEN RAMP DOWN AND OUT. GEO ISSUES	0	NA		15-Oct-20
-557777103	RJ830	H11	Other	Rocked (Perm)	--	Fill - Road	Excavate Soil	OLD FILL FAILURE WITH OVERSTEEPENED FAILING MATERIAL. EXCAVATE AND LAY BACK TOP OF FEATURE.	0	NA		15-Oct-20
-188995088	RJ829	H11	Other	Dirt (Seasonal)	III	Temporary Crossing	Excavate Soil	TEMPORARY CROSSING CHANNEL NOT EXCAVATED TO GRADE. LARGE SINK HAS APPEARED IN LOWER PORTION OF OLD EXCAVATION. EXCAVATE TOP TO BOTTOM. EXCAVATE CHANNEL WIDER THAN NATUAL CHANNEL WIDTH AND LAY BACK SLOPES TO 50% OR TO NATURAL SLOPE WHICHEVER IS STEEPER.	0	NA		15-Oct-20
-763552245	RJ828	H11	Other	Rocked (Perm)	III	Culv.	Other	PORTION OF FLOW AT CULVERT OUTLET FLOWS UNDER DOWNSPOUT. THIS CONDITION CONTRIBUTES TO HEADCUTTING AT DOWNSPOUT OUTLET. CORRECT BY INSURING ALL WATER FLOW INTO DOWNSPOUT. ALSO IF POSSIBLE HAND INSTALL DISSIPATOR AT DOWNSPOUT OUTLET TO REDUCE POTENTIAL	0	NA		15-Oct-20
218224242	RJ827	H11	Other	Rocked (Perm)	II	Culv.	Other	COUPLER BAND BROKEN WHERE FIRST SECTION OF FULL ROUND DOWNSPOUT IS ATTACHED TO CULVERT OUTLET. CULVERT OUTLET IS NOT LINED UP WITH FULL ROUND DOWNSPOUT INLET. POTENTIAL FOR WATER TO RUN UNDER DOWNSPOUT. REATTACH FULL ROUND DOWNSPOUT TO CULVERT OUTLET A	0	NA		15-Oct-20
-363167787	RJ826	H11	Other	Rocked (Perm)	III	Culv.	Other	MINOR EROSIOIN BELOW OUTLET. INSTALL DISSIPATOR	0	NA		15-Oct-20
-877071815	RJ822	H11	Other	Rocked (Perm)	III	Culv.	Culv. Maintenance	INLET HAS PLUGGED CAUSING OVERLAND FLOW WITHIN CRITICAL DIP AND EROSION OF OUTBOARD EDGE OF ROAD. UNPLUG OR REPLACE CULVERT AND REPAIR OUTBOARD EDGE OF ROAD.	65	100		15-Oct-20
832028979	RJ834	H11.33	High	Closed		Landslide - Shallow	Other	Excavate remaining over steepened fill material. Road will have to be reconstructed to treat site and to access sites beyond this point and then decommissioned	15	100	11810	15-Oct-20
-1660893192	RJ835	H11.33	High	Closed		Landslide - Shallow	Other	To gain access repair road and decommission road when done with road.	20	100	11811	15-Oct-20

Appendix C
Stitz Creek Road Sites Scheduled for Repair in 2019

WorkOrderID	Site	Road #	Priority	Road Class	Stream Class	Problem	Solution	Comments	Yards Soil	% Delivery	SedSiteID	Schedule
-693645594	RJ839	H11.3319	Low	Abandoned	III	Fill - NO Culvert	Excavate Soil	Excavated TOP to BOT. Excavated channel wider than natural channel. Layback slopes to 50% or to natural slope angle, which ever is steeper.	0	NA	11816	15-Oct-20
1925969561	RJ838	H11.3319	Low	Abandoned	III	Fill - Road	Excavate Soil	Treat site RJ839 and excavate channel across road at this Site RJ838 to remove delivery of potential erodible fill.	0	NA	11817	15-Oct-20
611508638	RJ831	H33.77	Other	Rocked (Perm)	--	Fill - Landing	Excavate Soil	SLASH MATERIAL LOCATED ON STEEP SLOPES WITH HOLES AND CRACKS AND SETTLING. SITE WELL VEGETATED AND LOCATED APPROX. 200FT ABOVE CLASS III WATERCOURSE. 130W X 15L X 6D ESTIMATED 105 DELIVERY. EXCAVATED MATERIAL.	0	NA		15-Oct-20
1560266150	RJ900	H11	High	Rocked (Perm)	III	Other	Other	MINOR EROSION AT INLET. INSTALL ENERGY DISIPATOR/ROCK ARMORING TO PREVENT CONTINUED EROSION	0	NA		15-Oct-20

THE PACIFIC LUMBER COMPANY (PALCO)

PRESCRIPTIONS

BASED ON WATERSHED ANALYSIS FOR

LOWER EEL AND EEL DELTA, CALIFORNIA

17 June 2004

Changes to HCP language:

6.3.3.7 Hillslope Management

The hillslope management mass-wasting strategy applies to all portions of PALCO's ownership, including the RMZs. The prescriptions in the RMZs for mass-wasting will not be less restrictive than the riparian prescription developed as part of watershed analysis, as appropriate and applicable to this Plan. The hillslope management prescriptions may be modified as a result of watershed analysis revisitation.

1. PALCO shall use the Lower Eel and Eel Delta (LEED) "Hillslope Management Checklist" for identifying areas at very high risk of mass-wasting to which the appropriate mass-wasting prescription (Table 1) will be applied when building roads and harvesting timber. If a very high prescription is not indicated through this, the registered professional forester (RPF) determines the appropriate prescription to be applied to the area consistent with the California Forest Practice Rules (FPRs).
2. PALCO has developed an office and field based training course for RPFs to educate them on the general geology, geologic processes, specific slope stability issues, and identifying unstable features on PALCO lands. The training includes education on proper use of the LEED Hillslope Management Checklist, and the information contained in CGS notes 45 and 50. PALCO will provide additional training as needed prior to implementation of the LEED prescriptions. Only RPFs that have taken this training can develop THPs using these new prescriptions.
3. Where geologic review is recommended from the checklist below, CGS Note 45 and other information and materials may be used as needed and appropriate.
4. Road stormproofing activities required by the HCP Section 6.3.3.2 (as revised April 13, 2003) are not restricted by these hillslope prescriptions. In addition, where an existing and approved stormproofing plan exists, road stormproofing, road closure, road decommissioning of existing roads and road sites on the mass-wasting areas of concern can be conducted without additional geologic review or Wildlife Agency approval.

Table 1: Summary of Riparian and Hillslope Protection Measures for the Lower Eel – Eel Delta Watershed Analysis Unit (WAU). This table is a summary only; more detailed information is described in the text.

<table>
<tr><th>Watercourse Class</th><th>Sub-Basin Group [a]</th><th>Slope Class [b]</th><th colspan="4">Distance From Streambank or Watercourse Transition Line (In Feet)
And Conservation Measures in Each Streamside Segment</th></tr>
<tr><td rowspan="3">Class I</td><td rowspan="3">All Sub-Basins in the Watershed Analysis Unit (WAU)</td><td></td><td>0-100 Feet</td><td>100-150 Feet</td><td>150-200 Feet</td><td>200-300 Feet</td></tr>
<tr><td>< 50 %</td><td>No Harvest
(0-100 feet)</td><td>Retain
≥ 50%
Post-Harvest
Canopy
Closure
(100-150 feet)
[c]</td><td colspan="2">Not Applicable</td></tr>
<tr><td>≥ 50 %</td><td>No Harvest
(0-100 feet)</td><td colspan="2">Geologic Review, and
50% Post-Harvest Canopy Closure
(100-200 feet) [d, e]</td><td>Geologic Review
(200-300 feet) [e]</td></tr>
<tr><td rowspan="3">Class II</td><td rowspan="3">South Eel
Sub-Basin Group
(Including Stitz Creek)</td><td></td><td>0-100 Feet</td><td colspan="2">100-200 Feet</td><td>200-300 Feet</td></tr>
<tr><td><50%</td><td>No Harvest
(0-100 feet)</td><td colspan="2">Not Applicable</td><td>Not Applicable</td></tr>
<tr><td>≥50%</td><td>No Harvest
(0-100 feet)</td><td colspan="2">Geologic Review and
Special Hillslope Prescription
(100-200 feet) [d, e]</td><td>Geologic Review
(200-300') [e]</td></tr>
<tr><td rowspan="3">Class II</td><td rowspan="3">North Eel and
Eel River Delta
Sub-Basin Groups
(Excluding Stitz Creek)</td><td></td><td>0-50 Feet</td><td>50-125 Feet</td><td>125-200 Feet</td><td>200-300 Feet</td></tr>
<tr><td>< 50 %
or <40% in Scotia</td><td>No Harvest
(0-50 feet)</td><td>≥ 60% Post-Harvest
Canopy Closure
(50-125 feet) [c]</td><td colspan="2">Not Applicable</td></tr>
<tr><td>≥ 50 % or ≥40% in Scotia</td><td>No Harvest
(0-50 feet)</td><td>Geologic Review, and
≥ 60% Post-Harvest
Canopy Closure
(50-125 feet) [c, e]</td><td>Geologic Review, and
Special Hillslope
Prescription
(125-200 feet) [d, e]</td><td>Geologic Review
(200-300 feet) [e]</td></tr>
<tr><td rowspan="2">Class III</td><td rowspan="2">All Sub-Basins in the Watershed Analysis Unit (WAU)</td><td rowspan="2">>50%</td><td colspan="4">Streambank or Watercourse Transition Line to Break-In-Slope or Hydrologic Divide</td></tr>
<tr><td colspan="4">Geologic Review [e]</td></tr>
</table>

Table 1 (Continued): Summary of Riparian and Hillslope Protection Measures for the Lower Eel – Eel Delta Watershed Analysis Unit (WAU).

Other Hillslope Features

Feature	Conservation Measures
Headwall Swale, Including 25-Foot Buffer Zone	No road construction, reconstruction or timber harvest without geologic review. The minimum retention is the Special Hillslope Prescription. [d, e]
Other Very High Hazard Features	Geologic Review [e]

Footnotes

Note	Subject	Discussion
[a]	Sub-basin groupings.	*South Eel Group*: Monument, Kiler, Dinner, Twin, Stafford, Stitz, Jordan, Greenlow, Pepperwood, Bear, Horse Collar, Chadd, and High Rock sub-basins. This group also includes the portion of the Eel River mainstem sub-basin lying south of the river channel. *North Eel Group*: Scotia, North Central, Sammy & Kari, Darnell, Shively, Bridge, Allen, Weber, Perrott, Strongs, Nanning, Dean, Howe, and Atwell sub-basins. This group also includes the portion of the Eel River mainstem sub-basin lying north of the river channel.
[b]	Slope class and prescription objectives.	Where slope class is < 50% (or < 40% in the Scotia sub-basin), the conservation measures address riparian management issues only. Where prescriptions apply to all slope classes, as in Class II watercourses in the South Eel Sub-Basin Group, and where the slope class is ≥ 50% (or ≥ 40% in the Scotia sub-basin), the conservation measures address a combination of hillslope and riparian management issues.
[c]	Post-harvest canopy closure requirements (applies to RMZ prescriptions only).	For Class I watercourses, see the prescription measures for the Class I outer band in revised section 6.3.4.1.2. For Class II watercourses, see the prescription measures for the Class II outer band in revised section 6.3.4.1.3.
[d]	Special Hillslope Prescription (applies to mass-wasting prescriptions only).	See "Special Hillslope Prescription" under definitions in revised section 6.3.3.7. Standards for application of the special hillslope prescription are found throughout revised section 6.3.3.7.
[e]	Geologic Review.	Standards, terms and conditions for geologic review are found throughout revised section 6.3.3.7.

The Hillslope Management Checklist for the Lower Eel and Eel Delta Watershed Analysis Unit

Modified from the CALIFORNIA LICENSED FORESTERS ASSOCIATION GUIDE TO DETERMINING THE NEED FOR INPUT FROM A LICENSED GEOLOGIST DURING THP PREPARATION

In order to identify areas of very high risk of mass-wasting, the following questions should be addressed by the RPF during Timber Harvesting Plan (THP) preparation.

1. *Are there unstable areas located within or adjacent to the proposed THP area?*
   - A. *Were active features indicated on the maps available for the watershed? The RPF will review WA maps and appropriate CGS maps, aerial photos, and previous THPs in the area to identify areas of concern. Areas identified as shallow landslides or active deep-seated landslides on these maps will receive the very high prescription.*
   - B. *Were unstable areas observed in the field?*
     - i. *Is an inner gorge or steep streamside area (as defined in this section), present? If the answer is yes, the appropriate prescription is to be applied. If the answer is no, proceed with the evaluation.*
     - ii. *Is an headwall swale (as defined in this section) present? If the answer is yes, the appropriate headwall swale prescription is to be applied. If the answer is no, proceed with the evaluation.*
     - iii. *If the area being reviewed is not underlain by previously mapped deep-seated mass-wasting features then the RPF should look for indicators of unstable areas that may include:*
       - *Hillslopes greater than 60%*
       - *Loose, unconsolidated soils*
       - *U-shaped swales*
       - *Irregular topography*
         - *Scarps*
         - *Benches*
         - *Hummocky ground*
         - *Surface cracks*
       - *Vegetative indicators*
         - *Leaning trees*
         - *Hydrophytes*
         - *Isolated patches of homogeneous vegetation*
       - *Disorganized drainage*
         - *Sag ponds*
         - *Seeps*
         - *Diverted watercourse*
       - *Road cut-bank failure*
       - *Road or landing fill failure*

     If any of the features listed above is observed, consider part C and answer question 2.

iv. *If the area being reviewed is underlain by previously mapped deep-seated mass-wasting features, then the RPF should look for indicators of unstable areas that may include:*

- *Hillslopes greater than 60%*
- *Ground cracks*
- *Sharp, fresh, or unvegetated scarps or grabens*
- *Debris slides or debris flows on the surface of the deep-seated feature*
- *Recent rock fall or rock slides on the surface of the deep-seated feature*
- *Fresh/recent ground, road, or landing displacement*
- *Ponded or disrupted drainage (e.g., displaced stream channels, sag ponds, hydrophytes)*
- *Displaced/stressed/missing forest cover, frequent leaning and/or recurved (bent) trees*
- *Steep toes of deep-seated landslides or earthflows along stream edges or stream escarpments*

If any of the features listed above is observed, consider part C and answer question 2.

C. *If unstable areas were identified in the THP area as listed in iii & iv, proposed timber operations on, adjacent to, upslope, or downslope of these features may have the potential to affect slope stability through:*

- *Displacement of soil*
- *Division or concentration of drainage*
- *Reduction in interception or transpiration, and/or*
- *Reduction in root strength*

Examples of timber operations that may produce these effects are:

- *Timber cutting*
- *Construction and maintenance of:*
  - *Roads*
  - *Stream watercourse crossings*
  - *Skid trails*
  - *Beds for felling of trees (layouts)*
  - *Fire breaks*
- *Mechanical site preparation*
- *Prescribed burning*

2. *Do the proposed timber operations have a reasonable potential to affect slope stability, and a potential for materials from landslides or unstable areas to affect public safety, water quality, fish habitat or other environmental resources? If the answer is yes, the area will receive the very high prescription. If the answer is no, the RPF determines the appropriate prescription to be applied to the area consistent with the California Forest Practice Rules.*

Very high prescription:

1) Steep streamside areas (see definition) including inner gorges on Class I and II watercourses in Bear, Pepperwood, Horse Collar, Chadd, High Rock, Jordan, Kiler, Twin, Dinner, Greenlaw, Stafford, Stitz, and Monument sub-basins and the portion of the Eel River mainstem sub-basin lying south of the river channel –
   a) Harvest – No harvest within 100 feet of Class I and Class II watercourses. The distance is measured from the watercourse transition line (HCP definition) or if present, the edge of the channel migration zone (CMZ) or the valley wall edge of "U" shaped channels (see definitions). If harvesting is proposed within the steep streamside area, between 100 to 200 feet (slope distance) from the watercourse, then an on-site geologic assessment shall be conducted by a California licensed geologist working with the RPF. On Class I waters, the minimum retention is 50% overstory canopy cover and 50% understory canopy covering the ground, and the post-harvest conifer canopy closure will not be reduced below an absolute value of 25%. On Class II waters, the minimum retention is the Special Hillslope Prescription Minimum Standard and must maintain or increase the QMD of the stand. The appropriate prescription shall be developed with due consideration of the risk of the resource. If harvesting is proposed within the steep streamside area, between 200 to 300 feet (slope distance) from the watercourse, then an on-site geologic assessment shall be conducted by a California licensed geologist working with the RPF. The appropriate prescription shall be developed with due consideration of the risk of the resource. If harvesting is proposed from 100 to 300 feet, then any required on-site geologic assessment will follow the procedures outlined in the CGS Note 45.

   b) Roads - If new road construction or reconstruction is proposed, an on-site geologic assessment is required and will follow the procedures outlined in the CGS Note 45. No new road construction or reconstruction will occur on any Class I inner gorge without review and approval by NOAA Fisheries and DFG.

2) Steep streamside areas including inner gorges on Class I and II watercourses in all other sub-basins in the LEED watershed –
   a) Harvest – No harvest within 100 feet of a Class I watercourse, and no harvest within 50 feet of a Class II watercourse. If harvesting is proposed between 100 to 200 feet on a Class I or between 50 to 200 feet on a Class II watercourse (slope distance) within the steep streamside area, then an on-site geologic assessment shall be conducted by a California licensed geologist working with the RPF. The appropriate prescription shall be developed with due consideration of the risk of the resource. On Class I watercourses, the final prescription developed must have a minimum retention of 50% overstory canopy cover and 50% understory canopy covering the ground, and the post-harvest conifer canopy closure will not be reduced below an absolute value of 25%. On Class II watercourses, the final prescription must follow the Special Hillslope Prescription Minimum Standard and must maintain or increase the QMD of the stand. From 100 to 150 feet on Class I watercourses with slope greater than 50% and from 50 to 125 feet on all Class II watercourses, if the

RMZ prescription is more conservative than the hillslope prescription, then the RMZ prescription applies.
b) If harvesting is proposed within the steep streamside area adjacent to Class I or II watercourses, between 200 to 300 feet (slope distance) from the watercourse, then an on-site geologic assessment shall be conducted by a California licensed geologist working with the RPF and the appropriate prescription developed with due consideration of the risk to the resource. If harvesting is proposed along a Class I from 100 to 300 feet, or in a Class II from 50 to 300 feet, then any required on-site geologic assessment will follow the procedures outlined in the CGS Note 45.
c) Roads - If new road construction or reconstruction is proposed, on-site geologic assessment is required and will follow the procedures outlined in the CGS Note 45. No new road construction or reconstruction will occur on any Class I inner gorge without review and approval by NOAA Fisheries and CDFG.

3) Class III watercourses
a) Harvest – On slopes greater than or equal to 50%, no timber harvest will be permitted unless on-site geologic assessment is conducted by a California licensed geologist working with the RPF and the appropriate prescription developed with due consideration of the risk to the resource. This geologic review zone shall extend from the bankfull width to the break-in-slope or to the hydrologic divide, whichever is less. If harvesting is proposed on these slopes adjacent to the Class III watercourse, then the required on-site geologic assessment will follow the procedures outlined in CGS Note 45.
b) While conducting the geologic review the geologist shall determine whether the proposed operations will result in a very high hazard. Specifically, the project geologist must determine whether the proposed timber operations have a reasonable potential to affect slope stability, and a potential for materials from landslides or unstable areas to affect public safety, water quality, fish habitat, or other environmental resources. If the proposed operations would result in a very high hazard then the Special Hillslope Minimum Prescription Standard shall be used.
c) Regardless of whether the Special Hillslope Minimum Prescription Standard is used, if the project geologist identifies supplemental recommendations that he/she deems necessary to mitigate the hazard associated with the proposed harvest, these recommendations shall be used.

4) Headwall Swales –
No timber harvest, road construction or reconstruction will be permitted unless on-site geologic assessment is conducted by a California licensed geologist working with the RPF and the appropriate prescription developed with due consideration of risk to the resource. The final prescription developed must include at least the Special Hillslope Prescription Minimum Standard post-harvest. In addition, a 25-foot buffer strip shall be flagged on the ground above the headwall swale. This buffer shall receive the same prescription that the headwall swale receives. Where appropriate, prescription development may include input from a fisheries biologist on potential biological impacts if a landslide were to occur.

5) Harvest on other identified very high hazard areas (including slopes greater than 60%)- No timber harvest will be permitted unless on-site geologic assessment is conducted by a California licensed geologist working with the RPF and the appropriate prescription developed with due consideration of risk to the resource. Where appropriate, prescription development may include input from a fisheries biologist on potential biological impacts if a landslide were to occur. The on-site geologic assessment will follow the procedures outlined in the CGS Note 45.

6) Road construction and reconstruction on other identified very high hazard areas - No road construction or reconstruction will be permitted unless on-site geologic assessment is conducted by a California licensed geologist working with the RPF and the appropriate prescription developed with due consideration of risk to the resource. Where appropriate, prescription development may include input from a fisheries biologist on potential biological impacts if a landslide were to occur. The on-site geologic assessment will follow the procedures outlined in the CGS Note 45. Other reference documents may be used as necessary and appropriate.

Definitions for this section:

1) Averaging Percent Slope – Average slopes over a 100 foot by 100 foot square block (i.e., 100 feet along streams by 100 feet inland). If slopes less than those that trigger a mass-wasting prescription exist from 0 to 100 feet, then the presence of steeper slopes beyond 100 feet do not trigger mass-wasting prescriptions specific to near stream areas. Other mass-wasting prescriptions such as slopes greater or equal to 60%, that result from the LEED Hillslope Management Checklist or geologic review, would apply. If slopes from 0 to 100 feet do trigger mass-wasting prescriptions associated with near stream areas, then any assessment of slopes beyond 100 feet will also be averaged using 100 foot by 100 foot blocks.

2) Headwall Swale- A concave slope, with convergent slopes of 50% or greater, that is connected to Class I, II, or III watercourses via a continuous linear depression (a linear depression interrupted by an active to dormant-young landslide deposit is considered continuous for this definition) (Concave, convergent slopes are a teardrop shaped depression in the hillside that lead directly to regulated watercourses).

3. Inner Gorge- A geomorphic feature formed by coalescing scars originating from landsliding and erosional processes caused by active stream erosion. The feature is identified as that area beginning immediately adjacent to the stream channel below the first break-in-slope.

4. QMD - The diameter at breast height of the tree of mean basal area in a population of trees greater than or equal to four inch DBH. A population of trees may consist of an unbiased sample or full census of a stand, or of an inventory stratum. Synonyms include quadratic mean diameter, basal-area-weighted-mean-DBH, DBAR, and DQMD.

5. Project Geologist – the California licensed geologist of record for the Timber Harvest Plan.

6. Special Hillslope Prescription Minimum Standard - A minimum of 150 square feet of average stand basal area would be maintained for any prescription (average stand basal area can be reduced by a maximum of 50%, or maintain a minimum of 150 square feet, whichever results in greater retention). Basal area will be determined on all trees four inches and larger at DBH as measured on a per acre basis through the silviculture selection zone.
   Retain a well distributed multistoried stand composed of a diversity of species similar to that found before the start of operations
   With due consideration to risk of resource, prescription analysis will include the appropriate resource specialist (e.g. fisheries or wildlife biologist). The on-site geologic assessment will follow the procedures outlined in the CGS Note 45. Other reference documents may be used as necessary and appropriate.

7. Steep streamside areas – In all sub-basins of Lower Eel and the Eel Delta except Scotia, areas adjacent to watercourses with a slope equal to or greater than 50%. In the Scotia sub-basin, areas adjacent to watercourses with a slope equal to or greater than 40%. In all cases, the steep streamside area ends with a break-in-slope (a break-in-slope is defined as a slope less than that of the feature (i.e., slopes $\geq$50% or $\geq$40%, as appropriate) for a distance of 100 feet or more).

8. U shaped channels - Except in the Eel River floodplain, watercourse reaches that have a U-shaped valley bottom including the area extending from immediately adjacent river terraces is a no harvest zone and the RMZ shall be measured from the valley-wall-edge. Within the Eel River floodplain, the HCP defined CMZ shall apply.

6.3.4.1.2 Class I RMZs

All fish bearing (or restorable) Class I watercourses will have an RMZ. The RMZ for Class I watercourses is divided into two bands, the inner band and the outer band. The width of the bands is based on slope distance. The inner band is 0 to 100 feet, and the outer band is 100 to 150 feet (Table 1), respectively, from the watercourse transition line, (HCP definition), or the outer edge of the CMZ (see below). Class I RMZ prescriptions may be modified as a result of watershed analysis re-visitation.

Prescriptions for the Entire Class I RMZ

1. The RMZ width shall be measured from the watercourse transition line (HCP definition) or if present, the outer CMZ edge on each side of the watercourse. Additionally, except in the Eel River floodplain, watercourse reaches that have a U-shaped valley bottom are a no-harvest zones, and the RMZ shall be measured from the valley-wall-edge including the area extending from immediately adjacent river terraces.
2. No sanitation salvage, exemption harvest, or emergency timber operations (as defined and allowed in the FPRs) shall occur in the RMZ, except as per prior agreement with the Wildlife Agencies.
3. All portions of downed wood (i.e., LWD), except as defined as slash in the FPRs, will be retained. Slash will be retained at those sites where it will contribute to soil stabilization and sediment filtration. Exceptions may be proposed in a THP and approved by the Wildlife Agencies.
4. Trees felled during current harvesting operations and THP-approved road construction are not considered downed wood for purposes of retention.
5. Felled hazard trees or snags not associated with a THP are considered downed wood and are to be retained in the general vicinity.
6. Trees that fall naturally onto roads, landings, or harvest units within the RMZ are considered downed wood and are to be retained in the general vicinity.
7. All non-hazard snags will be retained, as per the snag policy in the HCP.
8. The RMZ is an EEZ for timber operations, except for existing roads and permitted new road construction and equipment crossings.
9. Full suspension yarding will be used when feasible. Full suspension yarding is not feasible on flat ground, in other sites with limited deflection, where an adjacent landowner will not provide permission to secure a cable, or where a full suspension yarding system would jeopardize the safety of field personnel. For the purposes of this prescription, the expanded definition of feasibility according to the FPRs does not apply as an additional determination beyond that described above. For these conditions, yarding will be conducted in a manner that avoids ground disturbance that might deliver sediment to waters to the maximum extent practicable. Where ground disturbance occurs, PALCO will treat the site as per HCP 6.3.3.8 (revised April 14, 2003).

6.3.4.1.3 Class II RMZs

All Class II waters will have an RMZ as specified in Table 1. The RMZ will be measured from the watercourse transition line or the outer edge of the CMZ (see below). Class II RMZ prescriptions may be modified as a result of watershed analysis revisitation.

For the Class II seeps and springs containing southern torrent salamander habitat, the LEED Class II RMZ prescriptions apply. For other Class II seeps and springs, and for Class II waters situated within the prism of a road or landing, the prescriptions in the January 2004 Adaptive Management modifications to HCP sections 6.3.4.1.3 (d, e, and f) apply.

Prescriptions for the Entire Class II RMZ

1. The RMZ width[1] shall be measured from the watercourse transition line (HCP definition) or if present, the CMZ edge on each side of the watercourses.
2. No sanitation salvage, exemption harvest, or emergency timber operations (as defined and allowed in the FPRs) shall occur in the RMZ, except as per prior agreement with the Wildlife Agencies.
3. All portions of downed wood (i.e., LWD), except as defined as slash in the FPRs, will be retained. Slash will be retained at those sites where it will contribute to soil stabilization and sediment filtration. Exceptions may be proposed in a THP and approved by the Wildlife Agencies.
4. Trees felled during current harvesting operations and THP-approved road construction are not considered downed wood for purposes of retention.
5. Felled hazard trees or snags not associated with a THP are considered downed wood and are to be retained near the location of the removal.
6. Trees that fall naturally onto roads, landings, or harvest units within the RMZ are considered downed wood and are to be retained near the location of the removal.
7. All non-hazard snags will be retained, as per the snag policy in the HCP.
8. The RMZ is an EEZ for timber operations, except for existing roads and permitted new road construction and equipment crossings.
9. Full suspension yarding will be used when feasible. Full suspension yarding is not feasible on flat ground, in other sites with limited deflection, where an adjacent landowner will not provide permission to secure a cable, or where a full suspension yarding system would jeopardize the safety of field personnel. For the purposes of this prescription, the expanded definition of feasibility according to the FPRs does not apply as an additional determination beyond that described above. For these conditions, yarding will be conducted in a manner that avoids ground disturbance that might deliver sediment to waters

[1] RMZ width based on slope as shown in Table 1

to the maximum extent practicable. Where ground disturbance occurs, PALCO will treat the site as per HCP Section 6.3.3.8 (revised April 14, 2003).

10. Trees not marked for harvest may be felled within the RMZ to provide safety clearance for cable yarding corridors. Such felling will be done only as needed to ensure worker safety. In such cases, to the extent possible given site conditions and the FPRs, trees will be felled toward the waters to provide LWD and will be identified in THPs as an in lieu practice (14 CCR 916.1). Regardless, trees felled within the RMZ for safety purposes will be retained as downed wood.
11. Trees not marked for harvest which are damaged in the cable yarding corridors must be retained in place, either standing or as downed wood.
12. There will be a maximum of one entry every 20 years.
13. If any area within the RMZ is subject to mass wasting prescriptions, then the more restrictive of the RMZ and mass wasting prescriptions applies for that area.
14. Site preparation will be conducted according to HCP Section 6.3.4.2 (revised August 19, 2003).

Prescriptions for Class II Inner Band (0 to 50 feet in the North Eel and Eel Delta sub-basin groups and 0 to 100 feet in the South Eel sub-basin group)

1. Unless otherwise approved by the Wildlife Agencies, timber harvest will not occur within the inner band. This restriction includes sanitation salvage, exemption harvest, or emergency timber operations. For the purpose of adding LWD to the stream, or for the release of riparian stands for LWD to enhance development of trees capable of providing key-piece-sized LWD and future LWD recruitment, felling trees from within the 10 to 50 foot portion of the inner band will be allowed when approved by the Wildlife Agencies on a THP-by-THP basis in accordance with HCP Section 6.3.2.2 Item 7. Trees felled for these purposes are considered downed wood.
2. Road segments within the no-harvest band must be mitigated by extending the no-harvest band on the opposite side of the waters from the existing road an equivalent distance of that portion of the road prism within the no-harvest band. In the case of RMZ road crossings, the first 50 feet of road extending inland from the watercourse transition line is exempt from this mitigation.

Prescriptions for the Class II Outer Band, (in the North Eel and Eel Delta sub-basin groups, 50 to 125 feet)

1. The RMZ shall be clearly identified on the ground by the RPF who prepared the THP, or a supervised designee, with paint, flagging, or other suitable means prior to the preharvest inspection.

The specifics of this monitoring outline may be modified by agreement of PALCO and the Wildlife Agencies in the development of the detailed work plan for this monitoring program.

1. Streamside landslide monitoring

Objective: Monitor landslides in streamside areas to develop a better understanding of where they occur and what factors, such as geology, slope, landform, distance from watercourse, and management history affect their occurrence, size, and sediment delivery to streams.

Methods:

Part One

- The monitoring program will utilize the Forensic Landslide Investigation Standard Operating Procedures (Landslide SOP) developed by PALCO and the Wildlife Agencies.
- This Landslide SOP monitoring shall include both a helicopter survey and subsequent field review after each triggering event. The helicopter surveys shall include all Class I stream corridors on PALCO's ownership. In addition, helicopter surveys shall focus on quickly covering other portions of PALCO's ownership to identify slide sites. In addition, landslides identified during road inventories following triggering events will be incorporated into the monitoring. All fresh slide scarps will be noted and a representative sample, scheduled for on-site visits.
- Ground visits of identified slides will evaluate the following (many of these variables are already included in the Landslide SOP):
  - Depth of failure
  - Size of failure
  - Length of failure from head scarp
  - Estimate of the volume of sediment and LWD delivered to the watercourse
  - Vegetation and Seral stage of area surrounding failure
  - The landform where the failure occurred
  - Management features of area surrounding the failure (e.g., roads, landings, recent harvest, etc.)
  - Information that could help assign failure as management or non-management

Part Two

- The LEED Watershed Analysis identified small landslides as an important sediment source. This part of the monitoring program will be used to supplement information gathered in Part One, specifically to identify slides that are not visible in aerial surveys.
- The monitoring program will involve 10 or more survey reaches totaling 6,500 meters of stream length along Class I and II watercourses in Bear, Jordan, and Stitz Creek sub-basins, or whatever is agreed upon with the Wildlife Agencies.

- Sampled stream reaches will be selected to include a variety of Channel Geomorphic Units, with consideration of access and past landslide history also being used to select sites.
- Where such failures are observed, the field measurements and analysis will include all of the same variables included in Part One of the monitoring program. Within each sampled reach all visible shallow landslides will be mapped and measured during the first year after approval of the LEED Watershed Prescriptions.
- Subsequent surveys will focus on identifying new shallow landslides and/or reactivation of existing shallow landslides. The variables collected will include those listed in Part One.

Timeframe: Landslide SOP monitoring will occur following so called triggering events of greater than 3 inches of rainfall in 24 hours, or a significant earthquake in or near the LEED Watershed (significant to be agreed upon by PALCO, the Wildlife Agencies, and CGS). Field survey of selected river segments will occur 1 year, 3 years, and 5 years after adoption of the LEED Watershed Prescriptions.

Reporting: Provide all collected data and summary tables in a report to the Wildlife Agencies, in both electronic and hardcopy format with the annual report on June 1 of each year.

2. Class II temperature monitoring.

Objective:

- To develop a better understanding of water temperature conditions in Class II streams.

Methods:

- Monitor 10 Class II stream sites in warmer portions of the LEED watershed during each calendar year.
- At 5 sites each year, a continuously recording thermometer will be installed from June 1 to September 30 in Class II stream segments that do not have adjoining areas harvested within the past 15 years for at least 1,000 meters upstream from the monitoring site.
- At 5 sites each year, Class II streams passing through or adjacent to recently harvested areas will be selected. At such sites 1 continuously recording thermometer will be placed 100 meters upstream from the harvested area, and another immediately downstream from the harvested area to test for changes in water temperature. Such monitoring shall again extend from June 1 to September 30.

Timeframe: Monitoring for this component will be conducted annually for three years following approval of the LEED prescriptions.
Reporting: Provide all collected data, summary tables, analysis and QA/QC procedures to the Wildlife agencies with each annual report on June 1.

3. **Hillslope Monitoring** (Landslide SOP Monitoring) outlined here for the LEED Watershed is complemented by Hillslope Monitoring being conducted in Freshwater and by property-wide efforts. These efforts will help inform whether additional Hillslope Monitoring is needed in LEED, and if so, where and how to conduct such monitoring. In addition, monitoring in other watersheds or property-wide monitoring may indicate a need to modify the LEED prescriptions. Any additional monitoring or changes to prescriptions shall be developed by PALCO and the Wildlife Agencies.

4. **Scotia Sub basin Anomaly**

Of the 29 sub basins within the LEED, the Scotia sub basin indicated a significant number of streamside landslide originating on slopes greater than 40%. All other sub basins had a slope trigger of 50%. It has been suggested that this anomaly is the result of poor DEM's or other topographical errors.

With additional efforts within PALCO GIS department, and in conjunction with outside contractors (as necessary), PALCO will determine whether the lower slope trigger within the "Scotia" sub basin is justified or a simply a mapping error.

5. Stand Age Class Distribution

PALCO will monitor stand age classes in the Lower Eel sub-basins containing vegetation disturbance zones (see Map E-3 in the Channel Module) over the next 5 years. PALCO will work with the wildlife agencies to assess the distribution of these age classes, and their potential relationship to mass wasting, using methods to be jointly developed over the next year. This monitoring and assessment effort is not part of the LEED prescriptions but is a long term process that, in conjunction with the monitoring studies on mass wasting listed above, may be used to identify future approaches to reducing mass wasting events in the Lower Eel assessment areas.

REVISIONS TO

SECTION 6.3.3 "CONTROL OF SEDIMENT FROM ROADS AND OTHER SOURCES"

OF THE

MARCH 1999

HABITAT CONSERVATION PLAN (HCP)

FOR THE PROPERTIES OF HUMBOLDT REDWOOD COMPANY, LLC

August 1, 2011

6.3.3 Control of Sediment from Roads and Other Sources

6.3.3.1 Road Sediment Assessment and Planning (Revised August 1, 2011)

1. HRC shall assess the existing network of roads and associated sediment sources on its lands within ten years of the issuance of the ITP. Roads are defined for the purposes of Section 6.3.3 as including landings. Assessment of individual road segments shall be conducted within five years prior to the planned stormproofing. Road assessments will be conducted according to Pacific Watershed Associates protocols (HCP, Attachment 3) or a protocol proposed by HRC and approved by the Agencies. Initial road assessments must be completed for entire watersheds in the following order:

   -Elk River, Freshwater Creek, Lawrence Creek, Yager Creek (including Lower, North Fork, Middle, and South Fork), Van Duzen River, Middle Fork Eel River, Larabee/Sequoia Creek, Mattole River, Salmon Creek, Bear River.

2. Adjustments to the priority list above shall be made in consultation with the Wildlife Agencies.

3. HRC shall develop an annual road work plan. This plan shall include a prioritization and scheduling of stormproofing activities, a description of road work conducted in the previous year and road work anticipated to be conducted during the next 12 month period, beginning April 15. The plan shall also include maps and/or reports, as appropriate, with the following elements:

   3.1. Roads that have been closed or decommissioned,

   3.2. Locations of roads assessed and already stormproofed,

   3.3. Location, explanation, and justification of alternative measures undertaken in the previous year that result in less potential sediment delivery to Waters compared to prevention of diversion.

   3.4. Locations of roads anticipated to be stormproofed during the next 12-month period beginning May 1,

   3.5. Sites anticipated to be stormproofed and their priority ranking,

   3.6. Dates when roads were assessed according to Item 1, above,

   3.7. Locations of anticipated road construction and reconstruction,

   3.8. Roads that are anticipated to meet the standard of a permanent road, and

   3.9. Other information as appropriate.

   This annual plan shall be provided to the Signatory Agencies by April 15 for review. Stormproofing sites shall be prioritized as per Pacific Watershed Associates protocols (HCP, Attachments 3) or a protocol proposed by HRC and approved by the Agencies.

6.3.3.2 Road Stormproofing (Revised August 1, 2011)

1. Stormproofing will be completed on 750 miles within the first decade following issuance of the ITP and on an additional 750 miles in the second decade following issuance of the ITP. Stormproofing shall be completed at a minimum average rate of 75 miles per year. HRC can request that NMFS grant an exemption in writing from the requirement to maintain a minimum average of 75 miles per year based on lack of work time due to atypical summer wet weather patterns or the repair of an unusually high number of Water crossings. Such an exemption will be granted on showing of good cause. All stormproofing shall be completed within 20 years of the issuance of the ITP.

2. Roads shall be stormproofed according to the definition and criteria in Section 6.3.3.9 and to the standards identified in Weaver and Hagans (1994).

3. To the extent feasible, given logistics and the cost of moving equipment, HRC will stormproof the worst sites, i.e., those most likely to fail or deliver the greatest volume of sediment to Waters, in the first 10-year period following issuance of the ITP.

4. Stormproofing identified in and conducted as part of THPs shall count towards the yearly and per-decade totals. Stormproofing completed to the standards identified in Weaver and Hagans (1994) prior to issuance of the ITP shall also count towards the first decade totals. Roads that are closed or decommissioned according to the standards in Weaver and Hagans (1994) and that have the attributes presented under the definition of "stormproofed road" in Section 6.3.3.9 shall also be considered stormproofed and can be counted towards the yearly and per-decade totals.

5. Stormproofing conducted between May 1 and October 14, inclusive, shall not occur when saturated soil conditions exist within the hydrologically-connected road segment or when the Weather Forecast (defined in 6.3.3.9 Item 13) is a "chance" of precipitation equal to or greater than 30% on that day or as forecast for the next day, predicted on the

same-day early morning forecast. Operations shall cease and not resume as long as saturated soil conditions within the hydrologically-connected road segment are evidenced.

6. Stormproofing conducted between October 15 and April 30, inclusive, shall adhere to the conditions and measures defined in Section 6.3.3.3 Item 6.

7. Refueling of equipment and vehicles will be done outside of RMZs and Water crossings. Adding or draining lubricants, coolants, or hydraulic fluids will not be done in RMZs and Water crossings and all such fluids shall be properly disposed.

8. During and after stormproofing operations there shall be no resulting visible increase in turbidity in any receiving Class I, II, or III Waters.

9. When used in this Plan, the term stormproofing describes a process that involves the following elements:

   9.1. The assessments follow the Pacific Watershed Associates protocols (HCP, Attachment 3) or a protocol proposed by HRC and approved by the Agencies. A trained observer assesses a road segment and identifies actual or potential occurrences of erosion, slippage, mass wasting, blocked or perched culverts, or other sediment sources. The assessment documents, including but not limited to, instances of Humboldt crossings, unstable fill slopes for roads, Water crossings that have a moderate to high potential for culvert blockage and/or diversion of stream flows onto the road bed, insufficient drainage, and diversions of road drainage into Waters.

   9.2. The likelihood that each identified feature will deliver sediment to Waters shall also be evaluated as part of the road assessment, and the total volume of sediment that could be prevented from delivery to a Water is estimated.

   9.3. Based on the volume of sediment saved and the likelihood of delivery, sites are assigned a high, medium, or low priority and scheduled for corrective action based on a prescribed treatment plan. Corrective action typically requires an excavator, bulldozer, and one or more dump trucks to dig up and replace Water crossings, install drainage structures, remove unstable fill, alter the road bed to reduce the potential for diversion of flows on to the road surface, and install rolling dips and/or water bars to route water and sediment.

   9.4. Corrective action, if necessary, is completed, the road has the attributes of a stormproofed road, and the roads database and GIS layer is updated to show the road has been stormproofed.

6.3.3.3 Road Construction, Reconstruction, and Upgrades (Revised August 1, 2011)

1. Constructed and reconstructed roads shall:

   1.1. Meet specifications of a stormproofed road;

   1.2. Be single-lane width with periodic turnouts compatible with the type of equipment used in management operations and for which the road is built. Multi-lane roads may be permitted if explained and justified and if approved by the Wildlife Agencies following a 30 day review; and

   1.3. Have drainage facilities and structures installed at intervals along the road that are no greater than the guidelines in Table 20 of Weaver and Hagans (1994) and frequent enough to disperse road surface runoff so as to avoid gully formation and minimize erosion of the road surface, erosion of inside ditches and other drainage facilities, and erosion at the outfalls of drainage facilities and structures. Water captured by the road shall be diverted onto stable portions of the forest floor that dissipate energy, facilitate percolation, and avoid creating channelized flow or erosion of mineral soil that discharges to Waters.

      1.3.1. The drainage facility spacing guidelines in Table 20 of Weaver and Hagans (1994) shall not be exceeded except as provided in Item 1.3.2 below.

      1.3.2. In situations where conformance with the spacing requirements of Table 20 is not feasible due to throughcuts, some switchback scenarios, or would result in diverting concentrated runoff to unstable areas, a deviation from the guidelines in Table 20 may occur.

         1.3.2.1. Situations where such a deviation is necessary will be reviewed by a Registered Professional Forester or licensed geologist. Best Management Practices[1] for minimizing erosion and/or sediment delivery to Waters shall be implemented and maintained to function properly.

[1] Best Management Practices may include but are not limited to: installing effective erosion control measures; installing energy dissipaters and/or hillslope armoring at outlets of drainage facilities and structures; installing oversized culvert downspouts that are anchored to the culvert and hillslope; outsloping road segments.

1.3.2.2. Any other circumstances justifying exceptions (e.g., do more harm than good) to drainage facility guidelines will be documented and submitted to the Wildlife Agencies as soon as feasible after the work is done, and included in the Annual Road Plan.

2. All THP-related roads shall be upgraded, closed, or decommissioned.

   2.1. THP-related road upgrading, closure, or decommissioning shall result in sufficient sediment reduction in the planning watershed(s) to offset predicted sediment production from the THP. This requirement to offset sediment production will remain in effect until modified through or superseded by watershed analysis or adaptive management.

   2.2. Upgrading, closure, or decommissioning shall be completed no later than the time of filing of the THP report of completion of work with the Department of Forestry and Fire Protection. Sites identified as having signs of imminent failure shall be treated as soon as practical after THP approval.

3. Constructed and reconstructed Water crossings on fish-bearing and restorable fish-bearing Waters shall be designed, constructed, and maintained such that they shall allow for unrestricted passage of all life stages of fish. Where culverts are used, fish passage will be ensured by adhering to current crossing design standards developed by NMFS or DFG, or by review and approval of proposed alternate installation measures by NMFS or DFG.

4. Constructed and reconstructed roads shall be located outside RMZs except for RMZ crossings. Construction and reconstruction of roads within RMZs (and EEZs required by an associated steep slope provision) may occur if HRC submits information explaining and justifying why the proposed action would present levels of risk to aquatic resources at least equal to those presented under other feasible alternatives that are allowed under the HCP. Information explaining and justifying the proposed exception shall be provided to the Wildlife Agencies separate from the THP. The Wildlife Agencies shall have up to 60 days to determine if the exception will be allowed. This determination will be based on the likelihood of risk to aquatic resources and avoidance of significant adverse impacts compared with feasible alternatives allowable under the HCP. If any Wildlife Agency determines that the alternative will not be allowed, that Agency will work cooperatively with HRC and the other Wildlife Agencies to develop feasible alternative road locations and/or road specifications that will avoid significant impacts to aquatic resources.

5. No roads will be constructed or reconstructed across inner gorges, headwall swales, unstable areas, or areas having a high, very high, or extreme mass-wasting hazard rating, except as approved following the provisions of the hillslope management mass-wasting strategy in Section 6.3.3.7. Refer to Section 6.3.3.7 for road standards pre- and post-watershed analysis.

6. Construction, reconstruction (including, but not limited to, installation and removal of Water crossings), and upgrading of roads shall not occur during the wet weather period, defined for this purpose as October 15 to May 31, inclusive, unless each of the following conditions exist and measures are applied:

   6.1. Saturated soil conditions do not exist within the hydrologically-connected road segment, except as may occur on localized wet spots arising from emergent groundwater. Where such localized wet spots occur within proposed or existing hydrologically-connected road segments they shall be isolated concurrent with operations.

   6.2. Construction and reconstruction shall not cross an inner gorge, headwall swale, unstable area, extreme, very high, or high mass-wasting hazard area. Upgrading activities may occur in the above locations if equipment operations are limited to the road surface.

   6.3. Within the EEZ of Class I, II or III Waters the following measures shall be applied:

      6.3.1. Work will not be initiated on a day if the Weather Forecast (defined in 6.3.3.9 Item 13) is a "chance" of precipitation equal to or greater than 30% on that day, predicted on the same-day early morning forecast.

      6.3.2. Erosion control material of sufficient quantity shall be on-site or otherwise accessible (so as to be able to procure and apply that working day) before commencing construction, reconstruction and upgrading.

      6.3.3. Hydrologically-connected road segments shall be isolated prior to and concurrent with operations.

      6.3.4. Exposed mineral soil, except as defined in Section 6.3.3.8 Item 3, shall be treated with effective erosion control measures (1) at the end of the work day if the Weather Forecast (defined in 6.3.3.9 Item 13) is a "chance" of precipitation equal to or greater than 30% before or on the next day, (2) prior to weekend or other shutdown periods, and (3) upon completion of the project.

6.3.5. Roads shall be adequately drained to prevent saturated soil conditions caused by inadequate drainage of the road prism. Drainage measures shall be installed concurrent with described activities. An exception is that waterbreaks do not need to be constructed on roads in use, provided that waterbreaks are installed at the end of the work day, if the Weather Forecast (defined in 6.3.3.9 Item 13) is a "chance" of precipitation equal to or greater than 30% before or on the next day, and prior to weekend or other shutdown periods.

6.4. Construction, reconstruction (including, but not limited to, installation and removal of Water crossings), and upgrading of Class II and III Water crossings shall be subject to all of the following conditions and measures.

6.4.1. HRC shall submit a work plan to the Wildlife Agencies for proposed crossing construction or reconstruction (including, but not limited to, installation and removal of Water crossings). This submittal may be concurrent with application for a streambed alteration agreement. The work plan shall include a map depicting the location of proposed work and a written description that details the location, timing, type, and extent of work proposed. The Wildlife Agencies may require modification to the proposed work plan. HRC shall not carry out the proposed activity without approval of the Wildlife Agencies. The Wildlife Agencies shall have a maximum of 30 days to approve, approve with modifications, or deny the proposed work plan. The approved work plan shall be made enforceable under any applicable THP prior to the proposed activity occurring.

6.4.2. Work will not be initiated on a day if the Weather Forecast (defined in 6.3.3.9 Item 13) is a "chance" of precipitation equal to or greater than 30% on that day or as forecast for the next day, predicted on the same-day early morning forecast.

6.4.3. Waters shall be dry or have no more volume of water than can be effectively diverted around the work area by the shortest distance possible utilizing a 6 inch diameter pipe.

6.4.4. Erosion control material of sufficient quantity shall be stockpiled on-site or otherwise accessible (so as to be able to procure and apply that working day) before Water crossing installation and removal.

6.4.5. Any Water crossing installed shall be sized to accommodate the estimated 100-year flow.

6.4.6. All Water crossing construction, reconstruction, upgrading or removal work shall be conducted in one day. If equipment breakdowns prevent the completion of work in one day, work will be completed in the shortest period feasible.

6.5. Construction, reconstruction (including, but not limited to, installation and removal of Water crossings), and upgrading of Class I Water crossings shall be subject to all of the following conditions and measures.

6.5.1. HRC shall submit a work plan to the Wildlife Agencies for proposed crossing construction or reconstruction (including, but not limited to, installation and removal of Water crossings). This submittal may be concurrent with application for a streambed alteration agreement. The work plan shall include a map depicting the location of proposed work and a written description that details the location, timing, type, and extent of work proposed. The Wildlife Agencies may require modification to the proposed work plan. HRC shall not carry out the proposed activity without approval of the Wildlife Agencies. The Wildlife Agencies shall have a maximum of 30 days to approve, approve with modifications, or deny the proposed work plan. The approved work plan shall be made enforceable under any applicable THP prior to the proposed activity occurring.

6.5.2. Class I crossings shall not be constructed or reconstructed (including, but not limited to, installation and removal of Water crossings) after November 15 and prior to May 1.

6.5.3. Work will not be initiated on a day if the Weather Forecast (defined in 6.3.3.9 Item 13) is a "chance" of precipitation equal to or greater than 30% on that day or as forecast for the next day, predicted on the same-day early morning forecast.

6.5.4. All Water crossing construction, reconstruction, upgrading or removal work shall be conducted in one day. If equipment breakdowns prevent the completion of work in one day, work will be completed in the shortest period feasible.

6.5.5. Any crossing installed shall be sized to accommodate the estimated 100-year flow.

6.5.6. Prior to operations, on the day of the crossing installation, a qualified biologist shall survey for the presence of covered fish species and their redds within 100 feet upstream and 100 feet downstream from the crossing.

6.5.7. Crossings may be installed if covered fish species and their redds are not present within 100 feet upstream and 100 feet downstream from the crossing. If covered fish species or their redds are present the crossing may be installed only after consultation with and approval by the Wildlife Agencies.

6.5.8. If fill material needs to be placed within the channel or on the banks of the Water during bridge installation it shall be screened gravel, river run gravel, or logs or any combination thereof. Materials used as fill shall cause no siltation.

6.5.9. Low water bridges need not accommodate the estimated 100-year flow.

7. During and after construction, reconstruction, and upgrading there shall be no resulting visible increase in turbidity in any receiving Class I, II, or III Waters.
8. Refueling of equipment and vehicles will be done outside of RMZs and Water crossings. Adding, draining, or depositing lubricants, coolants, or hydraulic fluids will not be done in RMZs and Water crossings and all such fluids shall be properly disposed.
9. All applicable measures set forth in any associated Streambed Alteration Agreement shall be implemented.
10. A federal permit violation has not occurred if an activity that results in a unavoidable input of sediment to Waters occurs, even though all wet weather and construction, reconstruction and upgrade requirements were properly followed, in addition to all required erosion control measures being properly installed. This does not relieve HRC of any other requirements under other applicable federal and state laws.

6.3.3.4 Road Maintenance (Revised August 1, 2011)

1. Maintenance needs identified between May 1 and October 14, inclusive, will be performed prior to October 15.
2. Inboard ditches shall not be bladed or excavated except where blockage or insufficient capacity occurs.
3. Maintenance operations on non-paved roads shall cease when precipitation is sufficient to generate overland flow off the road surface in hydrologically-connected road segments. Maintenance shall not resume until such overland flow has abated and the road surface within hydrologically-connected road segments does not exhibit saturated soil conditions. This rule shall not prohibit vehicles from exiting the property.
4. During the wet weather period, defined as occurring between October 15 and May 31, inclusive, hydrologically-connected road segments shall be isolated prior to initiation of maintenance operations on any day when the Weather Forecast (defined in 6.3.3.9 Item 13) is a “chance” of precipitation equal to or greater than 30% on that day, predicted on the same-day early morning forecast, or when maintenance activities are likely to deposit mineral soil or road material over fill slopes of crossings. Effective erosion control measures shall be applied upon completion of maintenance operations. This requirement does not apply in emergency situations involving threats to human safety or road-related problems in the form of blocked culverts, imminent road fill failure, or other erosion problems which must be corrected to prevent or minimize significant adverse effects to the aquatic resource. Upon completion of emergency operations within hydrologically-connected road segments, effective erosion control measures shall be applied.
5. Refueling of equipment and vehicles will be done outside of RMZs and Water crossings. Adding, draining, or depositing lubricants, coolants, or hydraulic fluids will not be done in RMZs and Water crossings and all such fluids shall be properly disposed.

6.3.3.5 Road Inspections (Revised August 1, 2011)

1. All roads shall be inspected to identify maintenance needs at least once annually between May 1 and October 14, inclusive, to ensure that drainage structures and facilities are in proper condition. The Wildlife Agencies may exempt specific roads from inspection based on an evaluation of the risk of impacts caused by repair versus risk of impacts associated with failure or the timing of inspection completed prior to May 1.
2. All roads shall be inspected to identify maintenance needs, as soon as conditions permit, following any storm event that generates 3 inches or more of precipitation in a 24-hour period, as measured at the Scotia rain gauge. Multiple inspections during the winter period are encouraged. The Wildlife Agencies may waive this requirement based on the timing of the storm event in relation to the annual inspection period of May 1 to October 14, inclusive.
3. Roads that cannot be inspected, excluding those exempted by the Wildlife Agencies, during any one of the annual inspections between May 1 and October 14, inclusive, must be closed or decommissioned according to guidelines provided by Weaver and Hagans (1994). This work must be conducted within the same timeframe as stormproofing, as per HCP Section 6.3.3.2.

4. Closed and decommissioned roads shall be inspected after the first five-year storm event or five years after completion of work, whichever comes first, to ensure that treatments restore natural drainage and hillslope stability. If treatments have not restored natural drainage or hillslope stability, additional treatment shall occur if the volume of sediment prevented from entering a channel by additional treatment is greater than that incurred by re-entering the site. Additional treatments identified between May 1 and October 14, inclusive, shall be implemented prior to October 15. Additional treatments identified between October 15 and April 30, inclusive, shall be implemented between the next May 1 and October 14, inclusive, unless a lack of treatment constitutes an imminent threat to aquatic resources.

5. Documentation of annual inspection efforts will be provided to the Wildlife Agencies and CAL FIRE on the same schedule as the monitoring reports. Annual inspection logs will be made available to the Wildlife Agencies and CAL FIRE upon request.

6.3.3.6 Wet Weather Road Use Restrictions (Revised August 1, 2011)

1. All hauling (including logs, heavy equipment and/or rock), construction, reconstruction, and maintenance operations on non-paved roads shall cease when precipitation is sufficient to generate overland flow off the road surface in hydrologically-connected road segments. Use of the road shall not resume until such overland flow has abated and the road surface within hydrologically-connected road segments do not exhibit saturated soil conditions. This rule shall not prohibit vehicles from exiting the property. In addition, when road use ceases due to the above condition, log trucks at an active landing may be loaded and may exit the property. Log trucks returning to active landings when road use ceases due to the above condition shall be required to exit the property and shall not be loaded.

2. The wet weather period is defined as occurring between October 15 and May 31, inclusive.

3. On roads that do not meet the permanent standard, once hauling operations have ceased during the wet weather period due to Item 1, above, they shall not resume until June 1 or the road meets the permanent standard.

4. On roads that meet the permanent standard:

   4.1. Hauling operations during the wet weather period, in addition to complying with Item 1, above, shall cease when any of the following conditions exist:

      4.1.1. When previously hydrologically-disconnected road segments become hydrologically-connected road segments;

      4.1.2. When there is standing water within hydrologically-connected road segments;

      4.1.3. When equipment operation causes rutting to the extent that the ruts direct runoff from the road to discharge into a Water; or

      4.1.4. When equipment operation results in the transportation of sediment from hydrologically-disconnected road segments to hydrologically-connected road segments in amounts that result in a visible increase in turbidity in receiving Waters.

   4.2. When hauling operations during the wet weather period have ceased due to Item 4.1, above, they shall not resume until:

      4.2.1. All hydrologically-connected road segments have been isolated; and

      4.2.2. Maintenance has corrected the condition under Item 4.1, which resulted in cessation of hauling, and the road meets the permanent standard.

   4.3. When hauling operations during the wet weather period have ceased due to Item 4.1 above and hauling will not be resumed, then the road shall be returned to the upgraded standard as soon as practicable. If repairing damage requires heavy equipment, such that the effort would cause greater harm than good, then HRC shall treat the site with feasible effective erosion control measures as an interim measure.

5. During the wet weather period, all roads may be used by light vehicles (defined as vehicles with pay load ratings of 1 ton, or less, or smaller vehicles such as quadra-tracks or motorcycles). In addition, all roads may be used by water-tenders (maximum of three axles) providing support to prescribed fire operations undertaken as part of site preparation. If such use results in road-related damage within hydrologically-connected road segments to the road surface, drainage facilities, waterbreaks, or Water crossings, the damage will be repaired using hand tools prior to the end of the workday during which the initial damage occurred. Damage shall not be to such an extent that heavy equipment would be required for repairs.

6. Consistent with federal and state law and regulation, in order to prevent or minimize significant adverse effects to the aquatic resource, emergency access is allowed in order to correct emergency, road-related problems in the form of blocked culverts, imminent road fill failure, or other erosion problems, and emergency human life situations.

6.3.3.7 Hillslope Management (Revised February 22, 2006; updated August 1, 2011)

The hillslope management mass-wasting strategy applies to all portions of HRC's ownership, including the RMZs. The prescriptions in the RMZs for mass wasting will not be less restrictive than the riparian prescription developed as part of watershed analysis, as appropriate and applicable to this Plan. The hillslope management prescriptions may be modified as a result of watershed analysis.

1. Except as described below, HRC shall not harvest, including sanitation salvage, exemption harvest, and emergency timber operations, on mass-wasting areas of concern defined as areas of extreme mass-wasting hazard, very high mass-wasting hazard, high mass-wasting hazard, inner gorges, headwall swales, and unstable areas, including those within the RMZs on Class I, II, and III waters. This restriction may be modified as a result of watershed analysis.

   – Harvest may be permitted on mass wasting areas of concern (excluding inner gorges and headwall swales) located completely outside of 170-foot Class I and 130-foot Class II RMZs, provided a geologic analysis of the risk of hillslope failure has been conducted by a licensed geologist and concludes a low likelihood of the proposed timber operations resulting in increased potential for sediment delivery to Class I, II, or III waters. At minimum, the geologic analysis shall include assessment of the following environmental conditions relative to sediment delivery potential:

     - Geology/soil characteristics
     - Slope gradient
     - Slope morphology
     - Slope connectivity/continuity to nearest watercourse including distance
     - Potential failure type
     - Delivery of sediment by analogous features in the area
     - Absence/presence of emergent groundwater
     - Response to past management
     - Proposed management activity

2. Except as described below, HRC will not construct or reconstruct roads across mass-wasting areas of concern defined as areas of extreme mass-wasting hazard, very high mass-wasting hazard, high mass-wasting hazard, inner gorges, headwall swales and unstable areas, prior to watershed analysis.

   – Newly constructed and reconstructed roads (not including stormproofing) on mass-wasting areas of concern (defined above) may be permitted prior to watershed analysis if HRC provides the following:

     - A map of the mass-wasting areas of concern overlaid by all existing roads and all proposed new construction and reconstruction on a planning watershed scale for a one-year timeframe or longer
     - A geologic analysis of the risk of hillslope failure by the proposed new construction and reconstruction

   All the information will be provided to the wildlife agencies who will make a determination if all, some, or none of the proposed road construction or reconstruction will be permitted across the mass-wasting areas of concern. This determination will be based on the proposed road locations, road specifications, and the likelihood of avoidance of significant adverse impacts to covered species. The wildlife agencies will work cooperatively to provide consistent determinations to HRC within 60 days after receipt of the maps and geologic reports as described above. If any of the wildlife agencies determines that the proposed road construction/reconstruction will not be permitted, that agency will work cooperatively with HRC and the other wildlife agencies to develop feasible alternative road locations and/or road specifications or other access methods that will avoid significant impacts to covered species.

3. After watershed analysis, roads may be constructed or reconstructed across inner gorges, unstable areas, headwall swales, or areas having a high, very high, or extreme mass-wasting hazard rating if the watershed analysis indicates that roads across these areas are appropriate. This watershed analysis determination shall include, but is not limited to, an assessment of risk to the aquatic environment by qualified wildlife agency aquatic biologist(s) or aquatic biologists acceptable to the wildlife agencies. If the watershed analysis indicates that roads in these areas are

appropriate, the proposed roads and road specifications shall be evaluated, at the time of road design, by qualified professional geologist(s), including, but not limited to, certified engineering geologist(s) licensed by the state of California. The geologist(s) must make a determination that a road and the road specifications are sufficient to result in a stable road prism that is not likely to trigger or exacerbate mass wasting.

4. Road stormproofing, road closure, and road decommissioning of existing roads are acceptable and encouraged on the mass-wasting areas of concern (identified above).

5. Before and/or after watershed analysis, the mass-wasting areas of concern can be further defined on the ground (ground-truthed) with respect to the area boundaries (size) as part of individual THPs. This refinement shall be conducted by the California Geological Survey (CGS) or a qualified professional geologist, including but not limited to, certified engineering geologists licensed by the state of California.

6. The approximately 50,000-acre area that has not yet been characterized for mass wasting shall be treated in the interim, prior to characterization, as a mass-wasting area of concern and shall be correctly characterized with defined boundaries on a THP basis using the same process employed for the entire ownership or watershed analysis. The characterization will be conducted by CGS or a qualified professional geologist, including but not limited to, certified engineering geologists licensed by the state of California.

7. The wildlife agencies and HRC will jointly establish a mass-wasting scientific review panel (MWSRP) to evaluate the definitions of high, very high, and extreme mass-wasting areas of concern. The panel may modify the definitions. The high, very high, and extreme mass-wasting areas of concern will be redelineated for the entire ownership in accordance with any modified definitions.

8. The federal agencies, in consultation with state agencies, will provide a set of criteria to indicate whether mass-wasting events are to be considered significant for aquatic resources for use in the mass-wasting watershed analysis module.

9. Definitions of mass-wasting areas of concern:

   Inner Gorge—That area of a watercourse bank situated immediately adjacent to the watercourse channel, having side slope of 65 percent or greater and extending from the edge of the channel upslope to the first break-in-slope (a break-in-slope is defined as a slope less than 65 percent for a distance of 100 feet or more) above the watercourse channel.

   Unstable Area—Characterized by slide areas or by some or all of the following: hummocky topography consisting of rolling bumpy ground, frequent benches, and depressions; short irregular surface drainages that begin and end on the slope; tension cracks and head wall scarps; slopes that are irregular and may be slightly concave in the upper half and convex in the lower half from previous slope failure; evidence of impaired groundwater movement resulting in local zones of saturation within the soil mass which are indicated at the surface of sag ponds with standing water, springs, or patches of wet ground. Some or all of the following may be present: hydrophytic vegetation prevalent; leaning, jackstrawed, or split trees are common; pistol butted trees with excessive sweep may occur in areas of hummocky topography (leaning and pistol butted tress should be used as indicators of unstable areas only in the presence of other indicators).

   Headwall Swale—A concave depression, with convergent slopes of 65 percent or greater, that is connected to waters via a continuous linear depression (a linear depression interrupted by a landslide deposit is considered continuous for this definition).

   High, Very High, and Extreme Mass Wasting Hazard Areas—Refer to the July 1998 Draft HCP, Volume II, Part D, Landscape Assessment of Geomorphic Sensitivity for the sensitivity ratings and to Volume V, Map 13.

6.3.3.8 Measures to Minimize Surface Erosion in Riparian Areas (Revised August 1, 2011)

1. Within RMZs and EEZs, areas of mineral soil exceeding 100 contiguous square feet in size that have been exposed by forestry activities other than site preparation shall be treated with effective erosion control measures as defined in 6.3.3.9 Item 1. Treatment shall be completed prior to October 15, except that such bare areas created after October 14 and before June 1 shall be treated at the end of the work day if the Weather Forecast (defined in 6.3.3.9 Item 13) is a “chance” of precipitation equal to or greater than 30% before or on the next day as predicted on the same-day early morning forecast, and prior to weekend or other shutdown periods, and upon completion of the project. Areas

of exposed mineral soil resulting from site preparation operations shall be treated as per HCP Section 6.3.4.2.2 Item 13.

2. Within RMZs and EEZs, areas of mineral soil on hillslopes greater than 30 percent that have been exposed by forestry activities other than site preparation shall be treated with effective erosion control measures as defined in 6.3.3.9 Item 1. Treatment shall be completed prior to October 15, except that such bare areas created after October 14 and before June 1 shall be treated at the end of the work day if the Weather Forecast (defined in 6.3.3.9 Item 13) is a "chance" of precipitation equal to or greater than 30% before or on the next day as predicted on the same-day early morning forecast, and prior to weekend or other shutdown periods, and upon completion of the project. Areas of exposed mineral soil resulting from site preparation operations shall be treated as per HCP Section 6.3.4.2.2 Item 13.

3. The requirement to treat exposed mineral soil does not apply to the road surface or inside ditches. In addition, road cutslopes exceeding 65% do not need to be treated where straw mulch and/or seeding treatment measures are not feasible.

4. Cable corridors, firelines, and skid trails that divert or carry water away from the natural drainage pattern or channelize runoff such that it reaches Waters shall have waterbreaks installed at intervals per Section 914.6(c), Title 14, CCR.

6.3.3.9 Glossary of terms used in HCP Section 6.3.3 (Added August 11, 2004 and Revised August 1, 2011)

1. ***Effective Erosion Control Measures*** – are measures that prevent a visible increase in turbidity in receiving Class I, II, and III Waters and measures that minimize, to the extent feasible, the delivery of sediment to receiving Class I, II, and III Waters. These measures are maintained until the associated project site is no longer subject to surface erosion arising from exposure of bare mineral soil. Measures which the Wildlife Agencies find do not meet the above performance criteria shall not be considered effective erosion control measures.

2. ***Feasible*** – means capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, legal, social and technical factors.

3. ***Gully*** – An erosion channel, which is larger than 1 square foot in cross sectional area and is formed by concentrated surface runoff.

4. ***Hydrologically-Connected Road Segment*** – Is a road segment from which road runoff is delivered to a Water. These segments are typically located over Water crossings.

5. ***Hydrologically-Disconnected Road Segment*** – Is a road segment from which road runoff is not delivered to a Water. Hydrologically disconnecting a road segment is accomplished by the following: 1) installing drainage facilities and structures at sufficient intervals to minimize the volume of water being discharged from the road surface at any given point; 2) installing the last drainage facility up grade from the Water crossing where water can be discharged off the road without entering the Water via overland flow; and 3) diverting water that has been captured by the road onto stable portions of the forest floor that dissipates energy, facilitates percolation, and resists channelization.

6. ***Isolated*** – Is a condition (Treatment) in a hydrologically-connected road segment where effective erosion control measures are established prior to proposed operations and maintained concurrent with proposed operations. Examples of measures taken to isolate a hydrologically-connected road segment include, but are not limited to installation of silt fences, rock check dams in inside ditches, and hay bale filter traps. Areas requiring isolation typically occur at Water crossings.

7. ***Permanent Road*** –Is a road that has a surface adequate for hauling of forest products in non-wet weather periods, and in extended dry periods occurring during the wet weather period. A permanent road shall be an upgraded road and shall have a firm rocked, chipsealed, or paved surface on hydrologically-connected road segments, road segments within 150 feet of a Water, and road surface segments that drain to points within 150 feet of a Water. Operation of equipment shall not deform the surface such that hydrologically-disconnected road segments convey water to a hydrologically-connected road segment, or ruts in hydrologically-connected road segments direct runoff from the road to discharge into a Water, or there is standing water within a hydrologically-connected road segment (typically located over Water crossings). Permanent roads shall be maintained to minimize the delivery of fine sediment from their surfaces and drainage facilities during periods of operation specified in Section 6.3.3.6.

8. ***Road Maintenance*** – those road activities undertaken 1) to keep a safe and firm road surface and 2) to keep road drainage facilities, structures, fillslopes, and cutslopes in a condition to protect the road and minimize sediment

discharge to Waters. Examples of road maintenance include, but are not limited to, shaping and/or rocking a road surface, increasing the capacity of inboard ditches, removing blockages of inboard ditches, cross drains, or culverts, and repairing water bars.

9. ***Saturated Soil Conditions*** – means that soil and/or surface material pore spaces are filled with water to such an extent that runoff is likely to occur. Indicators of saturated soil conditions may include: (1) areas of ponded water, (2) pumping of fines from the soil or road surfacing material during timber operations, (3) loss of bearing strength resulting in the deflection of soil or road surfaces under a load, such as the creation of wheel ruts, (4) spinning or churning of wheels or tracks that produces a wet slurry, or (5) inadequate traction without blading wet soil or surfacing materials.

10. ***Stormproofed Road*** – Stormproofed roads shall be designed, constructed and maintained to minimize the delivery of fine sediment from roads and road drainage facilities to Waters, as well as to minimize, to the extent feasible, sediment discharge to Waters resulting from large magnitude, infrequent storms and floods. Stormproofed roads shall have all the attributes of an upgraded road and, at minimum, shall have all of the following additional attributes and shall have been treated, where necessary, as described in the following: (a) Unstable materials on fillslopes and cutbanks shall be stabilized or removed at all sites where field evidence indicates the material is subject to failure in the event of a storm (or flood) of low frequency and high magnitude. (b) Water crossings and associated fills and approaches shall be constructed or maintained to prevent diversion of flow down the road and to minimize erosion should the drainage structure become obstructed. Alternative measures that result in less potential sediment delivery to Waters compared to prevention of diversion may be undertaken if mapped, explained, and justified in the annual road plan. (c) Permanent Water crossings shall be sized to accommodate the estimated 100-year flood flow and to accommodate associated debris and sediment loads. A road shall be designated as stormproofed when it has been assessed using the Pacific Watershed Associates protocol (HCP, Attachment 3) or a protocol proposed by HRC and approved by the Wildlife Agencies, has been treated where necessary, has the attributes of a stormproofed road as described above, and the roads database and GIS have been updated to show that the subject roads have been stormproofed. The roads database and GIS shall disclose the extent of stormproofed road segments, and the dates when roads were assessed and treated.

11. ***THP-related roads*** – include: 1) roads within the THP boundary; and 2) roads that are appurtenant to the THP within the planning watershed(s) in which the THP is located. THP-related roads do not include those road segments within the THP boundary that are not used for timber operations and for which the risk of sediment discharge to Waters as a result of accessing and upgrading the road segments is greater than taking no action until the road is stormproofed.

12. ***Upgraded Road*** – An upgraded road is one that minimizes the amount of water delivered from the road drainage to Waters and shows no signs of imminent failure (e.g., as evidenced by slumping scarps or cracks in the road fill) that are likely to occur in the upcoming winter that could deliver sediment to a Water. An upgraded road shall have the following attributes and shall have been treated as described in the following: (a) The length of each hydrologically-connected road segment is minimized, to the extent feasible. (b) Except as provided in 6.3.3.3 Item 1.3.2, drainage facilities and structures shall be installed at intervals along the road that are no greater than the guidelines in Table 20 of Weaver and Hagans (1994) and frequent enough to disperse road surface runoff so as to avoid gully formation and minimize erosion of the road surface, erosion of inside ditches and other drainage facilities, and erosion at the outfalls of drainage facilities and structures. (c) Water captured by the road shall be diverted onto stable portions of the forest floor to dissipate energy and facilitate percolation to avoid creating channelized flow or erosion of mineral soil that discharges to Waters. (d) The surface of hydrologically-connected road segments shall be treated (e.g. with rock, chipseal or pavement) to avoid any visible increase in turbidity in Waters receiving runoff from the road surface of these road segments. (e) Upon removal, temporary crossings shall be excavated to form a channel that is as close as feasible to the natural channel grade and orientation, and that is wider than the natural channel to minimize bank and channel erosion. Excavated side slopes shall be are laid back to a 2:1(50%) or natural slope. (f) Unstable earth on fillslopes and cutbanks shall be stabilized or removed at sites showing signs of imminent failure that could deliver sediment to a Water. (g) Water crossings and associated fills and approaches shall be constructed or maintained to prevent diversion of flow down the road and to minimize erosion should the drainage structure become obstructed. Alternative measures that result in less potential sediment delivery to Waters compared to prevention of diversion may be undertaken if mapped, explained, and justified in the related THP (a reference to justification in the first exempted THP may be used for subsequent THPs).

13. ***Weather Forecast*** – The forecast from the Eureka, CA NOAA web site, using locations agreed upon by HRC and the wildlife agencies.

Water Quality Monitoring Summary for the Stitz Creek Watershed (1999-2018)

Humboldt Redwood Company

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Introduction

Long-term monitoring of fish-bearing (Class I) streams was initiated with adoption of the Habitat Conservation Plan (HCP) in 1999 with the goal to collect data to determine if salmonid habitat conditions across contemporary Humboldt Redwood Company (HRC) property meet, or are trending towards Aquatic Properly Functioning Condition (APFC). Current management activities by HRC are guided by the Aquatics Conservation Plan (ACP), part of the HCP, developed with state and federal agencies, and through various permits issued by the North Coast Regional Water Quality Control Board (NCRWQCB). Two Class I Aquatic Trends Monitoring (ATM) sites were established on HRC ownership in the Stitz Creek watershed in 1999. Both sites were selected with the advice and approval of HCP signatory agencies (NOAA Marine Fisheries and Department of Fish and Wildlife) and the NCRWQCB. The purpose of this document is to present methodology, summarize results, and discuss any trends observed in monitoring data collected since monitoring was instituted in the watershed.

Unlike *effectiveness* monitoring, *trend* monitoring is not specifically intended to evaluate specific management practices. Trend monitoring results may, over time, corroborate the findings of effectiveness monitoring, but are also strongly influenced and constrained by inherent watershed conditions and processes, apart from management, including drainage area, geology and geomorphology, topography, vegetation, and climate. Due to improvements in timber harvest practices required by the California Forest Practice Rules and HRC's HCP, recovery of aquatic habitat, where currently impaired, is expected to occur over time to the extent provided for by inherent watershed conditions. HRC's ATM program is designed to test this hypothesis as it tracks watershed trends over time.

Representative stream reaches included in the ATM program were chosen for a variety of factors that included access, distribution, gradient, percentage of HCP coverage in the watershed, and watershed interest. The basic design of this monitoring program is to repeatedly measure the habitat characteristics of stream reaches within the portion of watersheds most likely utilized by anadromous salmon (i.e. ≤ 4% gradient).

Stitz Creek is tributary to the Eel River south of Scotia, CA. The watershed (drainage area = ~10 km^2 [~4 mi^2]) is situated within the Lower Eel – Eel Delta (LEED) Watershed Analysis Unit (WAU). ATM habitat monitoring was conducted annually at two sites (ATM 171 and 172) within the watershed in 1999 and 2000 (Figure 1). Temperature monitoring was conducted at ATM-171 from 2004-2018 and at ATM-172 in 2016. Each monitoring reach is approximately 100 meters in length.

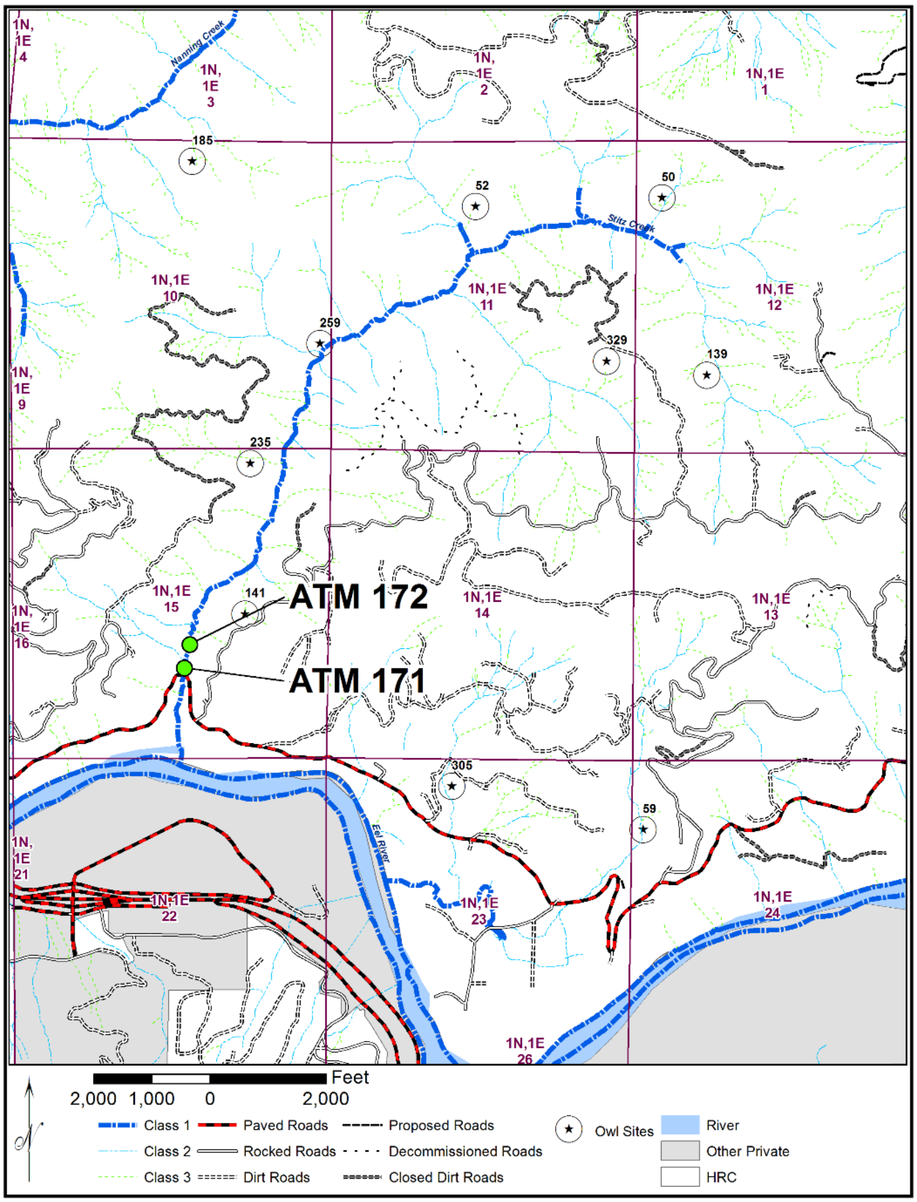


Figure 1. ATM stations 171 and 172, Stitz Creek, California

Methods and Result Summaries

Aquatic Trends Monitoring

Habitat parameters were measured in the summer of 2000 at both Stitz Creek ATM stations and stream temperature was monitored at ATM-171 from 2004-2018 (Tables 1 and 2). Data from these habitat surveys were compiled into simplified summary "report card" style tables used in the ATM reports submitted annually to all HCP signatory agencies. Habitat values are measured against Aquatic Properly Functioning Conditions (APFC) targets for stream and riparian characteristics, established by both state and federal agencies in 1997. HRC simplifies the presentation of habitat status by color-coding the values within the report cards into four categories:

- **Blue:** Habitat conditions meet APFC target criteria
- **White:** Habitat conditions do not meet APFC target criteria
- **Green:** There are currently no established APFC criteria to measure against
- **Grey:** There were no data collected for this parameter

Bed surface sampling data were utilized to construct a cumulative frequency plot with the corresponding relative frequency distribution of streambed particle sizes within each ATM station (See HRC SOP-13, *Surface and subsurface stream sediment sampling*, for detailed methodology). These analyses assess patterns of coarsening or fining in streambed substrate and are considered the current baseline for future comparison (Figure 2).

Physical measurements of pools were conducted to assess dimensions, abundance (i.e. the percentage of channel length comprised of pools), and association with large woody debris (LWD) (See HRC SOP-14, *Stream habitat typing and measurement*, for detailed methodology). Stream temperature is the longest continuously-monitored habitat parameter on record in Stitz Creek (See HRC SOP-09, *Temperature instrumentation and deployment*, for detailed methodology), with ten years of data at ATM-171 and one year at ATM-172 (Figure 3). Stream temperature (˚C) is recorded during the warmest part of the year (typically June through September) using continuous recording data loggers (Onset HOBO® Water Temp Pro v2).

Temperature data are used to calculate the maximum weekly average temperature (MWAT), or the average of the daily mean temperature measured during the warmest seven consecutive days each year. The APFC target value for MWAT is ≤16.8 ˚C.

Table 1. Habitat parameters measured at Stitz Creek ATM-171 (2000-2018)

ATM 171 Stitz Creek	Parameter	Target Value (# no target)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Bed Surface	D_{84} (mm)	#	79																		
	D_{50} (mm)	65-95	22																		
	D_{16} (mm)	#	<1																		
	D_5 (mm)	#	<1																		
Pool Characteristics	Pool Area (%)	≥25	64																		
	Pool Spacing (CW/pool)	≤6	3																		
	Residual Pool Depth (m)	≥.91	0.47																		
	Pools Assoc. w/wood (%)	≥50	86																		
Large Woody Debris	Total Piece Frequency (#/100 ft)	≥5.1																			
	Total Piece Count	#																			
Water Temperature	MWAT (°C)	≤16.8					17.9	16.6	17.1	17.3	16.3	16.0	14.8	15.3						16.8	15.8
Riparian Overstory	Canopy Over Stream (%)	≥90																			
	Canopy of Rip Forest (%)	≥85																			

Table 2. Habitat parameters measured at Stitz Creek ATM-172 (2000)

ATM 172 Stitz Creek	Parameter	Target Value (# no target)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Bed Surface	D_{84} (mm)	#	14																
	D_{50} (mm)	65-95	5																
	D_{16} (mm)	#	<1																
	D_5 (mm)	#	<1																
Pool Characteristics	Pool Area (%)	≥25	31																
	Pool Spacing (CW/pool)	≤6	2																
	Residual Pool Depth (m)	≥.91	0.25																
	Pools Assoc. w/wood (%)	≥50	75																
Large Woody Debris	Total Piece Frequency (#/100 ft)	≥5.1	1.9																
	Total Piece Count	#	169																
Water Temperature	MWAT (°C)	≤16.8																	15.80
Riparian Overstory	Canopy Over Stream (%)	≥90																	
	Canopy of Rip Forest (%)	≥85																	

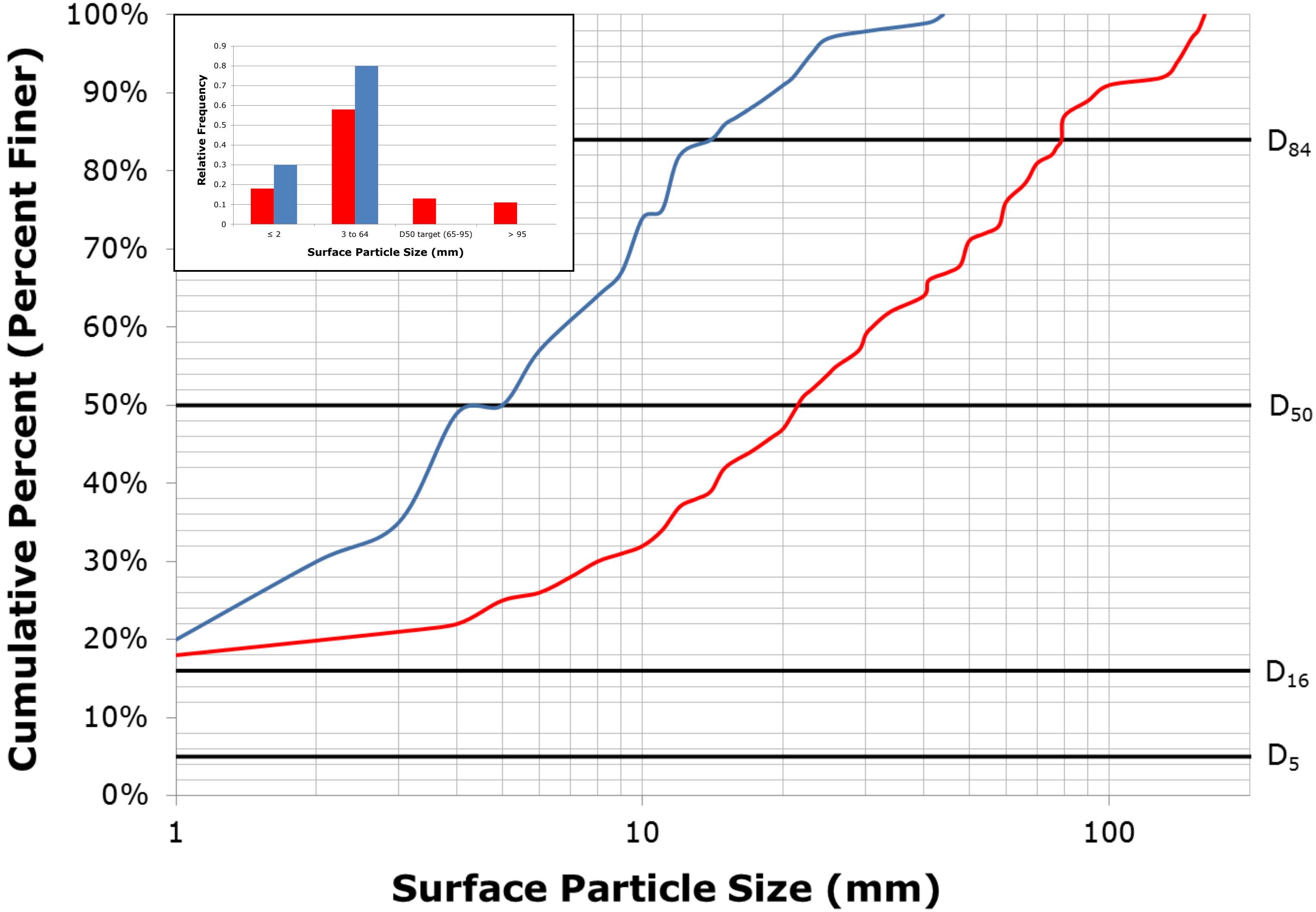


Figure 2. Cumulative percent (percent finer) and corresponding relative frequency distribution (insert) of surface substrate particle sizes at ATM-171 (red) and ATM-172 (blue) in Stitz Creek, 2000

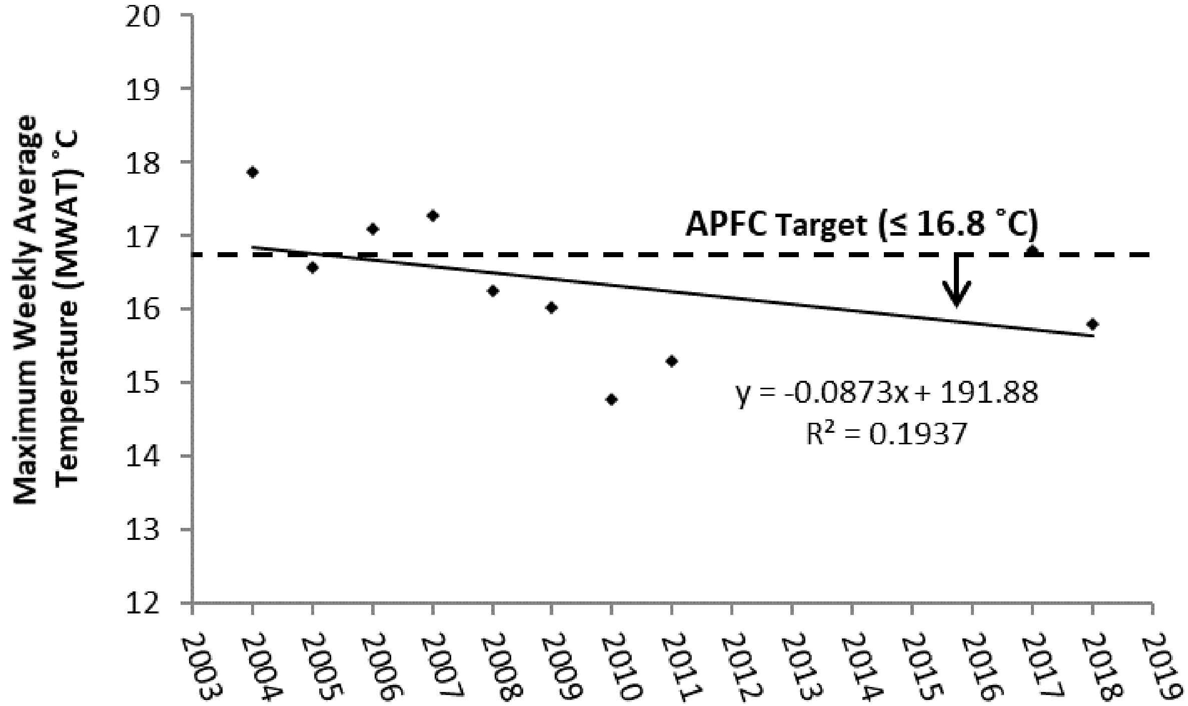


Figure 3. MWAT records at ATM-171 suggest a trend towards the APFC target for stream temperature in Stitz Creek (2004-2018)

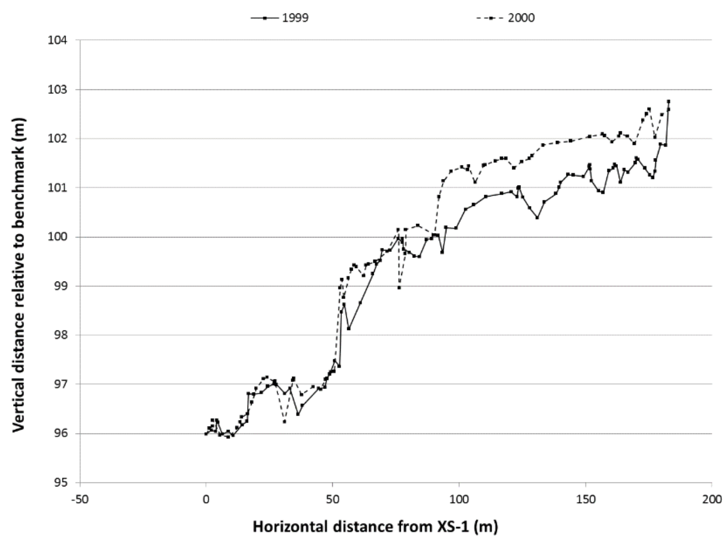
Biological Sampling and Habitat Inventory

Three surveys were conducted in Stitz Creek to document fish presence and/or quantify available salmonid habitat. The first survey, conducted in 1992 by the California Department of Fish and Game (DFG) as part of the North Coast Basin Planning Project (BPP), documented the presence of steelhead (*Oncorhynchus mykiss*), quantified available fish habitat, and identified a number of "problem sites" within the channel including road crossing(s) and log jams. The second survey, conducted in 2000 by Pacific Lumber Company (PALCO) field technicians, documented cutthroat trout (*Oncorhynchus clarki clarki*) and steelhead presence by electrofishing upstream of the 11 foot falls formed by the culvert crossing Shively Road. The third survey, conducted in 2010 by members of the Americorps Watershed Stewards Project (WSP) under the guidance of DFG, documented current habitat conditions and recommend potential habitat enhancement options for anadromous salmonids. The WSP survey also documented salmonid presence throughout the surveyed reach which extended approximately 3,300 feet upstream from the Eel River confluence.

All three surveys verified fish presence upstream of the Shively Road crossing. The culvert structure was identified as a candidate for modification in order to improve fish passage and is currently considered an anadromous barrier, though there remains a viable resident population of trout successfully reproducing upstream. Although the available fish habitat upstream of Shively Road is currently limited to resident salmonids, it was recommended that Stitz Creek be managed as an anadromous, natural production stream. Other fish species documented in Stitz Creek in 2010 included three-spined stickleback (*Gasterosteus aculeatus*), California roach (*Lavinia symmetrics*), and Sacramento pike minnow (*Ptychocheilus grandis*).

Streambed Elevation Surveys

A long profile thalweg survey was conducted within ATM-171 in 1999 and 2000 (Figure 4). The survey follows standard HRC operating procedures (see HRC SOP-31, *Survey with a total station*, for detailed methodology) extended approximately 180 meters beginning at the downstream extent of the ATM reach. Proceeding upstream, the position of the thalweg was established at each break between riffles and pools and within the deepest part of each pool. One cross-section (XS-1) was measured at the lowest point of the thalweg profile during each of the two survey years (Figure 5). Cross-sectional area was determined below a reference elevation typically set at a channel feature associated with bankfull depth.



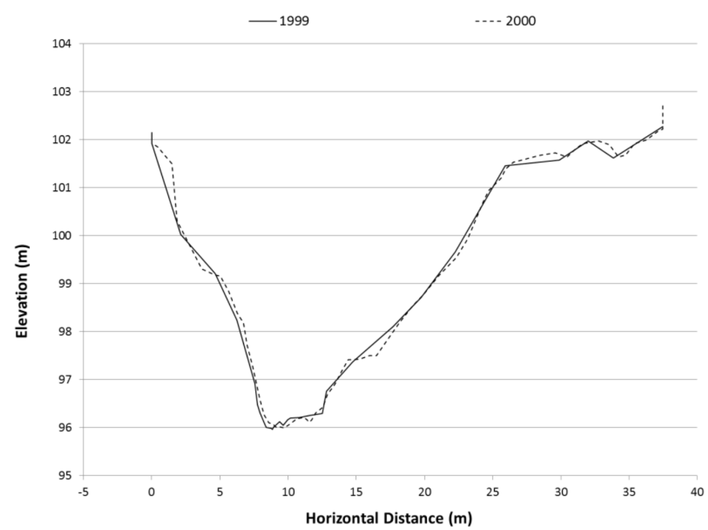


Figure 5. Long profile thalweg survey (above) and cross-section survey (below) data for Stitz Creek ATM-171, 1999-2000

Discussion

Given the limited scope of data collection, trends in habitat and stream morphology are difficult to assess in Stitz Creek. Pool area and pool wood association appeared to be sufficient in 2000 while other habitat parameters did not meet APFC targets that were established at that time. More data are available regarding water temperature and these measurements suggest favorable conditions in the watershed.

From 1999-2000 streambed elevations in lower portions of Stitz Creek aggraded towards the upper extent of the survey profile and remained fairly stable in the lower extent. Data from cross-section 1 reinforces the latter observation as very little change was measured during the same period. Thalweg and cross-sectional profiles were discontinued in 2000 due to access issues and the high abundance of large wood in the channel.

Based on the physical and biological data collected since 1992, the Stitz Creek watershed appears to provide sufficient habitat conditions which support a viable population of resident steelhead and cutthroat trout. Anadromy is currently limited to the lower stream reaches downstream of the Shively Road crossing. However, anadromy may be restored to the upper watershed through proper design and modification of the current road crossing. The extent to which anadromous fish might utilize the upper watershed is unknown due to relatively small surface substrate particle sizes, gradient limitations, and the presence of multiple LDAs (large woody accumulations).

References

PALCO, 1999. Habitat Conservation Plan §6.3.5.3 Class I Aquatic Trend Monitoring Program.

HRC, 2004. Aquatic trends monitoring site selection, monumenting and documentation, SOP-15, Humboldt Redwood Company, Scotia, CA.

HRC, 2004. Stream and riparian canopy cover measurement, SOP-12, Humboldt Redwood Company, Scotia, CA.

HRC, 2004. Stream habitat typing and measurement, SOP-14, Humboldt Redwood Company, Scotia, CA.

HRC, 2004. Surface and subsurface stream sediment sampling, SOP-13, Humboldt Redwood Company, Scotia, CA.

HRC, 2004. Temperature instrumentation and deployment, SOP-09, Humboldt Redwood Company, Scotia, CA.

HRC, 2005. Survey with total station, SOP-31, Humboldt Redwood Company, Scotia, CA.

STREAM INVENTORY REPORT

Stitz Creek

INTRODUCTION

A stream inventory was conducted July 29, 2010 on Stitz Creek. The survey began at the confluence with Eel River and extended upstream 0.6 miles.

The Stitz Creek inventory was conducted in two parts: habitat inventory and biological inventory. The objective of the habitat inventory was to document the habitat available to anadromous salmonids in Stitz Creek. The objective of the biological inventory was to document the presence and distribution of juvenile salmonid species.

The objective of this report is to document the current habitat conditions and recommend options for the potential enhancement of habitat for Chinook salmon, coho salmon, and steelhead trout. Recommendations for habitat improvement activities are based upon target habitat values suitable for salmonids in California's north coast streams.

WATERSHED OVERVIEW

Stitz Creek is a tributary to Eel River, which drains to the Pacific Ocean, located in Humboldt County, California (Map 1). Stitz Creek's legal description at the confluence with Eel River is T01N R01E S15. Its location is 40.4605 north latitude and 124.0535 west longitude, LLID number 1240523404607. Stitz Creek is a first order stream and has approximately 3.3 miles of blue line stream according to the USGS Scotia 7.5 minute quadrangle. Stitz Creek drains a watershed of approximately 4.0 square miles. Elevations range from about 67 feet at the mouth of the creek to 1,000 feet in the headwater areas. Mixed conifer forest dominates the watershed. The watershed is privately owned and is managed for timber production. Vehicle access exists via Highway 101 to Shively Road.

METHODS

The habitat inventory conducted in Stitz Creek follows the methodology presented in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al, 1998). The Watershed Stewards Project/AmeriCorps (WSP) Members that conducted the inventory were trained in standardized habitat inventory methods by the California Department of Fish and Game (DFG). This inventory was conducted by a two-person team.

SAMPLING STRATEGY

The inventory uses a method that samples approximately 10% of the habitat units within the survey reach. All habitat units included in the survey are classified according to habitat type and their lengths are measured. All pool units are measured for maximum depth, depth of pool tail crest (measured in the thalweg), dominant substrate composing the pool tail crest, and embeddedness. Habitat unit types encountered for the first time are measured for all the parameters and characteristics on the field form. Additionally, from the ten habitat units on each field form page, one is randomly selected for complete measurement.

HABITAT INVENTORY COMPONENTS

A standardized habitat inventory form has been developed for use in California stream surveys and can be found in the *California Salmonid Stream Habitat Restoration Manual*. This form was used in Stitz Creek to record measurements and observations. There are eleven components to the inventory form.

1. Flow:

Flow is measured in cubic feet per second (cfs) near the bottom of the stream survey reach using a Marsh-McBirney Model 2000 flow meter.

2. Channel Type:

Channel typing is conducted according to the classification system developed and revised by David Rosgen (1994). This methodology is described in the *California Salmonid Stream Habitat Restoration Manual*. Channel typing is conducted simultaneously with habitat typing and follows a standard form to record measurements and observations. There are five measured parameters used to determine channel type: 1) water slope gradient, 2) entrenchment, 3) width/depth ratio, 4) substrate composition, and 5) sinuosity. Channel characteristics are measured using a clinometer, hand level, hip chain, tape measure, and a stadia rod.

3. Temperatures:

Both water and air temperatures are measured and recorded at every tenth habitat unit. The time of the measurement is also recorded. Both temperatures are taken in degrees Fahrenheit at the middle of the habitat unit and within one foot of the water surface.

4. Habitat Type:

Habitat typing uses the 24 habitat classification types defined by McCain and others (1990). Habitat units are numbered sequentially and assigned a type identification number selected from a standard list of 24 habitat types. Dewatered units are labeled "dry". Stitz Creek habitat typing used standard basin level measurement criteria. These parameters require that the minimum length of a described habitat unit must be equal to or greater than the stream's mean wetted width. All measurements are in feet to the nearest tenth. Habitat characteristics are measured using a clinometer, hip chain, and stadia rod.

5. Embeddedness:

The depth of embeddedness of the cobbles in pool tail-out areas is measured by the percent of the cobble that is surrounded or buried by fine sediment. In Stitz Creek, embeddedness was ocularly estimated. The values were recorded using the following ranges: 0 - 25% (value 1), 26 - 50% (value 2), 51 - 75% (value 3) and 76 - 100% (value 4). Additionally, a value of 5 was assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate like bedrock, log sills, boulders or other considerations.

6. Shelter Rating:

Instream shelter is composed of those elements within a stream channel that provide juvenile salmonids protection from predation, reduce water velocities so fish can rest and conserve energy, and allow separation of territorial units to reduce density related competition for prey. The shelter rating is calculated for each fully-described habitat unit by multiplying shelter value and percent cover. Using an overhead view, a quantitative estimate of the percentage of the habitat unit covered is made. All cover is then classified according to a list of nine cover types. In Stitz Creek, a standard qualitative shelter value of 0 (none), 1 (low), 2 (medium), or 3 (high) was assigned according to the complexity of the cover. Thus, shelter ratings can range from 0-300 and are expressed as mean values by habitat types within a stream.

7. Substrate Composition:

Substrate composition ranges from silt/clay sized particles to boulders and bedrock elements. In all fully-described habitat units, dominant and sub-dominant substrate elements were ocularly estimated using a list of seven size classes and recorded as a one and two, respectively. In addition, the dominant substrate composing the pool tail-outs is recorded for each pool.

8. Canopy:

Stream canopy density was estimated using modified handheld spherical densiometers as described in the *California Salmonid Stream Habitat Restoration Manual*. Canopy density relates to the amount of stream shaded from the sun. In Stitz Creek, an estimate of the percentage of the habitat unit covered by canopy was made from the center of approximately every third unit in addition to every fully-described unit, giving an approximate 30% sub-sample. In addition, the area of canopy was estimated ocularly into percentages of coniferous or hardwood trees.

9. Bank Composition and Vegetation:

Bank composition elements range from bedrock to bare soil. However, the stream banks are usually covered with grass, brush, or trees. These factors influence the ability of stream banks to withstand winter flows. In Stitz Creek, the dominant composition type and the dominant vegetation type of both the right and left banks for each fully-described unit were selected from the habitat inventory form. Additionally, the percent of each bank covered by vegetation (including downed trees, logs, and rootwads) was estimated and recorded.

10. Large Woody Debris Count:

Large woody debris (LWD) is an important component of fish habitat and an element in channel forming processes. In each habitat unit all pieces of LWD partially or entirely below the elevation of bankfull discharge are counted and recorded. The minimum size to be considered is twelve inches in diameter and six feet in length. The LWD count is presented by reach and is expressed as an average per 100 feet.

11. Average Bankfull Width:

Bankfull width can vary greatly in the course of a channel type stream reach. This is especially true in very long reaches. Bankfull width can be a factor in habitat components like canopy density, water temperature, and pool depths. Frequent measurements taken at riffle crests (velocity crossovers) are needed to accurately describe reach widths. At the first appropriate velocity crossover that occurs after the beginning of a new stream survey page (ten habitat units), bankfull width is measured and recorded in the appropriate header block of the page. These widths are presented as an average for the channel type reach.

BIOLOGICAL INVENTORY

Biological sampling during the stream inventory is used to determine fish species and their distribution in the stream. Fish presence was observed from the stream banks in Stitz Creek. In addition, underwater observations were made at 11 sites using techniques discussed in the *California Salmonid Stream Habitat Restoration Manual*.

DATA ANALYSIS

Data from the habitat inventory form are entered into Stream Habitat 2.0.19, a Visual Basic data entry program developed by Karen Wilson, Pacific States Marine Fisheries Commission in conjunction with the California Department of Fish and Game. This program processes and summarizes the data, and produces the following ten tables:

- Riffle, Flatwater, and Pool Habitat Types
- Habitat Types and Measured Parameters
- Pool Types
- Maximum Residual Pool Depths by Habitat Types
- Mean Percent Cover by Habitat Type
- Dominant Substrates by Habitat Type
- Mean Percent Vegetative Cover for Entire Stream
- Fish Habitat Inventory Data Summary by Stream Reach (Table 8)
- Mean Percent Dominant Substrate / Dominant Vegetation Type for Entire Stream
- Mean Percent Shelter Cover Types for Entire Stream

Stitz Creek

Graphics are produced from the tables using Microsoft Excel. Graphics developed for Stitz Creek include:

- Riffle, Flatwater, Pool Habitat Types by Percent Occurrence
- Riffle, Flatwater, Pool Habitat Types by Total Length
- Total Habitat Types by Percent Occurrence
- Pool Types by Percent Occurrence
- Maximum Residual Depth in Pools
- Percent Embeddedness
- Mean Percent Cover Types in Pools
- Substrate Composition in Pool Tail-outs
- Mean Percent Canopy
- Dominant Bank Composition by Composition Type
- Dominant Bank Vegetation by Vegetation Type

HABITAT INVENTORY RESULTS

* ALL TABLES AND GRAPHS ARE LOCATED AT THE END OF THE REPORT *

The habitat inventory of July 29, 2010, was conducted by S. McSmith (DFG), C. Saeland (CCC) and B. Williams (WSP). The total length of the stream surveyed was 3,257 feet with an additional 145 feet of side channel.

Stream flow was measured near the bottom of the survey reach with a Marsh-McBirney Model 2000 flowmeter at 0.52 cfs on July 29, 2010.

Stitz Creek is a G2 channel type for 3,257 feet of the stream surveyed. G2 channels are entrenched "gully" step-pool channels on moderate gradients with low width /depth ratios and boulder-dominant substrates.

Water temperatures taken during the survey period ranged from 56 to 60 degrees Fahrenheit. Air temperatures ranged from 56 to 72 degrees Fahrenheit.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of occurrence there were 39% pool units, 31% riffle units, 24% flatwater units, 4% no survey units, 1% culvert units, and 1% dry units (Graph 1). Based on total length of Level II habitat types there were 31% flatwater units, 32% riffle units, 27% pool units, 4% culvert units, 3% dry units, and 3% no survey units (Graph 2).

Nine Level IV habitat types were identified (Table 2). The most frequent habitat types by percent occurrence were mid-channel pool units, 31%; low gradient riffle units, 24%; and run units 12% (Graph 3). Based on percent total length, low gradient riffle units made up 27%, mid-channel pool units 24%, and step run units 20%.

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A total of 31 pools were identified (Table 3). Main channel pools were the most frequently encountered at 81% (Graph 4), and comprised 87% of the total length of all pools (Table 3).

Table 4 is a summary of maximum residual pool depths by pool habitat types. Pool quality for salmonids increases with depth. Ten of the 31 pools (32%) had a residual depth of two feet or greater (Graph 5).

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 31 pool tail-outs measured, 2 had a value of 2 (6.5%); 13 had a value of 3 (41.9%); 9 had a value of 4 (29%); 7 had a value of 5 (22.6%) (Graph 6). On this scale, a value of 1 indicates the best spawning conditions and a value of 4 the worst. Additionally, a value of 5 was assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate such as bedrock, log sills, boulders, or other considerations.

A shelter rating was calculated for each habitat unit and expressed as a mean value for each habitat type within the survey using a scale of 0-300. Riffle habitat types had a mean shelter rating of 17, flatwater habitat types had a mean shelter rating of 20, and pool habitats had a mean shelter rating of 19 (Table 1). Of the pool types, the scour pools had the highest mean shelter rating at 22. Main channel pools had a mean shelter rating of 18 (Table 3).

Table 5 summarizes mean percent cover by habitat type. Boulders are the dominant cover type in Stitz Creek. Graph 7 describes the pool cover in Stitz Creek. Large woody debris is the dominant pool cover type followed by boulders.

Table 6 summarizes the dominant substrate by habitat type. Graph 8 depicts the dominant substrate observed in pool tail-outs. Gravel was the dominant substrate observed in 61% of the pool tail-outs. Large cobble was the next most frequently observed dominant substrate type and occurred in 16% of the pool tail-outs.

The mean percent canopy density for the surveyed length of Stitz Creek was 82%. Eighteen percent of the canopy was open. Of the canopy present, the mean percentages of hardwood and coniferous trees were 57% and 43%, respectively. Graph 9 describes the mean percent canopy in Stitz Creek.

For the stream reach surveyed, the mean percent right bank vegetated was 98%. The mean percent left bank vegetated was 99%. The dominant elements composing the structure of the stream banks consisted of 95% sand/silt/clay and 5% bedrock (Graph 10). Coniferous trees were the dominant vegetation type observed in 43.4% of the units surveyed. Additionally, 42.1% of the units surveyed had deciduous trees as the dominant vegetation type, and 14.5% had brush as the dominant vegetation type (Graph 11).

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BIOLOGICAL INVENTORY RESULTS

Survey teams conducted a snorkel survey at 11 sites for species composition and distribution in Stitz Creek on August 2, 2010. The sites were sampled by S. McSmith (DFG), and B. Williams (WSP).

The reach sites yielded 18 young-of-the-year steelhead/rainbow trout (SH/RT), 8 age 1+ SH/RT, 2 age 2+ SH/RT, 25 unidentified salmonids, 50 stickleback, 75 California roach, and 4 Sacramento pikeminnow.

The following chart displays the information yielded from these sites:

2010 Stitz Creek underwater observations.

Date	Survey Site #	Habitat Unit #	Habitat Type	Approx. Dist. from mouth (ft.)	SH/RT			Coho	
					YOY	1+	2+	YOY	1+
G2 Channel Type									
08/12/10	1	002	Pool	213	11	0	0	0	0
	2	016	Pool	775	0	0	0	0	0
	3	030	Pool	1,273	0	1	0	0	0
	4	037	Pool	1,592	0	0	0	0	0
	5	046	Pool	2,006	3	0	0	0	0
	6	049	Pool	2,081	0	0	1	0	0
	7	052	Pool	2,177	0	2	0	0	0
	8	061	Pool	2,513	2	2	0	0	0
	9	074	Pool	3,140	0	1	1	0	0
	10	076	Pool	3,213	2	2	0	0	0
	11	Above survey	Pool		0	0	0	0	0

DISCUSSION

Stitz Creek is a G2 channel type for the entire 3,257 feet of stream surveyed. The suitability of G2 channel types for fish habitat improvement structures is as follows: G2 channel types are fair for log cover.

The water temperatures recorded on the survey days July 29, 2010, ranged from 56 to 60 degrees Fahrenheit. Air temperatures ranged from 56 to 72 degrees Fahrenheit. This is a suitable water temperature range for salmonids. To make any conclusions, temperatures would need to be monitored throughout the warm summer months, and more extensive biological sampling would need to be conducted.

Flatwater habitat types comprised 31% of the total length of this survey, riffles 32%, and pools 27%. Ten of the 31 (32%) pools had a maximum residual depth greater than 2 feet. In general, pool enhancement projects are considered when primary pools comprise less than 40% of the length of total stream habitat. In first and second order streams, a primary pool is defined to have a maximum residual depth of at least two feet, occupy at least half the width of the low flow channel, and be as long as the low flow channel width. Installing structures that will increase or deepen pool habitat is recommended.

Two of the 31 pool tail-outs measured had embeddedness ratings of 1 or 2. Twenty-two of the pool tail-outs had embeddedness ratings of 3 or 4. Seven of the pool tail-outs had a rating of 5, which is considered unsuitable for spawning. Cobble embeddedness measured to be 25% or less, a rating of 1, is considered to indicate good quality spawning substrate for salmon and steelhead. Sediment sources in Stitz Creek should be mapped and rated according to their potential sediment yields, and control measures should be taken.

Twenty-one of the 31 pool tail-outs measured had gravel or small cobble as the dominant substrate. This is generally considered good for spawning salmonids.

The mean shelter rating for pools is 19. The shelter rating in the flatwater habitats is 20. A pool shelter rating of approximately 100 is desirable. The amount of cover that now exists is being provided primarily by boulders in Stitz Creek. Large woody debris is the dominant cover type in pools followed by boulders. Log and root wad cover structures in the pool and flatwater habitats would enhance both summer and winter salmonid habitat. Log cover structure provides rearing fry with protection from predation, rest from water velocity, and also divides territorial units to reduce density related competition.

The mean percent canopy density for the stream was 82%. In general, revegetation projects are considered when canopy density is less than 80%.

The percentage of right and left bank covered with vegetation was 98% and 99%, respectively. In areas of stream bank erosion or where bank vegetation is sparse, planting endemic species of coniferous and hardwood trees, in conjunction with bank stabilization, is recommended.

RECOMMENDATIONS

1) Stitz Creek should be managed as an anadromous, natural production stream.

2) The limited water temperature data available suggest that maximum temperatures are within the acceptable range for juvenile salmonids. To establish more complete and meaningful temperature regime information, 24-hour monitoring during the July and August temperature extreme period should be performed for 3 to 5 years.

Stitz Creek

3) Conduct a fish passage assessment of the Shively Road stream crossing at 1291 feet. Develop alternatives for improving fish passage.

4) Increase woody cover in the pools and flatwater habitat units. Most of the existing cover in the pools is from large woody debris. Adding high quality complexity with woody cover in the pools is desirable.

5) Active and potential sediment sources related to the road system need to be identified, mapped, and treated according to their potential for sediment yield to the stream and its tributaries.

COMMENTS AND LANDMARKS

The following landmarks and possible problem sites were noted. All distances are approximate and taken from the beginning of the survey reach.

Position (ft):	Habitat unit #:	Comments:
0	0001.00	Start survey at confluence with the Eel River flood plain.
121	0002.00	Bridge #01 is 75' high x 50' wide x 150' long. It is a railroad trellis consisting of concrete footings and heavy timber.
213	0003.00	Log debris accumulation (LDA) #01 contains 9 pieces of large woody debris (LWD) and measures 4.5' high x 46' wide x 20' long. Water flows over and there are no visible gaps. Retained sediment ranges from fines to boulder and measures 47' wide x 100' long x 4 deep. The Eel River may back flood in the winter providing access. Fish are present above the LDA. There is a 4.3' log plunge.
412	0007.00	There is a 3.9' log plunge. The creek is heavily populated with aquatic snails.
745	0016.00	There is a 3.7' boulder plunge.
887	0020.00	Salmonids and rough skinned newts have been observed throughout the survey.
1247	0030.00	There is an 11' boulder/LWD/concrete plunge from a concrete apron. It is the downstream end of the Shively Road culvert.
1273	0031.00	This is the concrete apron to the Shively Road culvert.

Stitz Creek

1291	0032.00	Culvert #01 is the Shively Road crossing, and is 8.5' high (bottom 1' is flat concrete, giving 7.5' of clearance) x 7.8' wide x 120' long. It is composed of a single culvert, and is made of corrugated metal with a flat concrete bottom. The culvert's diameter was 8', its plunge height is 3.7', and it has a maximum depth of 0.8' within 5' of the outlet. The condition is good. The culvert, in addition to the apron and approach to the apron, is a probable barrier to salmonids. The pool leading to the culvert has a maximum depth of 2.5', then there is an 11' jump through LWD and boulders, followed by a flat concrete apron having a maximum depth of 0.8' with a 3.7' jump into the culvert.
1576	0036.02	Log debris accumulation (LDA) #02 contains 16 pieces of large woody debris (LWD) and measures 7.2' high x 38.8' wide x 12.4' long. Water does not flow through and there are no visible gaps. There is no retained sediment.
1576	0037.00	There is a 2.9' log plunge.
1592	0038.00	Log debris accumulation (LDA) #3 contains 11 pieces of large woody debris (LWD) and measures 3.9' high x 16.3' wide x 11.4' long. Water flows over and there are visible gaps. Retained sediment ranges from fines to gravel and measures 15' wide x 50' long x 4' deep. Fish are present above the LDA.
1657	0040.00	Log debris accumulation (LDA) #04 contains 15 pieces of large woody debris (LWD) and measures 8.4' high x 32.6' wide x 31' long. Water flows under and there are visible gaps. Retained sediment ranges from fines to gravel and measures 50' wide x 50' long x 3' deep. Fish are present above the LDA.
2177	0053.00	Log debris accumulation (LDA) #05 contains 7 pieces of large woody debris (LWD) and measures 8' high x 48' wide x 14' long. Water flows through and there are visible gaps. There is no sediment being retained. Fish are present above the LDA.
2254	0055.00	Log debris accumulation (LDA) #06 contains 16 pieces of large woody debris (LWD) and measures 9' high x 26' wide x 46' long. Water flows under and there are no visible gaps. Retained sediment ranges from sand to large cobble and measures 25' wide x 75' long x 3' deep. Fish are present above the LDA.
3052	0072.00	The left bank is cut 10' high x 20' long and it is contributing silt to large cobble. There is a seep on the right bank.
3213	0077.00	Log debris accumulation (LDA) #07 contains 50+ pieces of large woody debris (LWD) and measures 21' high x 32' wide x 84' long. Water flows

		over and there are no visible gaps. Retained sediment ranges from sand to large cobble and measures 32' wide x 200' long x 33' deep. Fish are present above the LDA. Redwoods are living in the center of the LDA. There is a pool at a height of 11' though it is not flowing. The creek plunges from 21'.
3239	0078.00	The LDA continues upstream 80' further. At 150' upstream from the top of the LDA, 8 1+ salmonids were observed in 1 pool and YOY were in pools within the 150'.
3257	0078.00	End of survey.

REFERENCES

Flosi, G., Downie, S., Hopelain, J., Bird, M., Coey, R., and Collins, B. 1998. *California Salmonid Stream Habitat Restoration Manual*, 3rd edition. California Department of Fish and Game, Sacramento, California.

Stitz Creek

LEVEL III and LEVEL IV HABITAT TYPES

RIFFLE			
Low Gradient Riffle	(LGR)	[1.1]	{ 1}
High Gradient Riffle	(HGR)	[1.2]	{ 2}
CASCADE			
Cascade	(CAS)	[2.1]	{ 3}
Bedrock Sheet	(BRS)	[2.2]	{24}
FLATWATER			
Pocket Water	(POW)	[3.1]	{21}
Glide	(GLD)	[3.2]	{14}
Run	(RUN)	[3.3]	{15}
Step Run	(SRN)	[3.4]	{16}
Edgewater	(EDW)	[3.5]	{18}
MAIN CHANNEL POOLS			
Trench Pool	(TRP)	[4.1]	{ 8 }
Mid-Channel Pool	(MCP)	[4.2]	{17}
Channel Confluence Pool	(CCP)	[4.3]	{19}
Step Pool	(STP)	[4.4]	{23}
SCOUR POOLS			
Corner Pool	(CRP)	[5.1]	{22}
Lateral Scour Pool - Log Enhanced	(LSL)	[5.2]	{10}
Lateral Scour Pool - Root Wad Enhanced	(LSR)	[5.3]	{11}
Lateral Scour Pool - Bedrock Formed	(LSBk)	[5.4]	{12}
Lateral Scour Pool - Boulder Formed	(LSBo)	[5.5]	{20}
Plunge Pool	(PLP)	[5.6]	{ 9 }
BACKWATER POOLS			
Secondary Channel Pool	(SCP)	[6.1]	{ 4 }
Backwater Pool - Boulder Formed	(BPB)	[6.2]	{ 5 }
Backwater Pool - Root Wad Formed	(BPR)	[6.3]	{ 6 }
Backwater Pool - Log Formed	(BPL)	[6.4]	{ 7 }
Dammed Pool	(DPL)	[6.5]	{13}
ADDITIONAL UNIT DESIGNATIONS			
Dry	(DRY)	[7.0]	
Culvert	(CUL)	[8.0]	
Not Surveyed	(NS)	[9.0]	
Not Surveyed due to a marsh	(MAR)	[9.1]	

Table 1 - Summary of Riffle, Flatwater, and Pool Habitat Types

Stream Name: Stitz Creek — LLID: 1240523404607 — Drainage: Eel River - Lower

Survey Dates: 7/29/2010 to 7/29/2010

Confluence Location: Quad: SCOTIA — Legal Description: T01NR01ES15 — Latitude: 40:27:39.0N — Longitude: 124:03:08.0W

Habitat Units	Units Fully Measured	Habitat Type	Habitat Occurrence (%)	Mean Length (ft.)	Total Length (ft.)	Total Length (%)	Mean Width (ft.)	Mean Depth (ft.)	Mean Max Depth (ft.)	Mean Area (sq.ft.)	Estimated Total Area (sq.ft.)	Mean Volume (cu.ft.)	Estimated Total Volume (cu.ft.)	Mean Residual Pool Vol (cu.ft.)	Mean Shelter Rating
1	0	CULVERT	1.3	120	120	3.5									
1	0	DRY	1.3	117	117	3.4									
19	2	FLATWATER	23.8	56	1059	31.1	8.5	0.7	1.0	449	8535	314	5974		20
3	0	NOSURVEY	3.8	34	103	3.0									
31	31	POOL	38.8	30	924	27.2	14.1	0.9	1.5	374	11609	459	14238	331	19
25	5	RIFFLE	31.3	43	1079	31.7	8.6	0.5	0.8	184	4604	87	2167		17

Total Units	Total Units Fully Measured	Total Length (ft.)	Total Area (sq.ft.)	Total Volume (cu.ft.)
80	38	3402	24747	22379

Table 2 - Summary of Habitat Types and Measured Parameters

Stream Name: Stitz Creek LLID: 1240523404607 Drainage: Eel River - Lower

Survey Dates: 7/29/2010 to 7/29/2010

Confluence Location: Quad: SCOTIA Legal Description: T01NR01ES15 Latitude: 40:27:39.0N Longitude: 124:03:08.0W

Habitat Units	Units Fully Measured	Habitat Type	Habitat Occurrence (%)	Mean Length (ft.)	Total Length (ft.)	Total Length (%)	Mean Width (ft.)	Mean Depth (ft.)	Max Depth (ft.)	Mean Area (sq.ft.)	Estimated Total Area (sq.ft.)	Mean Volume (cu.ft.)	Estimated Total Volume (cu.ft.)	Mean Residual Pool Vol (cu.ft.)	Mean Shelter Rating	Mean Canopy (%)
19	3	LGR	23.8	48	903	26.5	9	0.4	0.9	214	4067	87	1661		18	83
5	1	HGR	6.3	32	158	4.6	9	0.8	1	149	745	119	596		30	93
1	1	BRS	1.3	18	18	0.5	7	0.4	0.8	130	130	52	52		0	40
10	1	RUN	12.5	36	364	10.7	9	0.7	0.9	380	3802	266	2661		10	79
9	1	SRN	11.3	77	695	20.4	8	0.7	1	518	4664	363	3265		30	96
25	25	MCP	31.3	32	800	23.5	11	0.9	2.4	354	8845	451	11284	322	18	84
1	1	LSL	1.3	13	13	0.4	26	0.5	1.2	304	304	274	274	152	10	60
5	5	PLP	6.3	22	111	3.3	26	0.9	2.3	492	2460	536	2680	414	25	77
1	0	DRY	1.3	117	117	3.4										
1	0	CUL	1.3	120	120	3.5										
3	0	NS	3.8	34	103	3.0										

Total Units	Total Units Fully Measured	Total Length (ft.)	Total Area (sq.ft.)	Total Volume (cu.ft.)
80	38	3402	25016	22473

Table 3 - Summary of Pool Types

Stream Name: Stitz Creek   LLID: 1240523404607   Drainage: Eel River - Lower

Survey Dates: 7/29/2010 to 7/29/2010

Confluence Location: Quad: SCOTIA   Legal Description: T01NR01ES15   Latitude: 40:27:39.0N   Longitude: 124:03:08.0W

Habitat Units	Units Fully Measured	Habitat Type	Habitat Occurrence (%)	Mean Length (ft.)	Total Length (ft.)	Total Length (%)	Mean Width (ft.)	Mean Residual Depth (ft.)	Mean Area (sq.ft.)	Estimated Total Area (sq.ft.)	Mean Residual Pool Vol (cu.ft.)	Estimated Total Resid.Vol. (cu.ft.)	Mean Shelter Rating
25	25	MAIN	81	32	800	87	11.3	0.9	354	8845	322	8049	18
6	6	SCOUR	19	21	124	13	25.9	0.8	461	2764	370	2222	23

Total Units	Total Units Fully Measured	Total Length (ft.)	Total Area (sq.ft.)	Total Volume (cu.ft.)
31	31	924	11609	10271

Table 4 - Summary of Maximum Residual Pool Depths By Pool Habitat Types

Stream Name: Stitz Creek LLID: 1240523404607 Drainage: Eel River - Lower

Survey Dates: 7/29/2010 to 7/29/2010

Confluence Location: Quad: SCOTIA Legal Description: T01NR01ES15 Latitude: 40:27:39.0N Longitude: 124:03:08.0W

Habitat Units	Habitat Type	Habitat Occurrence (%)	< 1 Foot Maximum Residual Depth	< 1 Foot Percent Occurrence	1 < 2 Feet Maximum Residual Depth	1 < 2 Feet Percent Occurrence	2 < 3 Feet Maximum Residual Depth	2 < 3 Feet Percent Occurrence	3 < 4 Feet Maximum Residual Depth	3 < 4 Feet Percent Occurrence	>= 4 Feet Maximum Residual Depth	>= 4 Feet Percent Occurrence
25	MCP	81	5	20	12	48	8	32	0	0	0	0
1	LSL	3	0	0	1	100	0	0	0	0	0	0
5	PLP	16	0	0	3	60	2	40	0	0	0	0

Total Units	Total < 1 Foot Max Resid. Depth	Total < 1 Foot % Occurrence	Total 1< 2 Foot Max Resid. Depth	Total 1< 2 Foot % Occurrence	Total 2< 3 Foot Max Resid. Depth	Total 2< 3 Foot % Occurrence	Total 3< 4 Foot Max Resid. Depth	Total 3< 4 Foot % Occurrence	Total >= 4 Foot Max Resid. Depth	Total >= 4 Foot % Occurrence
31	5	16	16	52	10	32	0	0	0	0

Mean Maximum Residual Pool Depth (ft.): 1.5

Table 5 - Summary of Mean Percent Cover By Habitat Type

Stream Name: Stitz Creek LLID: 1240523404607 Drainage: Eel River - Lower

Survey Dates: 7/29/2010 to 7/29/2010 Dry Units: 1

Confluence Location: Quad: SCOTIA Legal Description: T01NR01ES15 Latitude: 40:27:39.0N Longitude: 124:03:08.0W

Habitat Units	Units Fully Measured	Habitat Type	Mean % Undercut Banks	Mean % SWD	Mean % LWD	Mean % Root Mass	Mean % Terr. Vegetation	Mean % Aquatic Vegetation	Mean % White Water	Mean % Boulders	Mean % Bedrock Ledges
19	3	LGR	0	0	0	0	0	0	0	100	0
5	1	HGR	0	0	0	0	0	0	0	100	0
1	1	BRS	0	0	0	0	0	0	0	0	0
25	5	TOTAL RIFFLE	0	0	0	0	0	0	0	100	0
10	1	RUN	0	0	0	0	0	0	0	100	0
9	1	SRN	0	0	30	0	0	0	0	70	0
19	2	TOTAL FLAT	0	0	15	0	0	0	0	85	0
25	25	MCP	1	1	34	16	8	0	1	39	0
1	1	LSL	0	0	50	0	0	0	0	50	0
5	5	PLP	0	5	48	5	15	0	23	5	0
31	31	TOTAL POOL	1	2	37	13	9	0	4	34	0
1	0	CUL									
3	0	NS									
80	38	TOTAL	1	2	31	11	7	0	3	46	0

Table 6 - Summary of Dominant Substrates By Habitat Type

Stream Name: Stitz Creek | LLID: 1240523404607 | Drainage: Eel River - Lower

Survey Dates: 7/29/2010 to 7/29/2010 | Dry Units: 1

Confluence Location: Quad: SCOTIA | Legal Description: T01NR01ES15 | Latitude: 40:27:39.0N | Longitude: 124:03:08.0W

Habitat Units	Units Fully Measured	Habitat Type	% Total Silt/Clay Dominant	% Total Sand Dominant	% Total Gravel Dominant	% Total Small Cobble Dominant	% Total Large Cobble Dominant	% Total Boulder Dominant	% Total Bedrock Dominant
19	3	LGR	0	0	67	0	33	0	0
5	1	HGR	0	100	0	0	0	0	0
1	1	BRS	0	0	0	0	0	0	100
10	1	RUN	0	100	0	0	0	0	0
9	1	SRN	0	0	100	0	0	0	0
25	25	MCP	12	44	40	4	0	0	0
1	1	LSL	0	0	100	0	0	0	0
5	5	PLP	20	20	60	0	0	0	0

Table 7 - Summary of Mean Percent Canopy for Entire Stream

Stream Name: Stitz Creek | LLID: 1240523404607 | Drainage: Eel River - Lower

Survey Dates: 7/29/2010 to 7/29/2010

Confluence Location: Quad: SCOTIA | Legal Description: T01NR01ES15 | Latitude: 40:27:39.0N | Longitude: 124:03:08.0W

Mean Percent Canopy	Mean Percent Conifer	Mean Percent Hardwood	Mean Percent Open Units	Mean Right Bank % Cover	Mean Left Bank % Cover
82	43	57	0	98	99

Note: Mean percent conifer and hardwood for the entire reach are means of canopy components from units with canopy values greater than zero.

Open units represent habitat units with zero canopy cover.

Table 8 - Fish Habitat Inventory Data Summary

Stream Name: Stitz Creek LLID: 1240523404607 Drainage: Eel River - Lower

Survey Dates: 7/29/2010 to 7/29/2010 Survey Length (ft.): 3402 Main Channel (ft.): 3257 Side Channel (ft.): 145

Confluence Location: Quad: SCOTIA Legal Description: T01NR01ES15 Latitude: 40:27:39.0N Longitude: 124:03:08.0W

Summary of Fish Habitat Elements By Stream Reach

STREAM REACH: 1

Channel Type: G2
Reach Length (ft.): 3257
Riffle/Flatwater Mean Width (ft.): 8.5
BFW:
Range (ft.): 22 to 42
Mean (ft.): 29
Std. Dev.: 6
Base Flow (cfs.): 0.5
Water (F): 56 - 60 Air (F): 56 - 72
Dry Channel (ft): 117

Canopy Density (%): 81.8
Coniferous Component (%): 42.8
Hardwood Component (%): 57.2
Dominant Bank Vegetation: Coniferous Trees
Vegetative Cover (%): 98.6
Dominant Shelter: Boulders
Dominant Bank Substrate Type: Sand/Silt/Clay
Occurrence of LWD (%): 26
LWD per 100 ft.:
Riffles: 5
Pools: 5
Flat: 4

Pools by Stream Length (%): 27.2
Pool Frequency (%): 38.8
Residual Pool Depth (%):
< 2 Feet Deep: 68
2 to 2.9 Feet Deep: 32
3 to 3.9 Feet Deep: 0
>= 4 Feet Deep: 0
Mean Max Residual Pool Depth (ft.): 1.5
Mean Pool Shelter Rating: 19

Pool Tail Substrate (%): Silt/Clay: 3 Sand: 3 Gravel: 61 Sm Cobble: 6 Lg Cobble: 16 Boulder: 10 Bedrock: 0

Embeddedness Values (%): 1. 0.0 2. 6.5 3. 41.9 4. 29.0 5. 22.6

Table 9 - Mean Percentage of Dominant Substrate and Vegetation

Stream Name: Stitz Creek LLID: 1240523404607 Drainage: Eel River - Lower

Survey Dates: 7/29/2010 to 7/29/2010

Confluence Location: Quad: SCOTIA Legal Description: T01NR01ES15 Latitude: 40:27:39.0N Longitude: 124:03:08.0W

Mean Percentage of Dominant Stream Bank Substrate

Dominant Class of Substrate	Number of Units Right Bank	Number of Units Left Bank	Total Mean Percent (%)
Bedrock	2	2	5.3
Boulder	0	0	0.0
Cobble / Gravel	0	0	0.0
Sand / Silt / Clay	36	36	94.7

Mean Percentage of Dominant Stream Bank Vegetation

Dominant Class of Vegetation	Number of Units Right Bank	Number of Units Left Bank	Total Mean Percent (%)
Grass	0	0	0.0
Brush	5	6	14.5
Hardwood Trees	20	12	42.1
Coniferous Trees	13	20	43.4
No Vegetation	0	0	0.0

Total Stream Cobble Embeddedness Values: 4

Table 10 - Mean Percent of Shelter Cover Types For Entire Stream

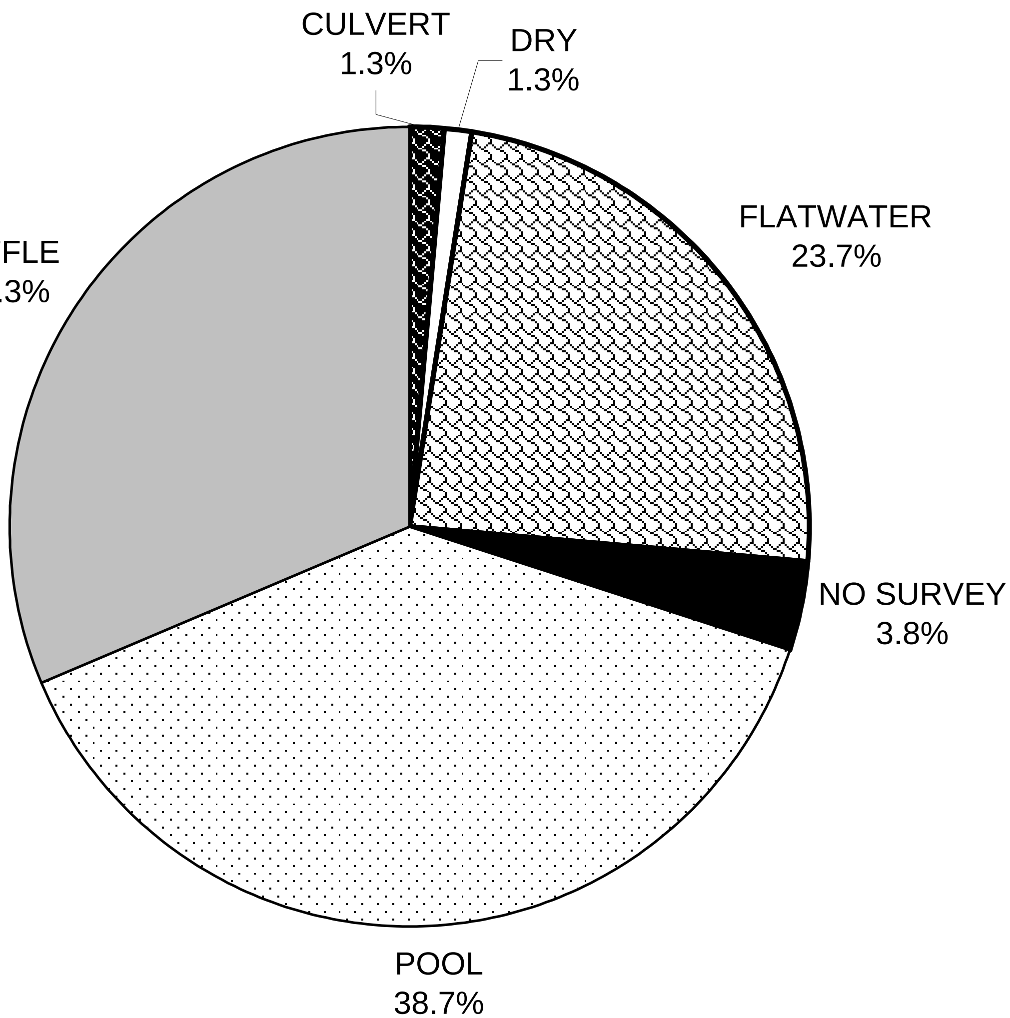
StreamName: Stitz Creek   LLID: 1240523404607   Drainage: Eel River - Lower

Survey Dates: 7/29/2010 to 7/29/2010

Confluence Location: Quad: SCOTIA   Legal Description: T01NR01ES15   Latitude: 40:27:39.0N   Longitude: 124:03:08.0W

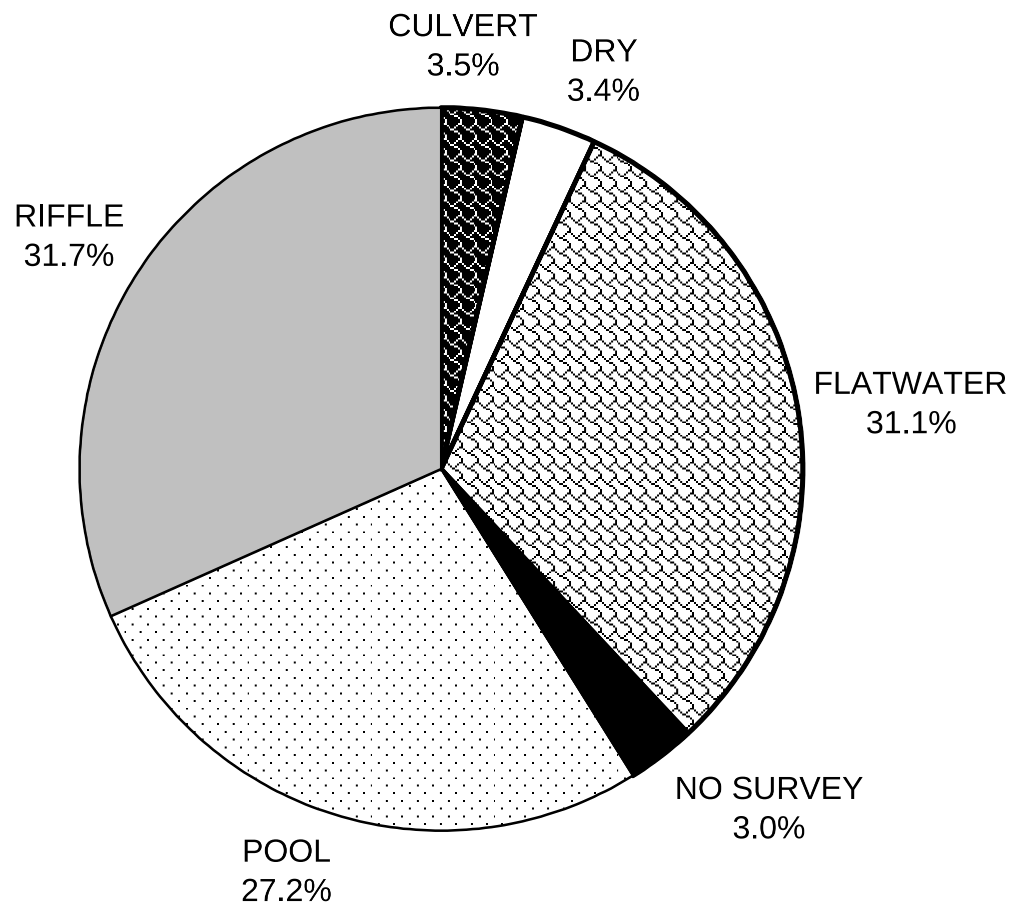
	Riffles	Flatwater	Pools
UNDERCUT BANKS (%)	0	0	1
SMALL WOODY DEBRIS (%)	0	0	2
LARGE WOODY DEBRIS (%)	0	15	37
ROOT MASS (%)	0	0	13
TERRESTRIAL VEGETATION (%)	0	0	9
AQUATIC VEGETATION (%)	0	0	0
WHITEWATER (%)	0	0	4
BOULDERS (%)	100	85	34
BEDROCK LEDGES (%)	0	0	0

STITZ CREEK 2010
HABITAT TYPES BY PERCENT OCCURRENCE



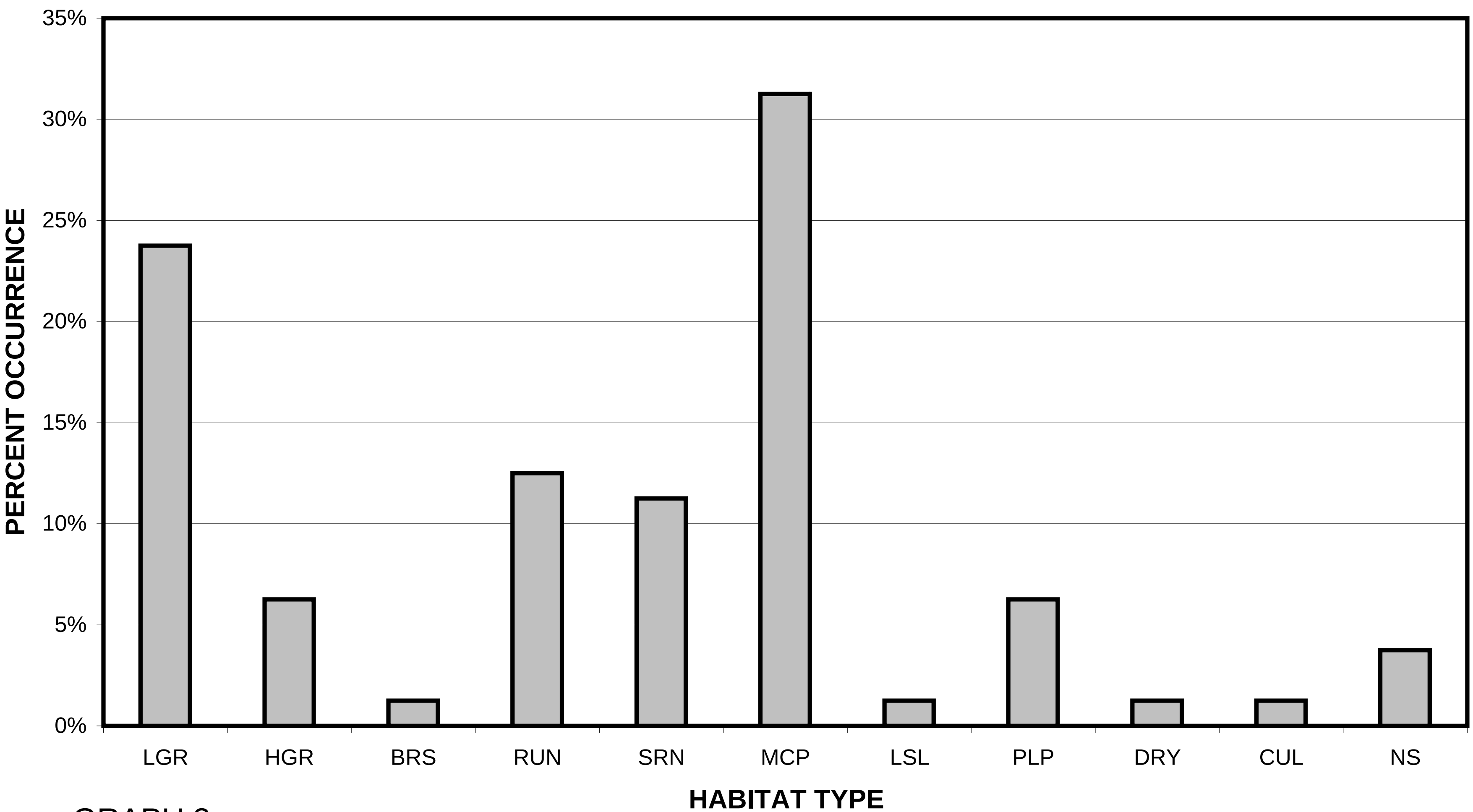
GRAPH 1

STITZ CREEK 2010
HABITAT TYPES BY PERCENT TOTAL LENGTH



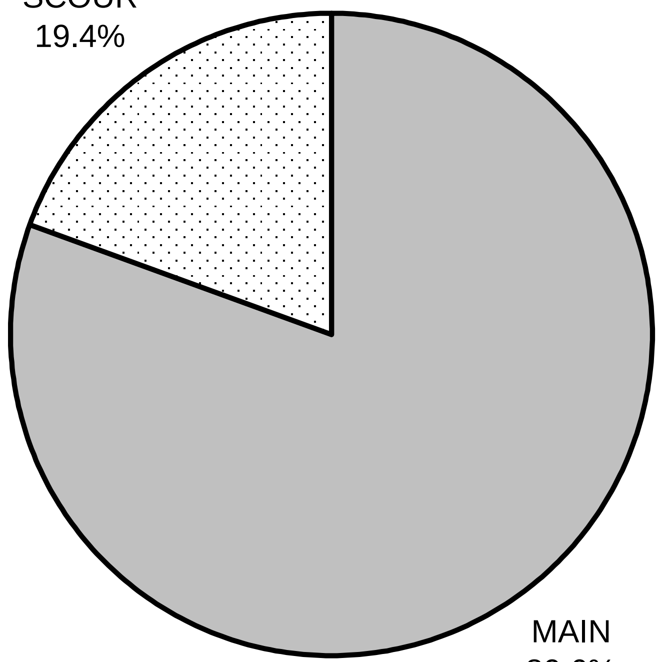
GRAPH 2

STITZ CREEK 2010
HABITAT TYPES BY PERCENT OCCURRENCE

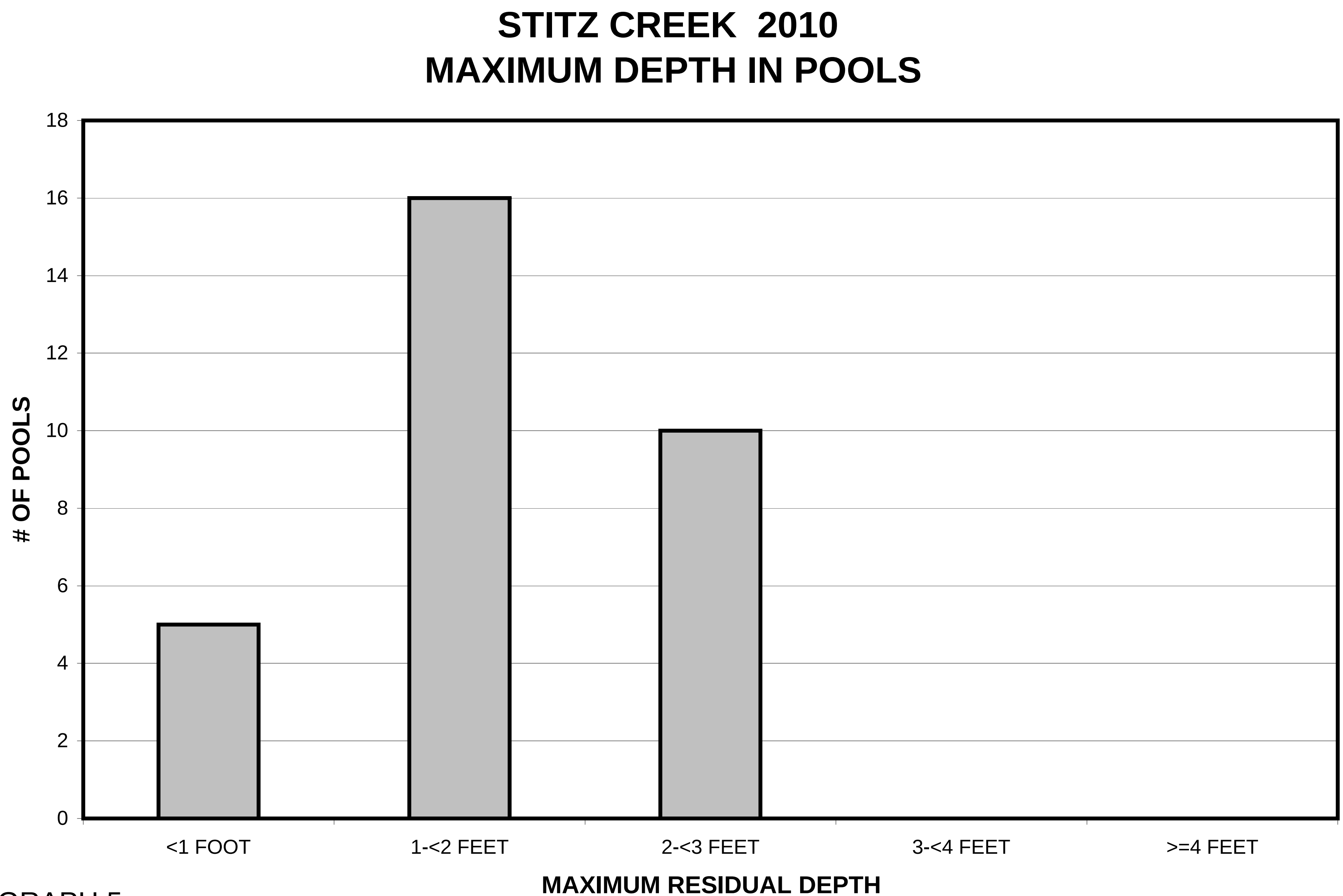


GRAPH 3

STITZ CREEK 2010
POOL TYPES BY PERCENT OCCURRENCE

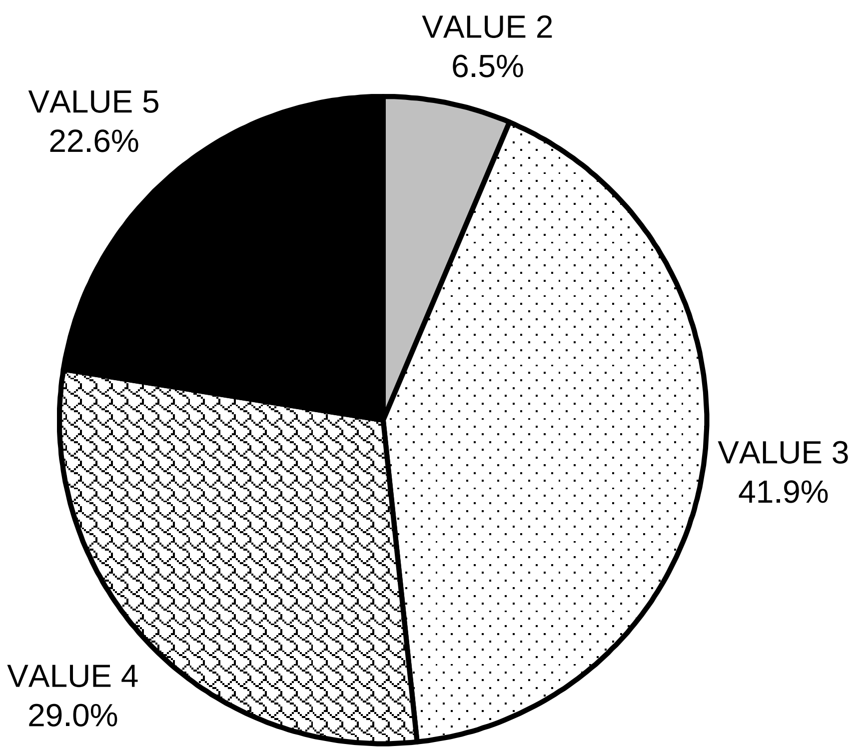


GRAPH 4


STITZ CREEK 2010
MAXIMUM DEPTH IN POOLS
OF POOLS
18
16
14
12
10
8
6
4
2
0
<1 FOOT
1-<2 FEET
2-<3 FEET
3-<4 FEET
>=4 FEET
MAXIMUM RESIDUAL DEPTH

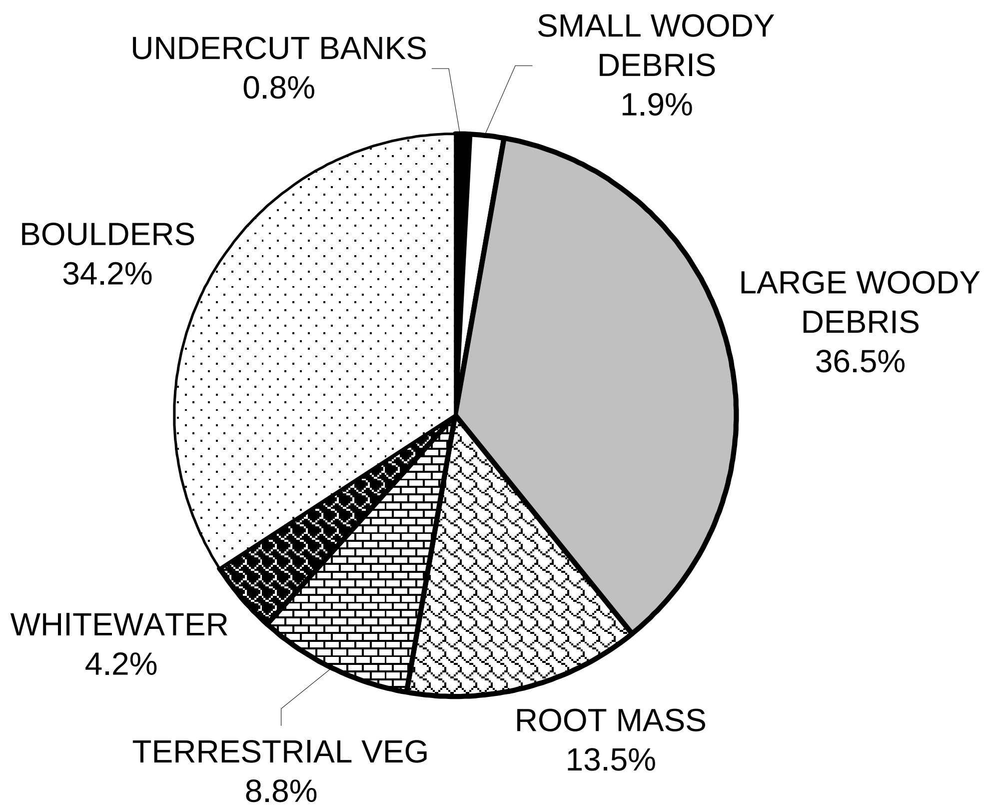
GRAPH 5

STITZ CREEK 2010
PERCENT EMBEDDEDNESS



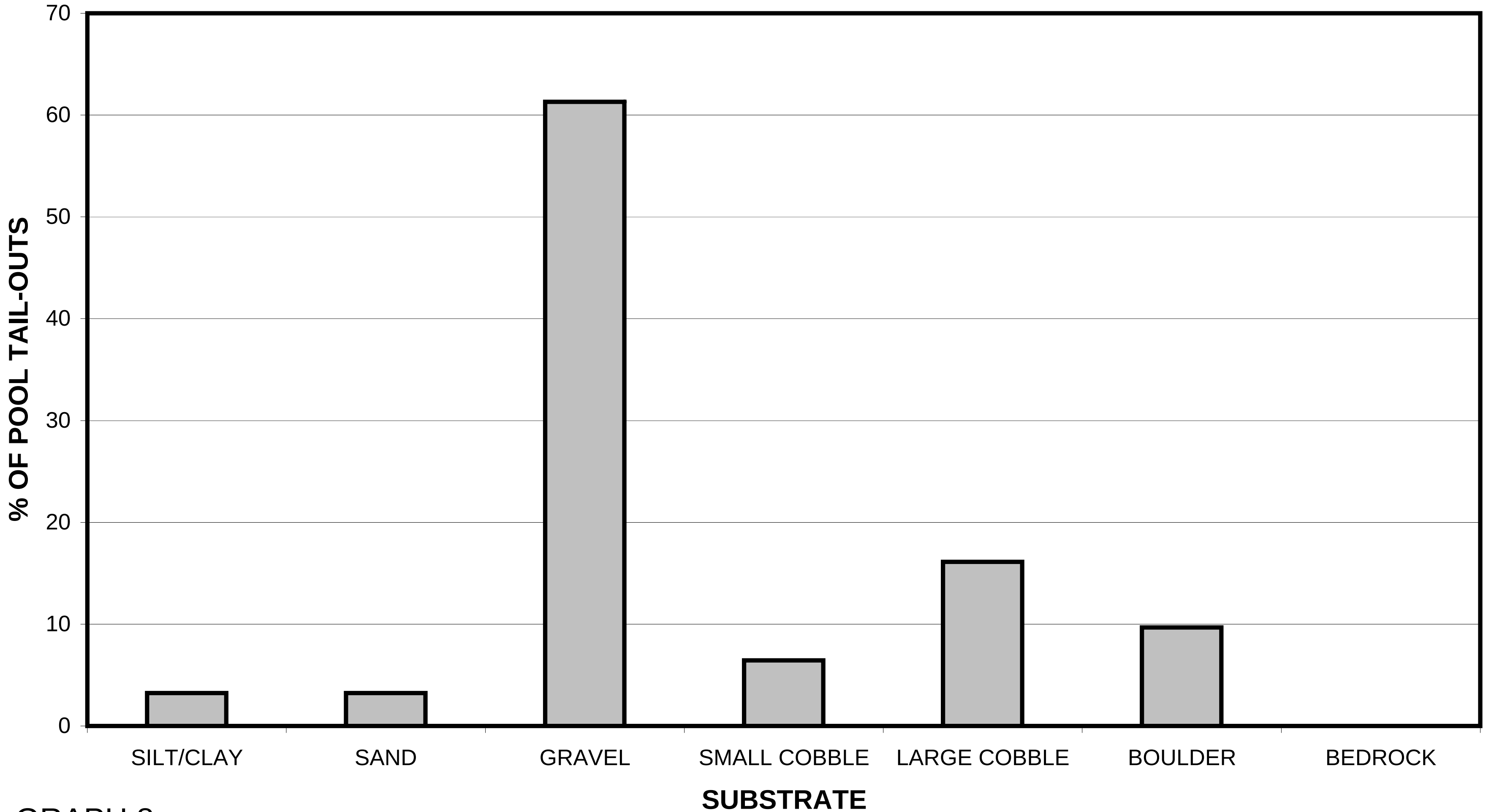
GRAPH 6

STITZ CREEK 2010
MEAN PERCENT COVER TYPES IN POOLS



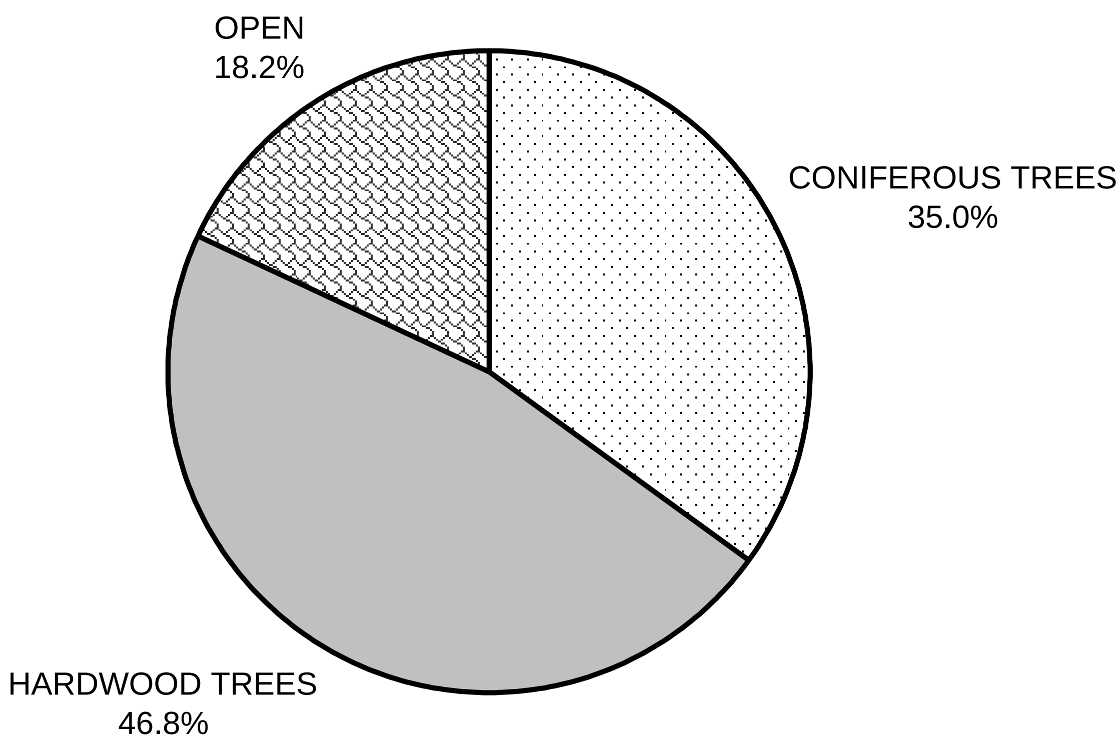
GRAPH 7

STITZ CREEK 2010
SUBSTRATE COMPOSITION IN POOL TAIL-OUTS



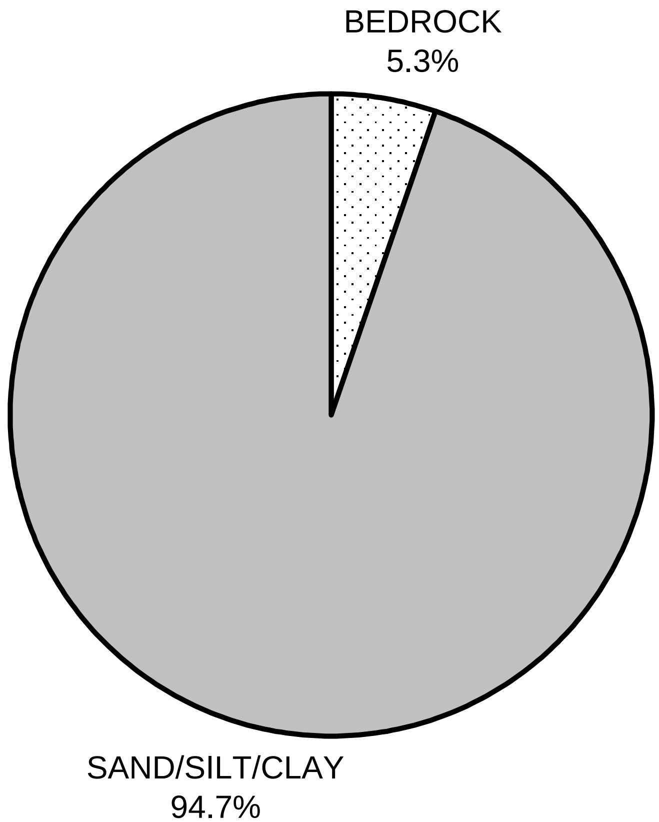
GRAPH 8

STITZ CREEK 2010
MEAN PERCENT CANOPY



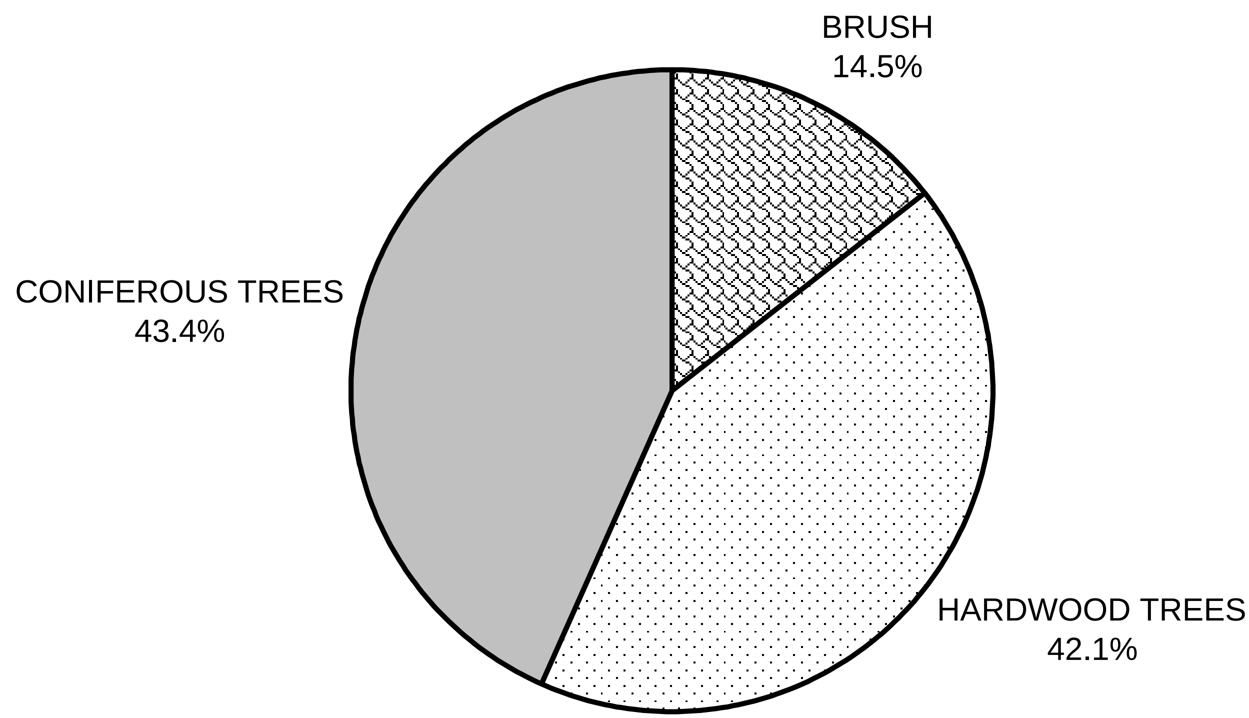
GRAPH 9

STITZ CREEK 2010
DOMINANT BANK COMPOSITION IN SURVEY REACH

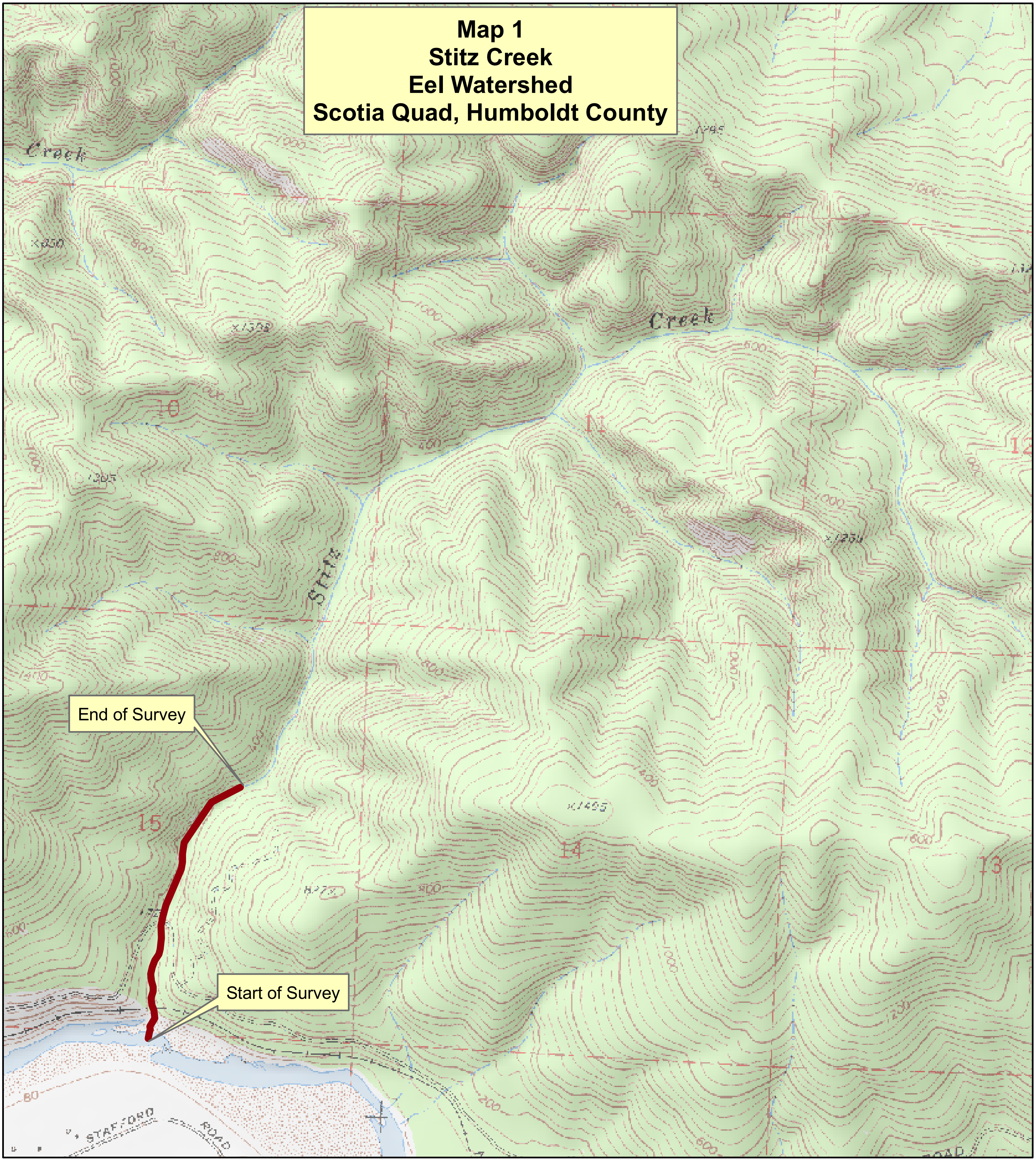


GRAPH 10

STITZ CREEK 2010
DOMINANT BANK VEGETATION IN SURVEY REACH



GRAPH 11



Legend

Reach 1, G2 Channel Type

0 2,000 Feet

SALMON AND STEELHEAD RESTORATION AND ENHANCEMENT PROGRAM

NORTH COAST

BASIN PLANNING PROJECT

STREAM INVENTORY REPORT

STITZ CREEK

CALIFORNIA DEPARTMENT OF FISH AND GAME

SPORT FISH RESTORATION ACT

199~~5~~7

North Coast Basin Planning Project

NORTH COAST BASIN PLANNING PROJECT

The North Coast Basin Planning Project (BPP) was begun in 1991 to develop salmon and steelhead restoration and enhancement programs in North Coast watersheds for the Department of Fish and Game (DFG). The objectives of the project conform with the goals of California's Salmon and Steelhead Restoration and Enhancement Program of 1988. The Restoration Program strives to enhance the status of anadromous salmonid populations and improve the fishing experience for Californians. The program intends to achieve a doubling of the population of salmon and steelhead by the year 2000. The project is supported by the Sport Fish Restoration Act, which uses sport fishermen's funds to improve sport fisheries.

The BPP conducts stream and habitat inventories according to the standard methodologies discussed in the *California Salmonid Stream Habitat Restoration Manual* (Flosi and Reynolds, 1994). Biological sampling is conducted using electrofishing and direct observation to determine species presence and distribution; selected streams are electrofished for population estimates. Some streams are also sampled for sediment composition. Collected information is used for base-line data, public cooperation development, restoration program planning, specific project design and implementation, and for project evaluation.

The Eel River system was identified as the initial basin for project planning activities. Most anadromous tributaries to the Van Duzen, South Fork Eel, Mainstem Eel, Middle Fork Eel, and North Fork Eel rivers have been inventoried since 1991. Initial field inventory of the Eel River system should be essentially complete in 1996. BPP personnel have also worked in cooperation with the DFG Salmon Restoration Project's staff to inventory streams on the Mattole River, Mendocino Coast, and Humboldt Bay.

STREAM INVENTORY REPORT

STITZ CREEK

INTRODUCTION

A stream inventory was conducted during the summer of 1992 on Stitz Creek to assess habitat conditions for anadromous salmonids. The inventory was conducted in two parts: habitat inventory and biological inventory. The objective of the habitat inventory was to document the habitat available to anadromous salmonids in Stitz Creek. The objective of the biological inventory was to document the salmonid species present and their distribution. After analysis of the information and data gathered, stream restoration and enhancement recommendations are presented.

There is no known record of adult spawning surveys having been conducted on Stitz Creek. The objective of this report is to document the current habitat conditions, and recommend options for the potential enhancement of habitat for chinook salmon, coho salmon and steelhead trout.

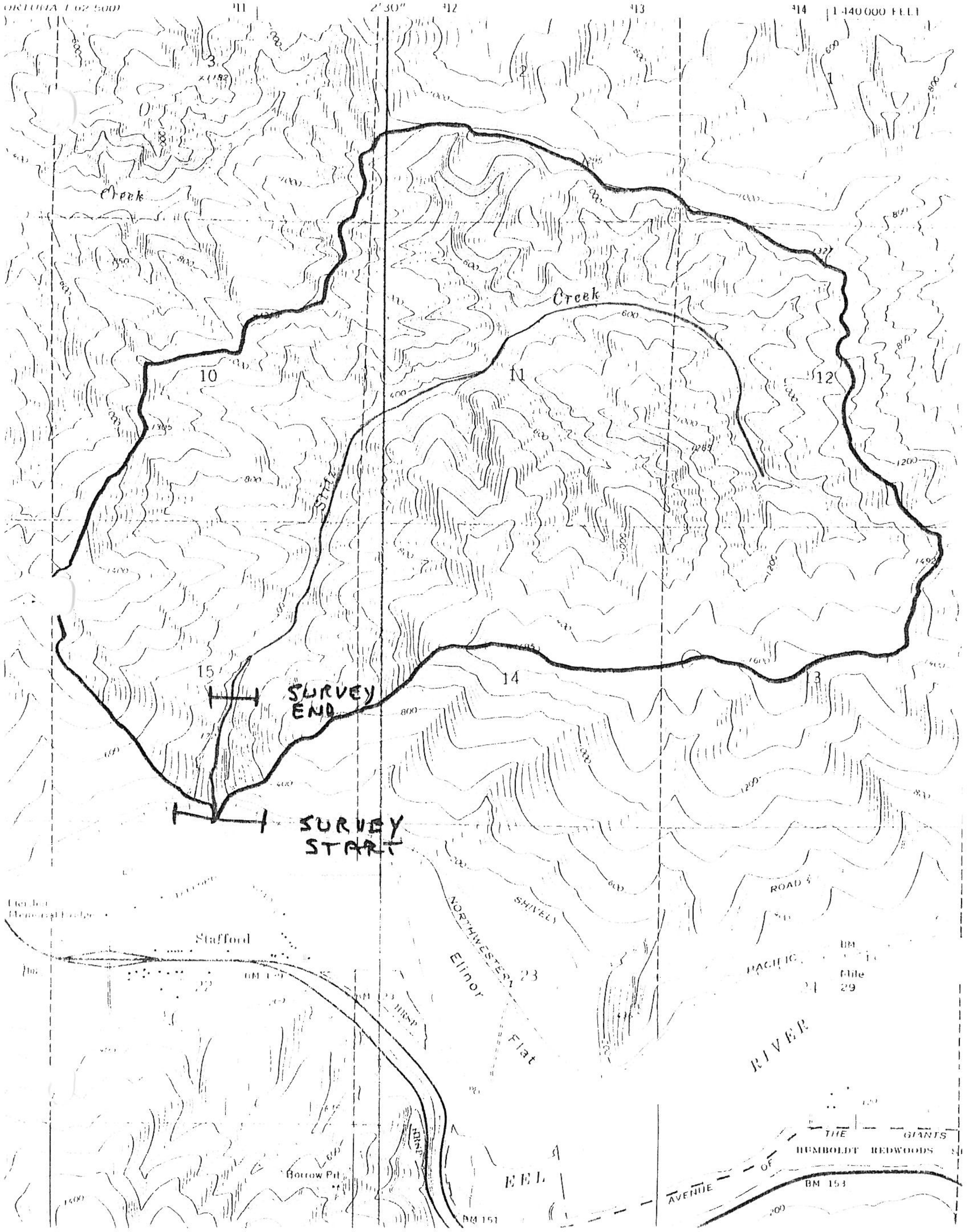
WATERSHED OVERVIEW

Stitz Creek is tributary to the Eel River, located in Humboldt County, California (Figure 1). Stitz Creek's legal description at the confluence with the Eel River is T1N R1E S15. Its location is 40°27'39" N. latitude and 124°03'08" W. longitude. Stitz Creek is a first order stream and has approximately 3.4 miles of blue line stream, according to the USGS Scotia 7.5 minute quadrangle.

Stitz Creek drains a watershed of approximately 4.0 square miles. Elevations range from about 80 feet at the mouth of the creek to 1,000 feet in the headwater areas. Redwood forest dominates the watershed. The watershed is owned by the Pacific Lumber Company and is managed for timber production. Vehicle access exists from U.S. Highway 101 approximately 1/2 mile north of Stafford, via Shively Road.

METHODS

The habitat inventory conducted in Stitz Creek follows the methodology presented in the <u>California Salmonid Stream Habitat Restoration Manual</u> (Flosi and Reynolds, 1991). The California Conservation Corps (CCC) Technical Advisors that conducted the inventory were trained in standardized habitat inventory methods by the California Department of Fish and Game (DFG). Stitz Creek personnel were trained in May and June, 1992, by Gary Flosi and Scott Downie. This inventory was conducted by two person teams.



Creek
Creek
Stitz
10
11
12
14
15
SURVEY END
SURVEY START
Stafford
Elinor
Flat
NORTHWESTERN
PACIFIC
SHIVELY
ROAD
RIVER
EEL
AVENUE
OF
THE
GIANTS
HUMBOLDT REDWOODS
Borrow Pit
Mile
29
1 440 000 FEET
2'30"

Stitz Creèk

HABITAT INVENTORY COMPONENTS:

A standardized habitat inventory form has been developed for use in California stream surveys and can be found in the California Salmonid Stream Habitat Restoration Manual. This form was used in Stitz Creek to record measurements and observations. There are nine components to the inventory form.

1. Flow:

Flow is measured in cubic feet per second (cfs) at the bottom of the stream survey reach using standard flow measuring equipment, if available. In some cases flows are estimated. Flows should also be measured or estimated at major tributary confluences.

2. Channel Type:

Channel typing is conducted according to the classification system developed by David Rosgen (1985). This methodology is described in the California Salmonid Stream Habitat Restoration Manual. Channel typing is conducted simultaneously with habitat typing and follows a standard form to record measurements and observations. There are four measured parameters used to determine channel type: 1) water slope gradient, 2) channel confinement, 3) width/depth ratio, 4) substrate composition.

3. Temperatures:

Both water and air temperatures are taken and recorded at each tenth unit typed. The time of the measurement is also recorded. Both temperatures are taken in fahrenheit at the middle of the habitat unit and within one foot of the water surface.

4. Habitat Type:

Habitat typing uses the 24 habitat classification types defined by McCain and others (1988). Habitat units are numbered sequentially and assigned a type identification number selected from a standard list of 24 habitat types. Dewatered units are labeled "dry". Stitz Creek habitat typing used standard basin level measurement criteria. These parameters require that the minimum length of a described habitat unit must be equal to or greater than the stream's mean wetted width. Channel dimensions were measured using hip chains, range finders, tape measures, and stadia rods. Unit measurements included mean length, mean width, mean depth, and maximum depth. Depth of the pool tail crest at each pool habitat unit was measured at the thalweg. All measurements were taken in feet to the nearest tenth.

5. Embeddedness:

The depth of embeddedness of the cobbles in pool tail-out reaches is measured by the percent of the cobble that is surrounded or buried by fine sediment. In Stitz Creek, embeddedness was ocularly estimated. The values were recorded using the following ranges: 0 - 25% (value 1), 26 - 50% (value 2), 51 - 75% (value 3), 76 - 100% (value 4).

6. Shelter Rating:

Instream shelter is composed of those elements within a stream channel that provide salmonids protection from predation, reduce water velocities so fish can rest and conserve energy, and allow separation of territorial units to reduce density related competition. The shelter rating is calculated for each habitat unit by multiplying shelter value and percent cover. Using an overhead view, a quantitative estimate of the percentage of the habitat unit covered is made. All cover is then classified according to a list of nine cover types. In Stitz Creek, a standard qualitative shelter value of 0 (none), 1 (low), 2 (medium), or 3 (high) was assigned according to the complexity of the cover. Thus, shelter ratings can range from 0-300, and are expressed as mean values by habitat types within a stream.

7. Substrate Composition:

Substrate composition ranges from silt/clay sized particles to boulders and bedrock elements. In all habitat units, dominant and sub-dominant substrate elements were ocularly estimated using a list of seven size classes.

8. Canopy:

Stream canopy is estimated using handheld spherical densiometers and is a measure of the water surface shaded during periods of high sun. In Stitz Creek, an estimate of the percentage of the habitat unit covered by canopy was made from the center of each unit. The area of canopy was further analyzed to estimate its percentages of coniferous or deciduous trees, and the results recorded.

9. Bank Composition:

Bank composition elements range from bedrock to bare soil. However, the stream banks are usually covered with grass, brush, or trees. These factors influence the ability of stream banks to withstand winter flows. In Stitz Creek, the dominant composition type in both the right and left banks was selected from a list of eight options on the habitat inventory form. Additionally, the percent of each bank covered by vegetation was estimated and recorded.

BIOLOGICAL INVENTORY:

Biological sampling during stream inventory is used to determine fish species and their distribution in the stream. Biological inventory is conducted using one or more of three basic methods: 1) stream bank observation, 2) underwater observation, 3) electrofishing. These sampling techniques are discussed in the California Salmonid Stream Habitat Restoration Manual.

Biological inventory was conducted in Stitz Creek to document the fish species composition and distribution. Three sites were electrofished in Stitz Creek using one Smith Root Model 12 electrofisher. Each site was end-blocked with nets to contain the fish within the sample reach. Fish from each site were counted by species, measured, and returned to the stream.

DATA ANALYSIS:

Data from the habitat inventory form are entered into Runtime, a dBASE 4.1 data entry program developed by the Department and Fish and Game. This program processes and summarizes the data.

The Runtime program produces the following summary tables:

- Riffle, flatwater, and pool habitat types
- Habitat types and measured parameters
- Pool types
- Maximum pool depths by habitat types
- Dominant substrates by habitat types
- Mean percent shelter by habitat types

Graphics are produced from the tables using Lotus 1,2,3. Graphics developed for Stitz Creek include:

- Riffle, flatwater, pool habitats by percent occurrence
- Riffle, flatwater, pool habitats by total length
- Total habitat types by percent occurrence
- Pool types by percent occurrence
- Total pools by maximum depths
- Embeddedness
- Pool cover by cover type
- Dominant substrate in low gradient riffles
- Percent canopy
- Bank composition by composition type

Stitz Crèek

HABITAT INVENTORY RESULTS:

* ALL TABLES AND GRAPHS ARE LOCATED AT THE END OF THE REPORT *

The habitat inventory of June 5 and 8, 1992, was conducted by Jason Cleckler, Judah Sanders, and Craig Mesman (contract seasonals). The total length of the stream surveyed was 1,983 feet, with an additional 107 feet of side channel.

Flow was not measured on Stitz Creek.

Stitz Creek is a B3 channel type for the entire 1,983 feet of stream reach surveyed. B3 channels are moderate gradient (1.5-4.0%), well confined streams, with unstable stream banks.

Water temperatures ranged from 56 to 57 degrees fahrenheit. Air temperatures ranged from 57 to 73 degrees fahrenheit.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. By percent **occurrence**, riffles made up 40.0%; pools 36.7%; and flatwater types 23.3% (Graph 1). Riffles made up 52.4% of the total survey **length**, pools 25.5%, and flatwater habitat types 22.1% (Graph 2).

Eleven Level IV habitat types were identified. The data are summarized in Table 2. The most frequent habitat types by percent **occurrence** were low gradient riffles, 20.0%; mid-channel pools, also 20.0%; and high gradient riffles, 18.3% (Graph 3). By percent total **length**, low gradient riffles made up 32.4%, high gradient riffles 19.2%, and mid-channel pools 13.8% (Table 2).

Twenty-two pools were identified (Table 3). Main-channel pools were most often encountered at 63.6%, and comprised 36.4% of the total length of pools (Graph 4).

Table 4 is a summary of maximum pool depths by pool habitat types. Depth is an indicator of pool quality. Thirteen of the 22 pools (59%) had a depth of two feet or greater (Graph 5).

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 21 pool tail-outs measured, zero had a value of 1 (0.0%); One had a value of 2 (4.8%); 15 had a value of 3 (71.4%); and 5 had a value of 4 (23.8%). On this scale, a value of one is the best for fisheries (Graph 6).

A shelter rating was calculated for each habitat unit and expressed as a mean value for each habitat type within the survey using a scale of 0-300. Pools had the highest shelter rating at 51.6. Riffle habitats followed with a rating of 49.6 (Table 1).

Stitz Creek

Of the pool types, the scour pools had the highest mean shelter rating at 52.5, and main channel pools rated 51.1 (Table 3).

Table 5 summarizes mean percent cover by habitat type. Boulders are the dominant cover type in Stitz Creek and are extensive. Large woody debris is the next most common cover type. Graph 7 describes the pool cover in Stitz Creek.

Table 6 summarizes the dominant substrate by habitat type. Silt/clay was the dominant substrate observed in four of the 12 low gradient riffles (33.3%). Large cobble was the next most frequently observed dominant substrate type, and occurred in 25.0% of the low gradient riffles (Graph 8).

Eighteen percent of the survey reach lacked shade canopy. Of the 82% of the stream covered with canopy, 68% was composed of deciduous trees, and 32% was composed of coniferous trees. Graph 9 describes the canopy in Stitz Creek.

Table 2 summarizes the mean percentage of the right and left stream banks covered with vegetation by habitat type. For the stream reach surveyed, the mean percent right bank vegetated was 73.5%. The mean percent left bank vegetated was 73.1%. The dominant elements composing the structure of the stream banks consisted of 0.8% bedrock, 1.8% boulder, 0.8% cobble/gravel, 5.2% bare soil, 0.8% grass, 18.9% brush. Additionally, 58.7% of the banks were covered with deciduous trees, and 12.9% with coniferous trees, including downed trees, logs, and root wads (Graph 10).

BIOLOGICAL INVENTORY RESULTS

Three electrofishing sites were sampled on Stitz Creek. The objective was to identify fish species and distribution. The units were sampled on June 30, 1992 by Erick Elliot and Brian Humphrey (CCC). Each unit was end-blocked with nets to contain the fish within the sample reach. Three passes were conducted at each site, fork lengths (FL) measured and recorded, and the fish returned to the stream.

The first site sampled was habitat unit 026, a plunge pool, approximately 798 feet from the confluence with the Eel River. This site had an area of 399 sq ft, and a volume of 399 cu ft. The unit yielded one steelhead, 65 mm FL.

The second sample site was habitat unit 043, a plunge pool, located approximately 1,470 feet above the creek mouth. This site had an area of 455 sq ft, and a volume of 364 cu ft. One steelhead was sampled, 147 mm FL.

Stitz Creek

The third site sampled was a step run, located approximately 2,013 feet above the creek mouth and 30 feet above the end of the habitat survey. Two steelhead were sampled, 110 and 134 mm FL.

GRAVEL SAMPLING RESULTS

No gravel samples were taken on Stitz Creek.

DISCUSSION

The B3 channel type is generally not suitable for fish habitat improvement structures. B3 channels are found in moderate gradient stream reaches. They have channels dominated by cobble and gravel, and have unstable stream banks.

The water temperatures recorded on the survey days June 5 & 8, 1992, ranged from 56° F to 57° F. Air temperatures ranged from 57° F to 73° F. This is a very good water temperature regime for salmonids. However, to make any further conclusions, temperatures would need to be monitored throughout the warm summer months, and more extensive biological sampling conducted.

Riffle habitat types comprised 52.4% of the total **length** of this survey, pools 25.5%, and flatwater 22.1%. The pools are relatively deep with 13 of the 22 pools having a maximum depth greater than 2 feet. However, in coastal coho and steelhead streams, it is generally desirable to have primary pools comprise approximately 50% of total habitat. Therefore, installing structures that will increase or deepen pool habitat is recommended for locations where their installation will not interfere with the unstable stream banks of the B3 channel type.

Twenty of the 21 pool tail-outs measured had embeddedness ratings of 3 or 4. None had a 1 rating. Embeddedness in excess of 26%, a rating of 2 or more, is considered poor quality for fish habitat. In Stitz Creek, sediment sources should be mapped and rated according to their potential sediment yields, and control measures taken.

The mean shelter rating for pools was moderate with a rating of 51.6. The shelter rating in the flatwater habitats was lower at 38.2. However, a pool shelter rating of approximately 100 is desirable. The cover that now exists is being provided primarily by boulders in all habitat types. Additionally, large and small woody debris contribute a small amount. Log and root wad cover structures in the pool and flatwater habitats are needed to improve both summer and winter salmonid habitat. Log cover structure provides rearing fry with protection from predation, rest from water velocity, and also divides territorial units to reduce density related competition.

Only three of the 12 low gradient riffles had gravel or small cobble as the dominant substrate. Four of the riffles had silt/clay as the dominant substrate. This is generally considered a poor spawning environment for salmonids.

The mean percent canopy for the stream was 82%. This is a relatively high percentage of canopy, since 80 percent is generally considered optimum in these north coast streams. In areas of stream bank erosion, planting endemic species of coniferous and deciduous trees, in conjunction with bank stabilization, is recommended.

RECOMMENDATIONS

1) Stitz Creek should be managed as an anadromous, natural production stream.

2) Where feasible, design and engineer pool enhancement structures to increase the number of pools. This must be done where the banks are stable or in conjunction with stream bank armor to prevent erosion.

3) Increase woody cover in the pools and flatwater habitat units. Most of the existing cover is from boulders. Adding high quality complexity with woody cover is desirable and in some areas the material is at hand.

4) There are several log debris accumulations present on Stitz Creek that are retaining large quantities of fine sediment. The modification of these debris accumulations is desirable, but must be done carefully over time to avoid excessive sediment loading in downstream reaches. The stream is already over-loaded in fine sediments.

5) Inventory and map sources of stream bank erosion, and prioritize them according to present and potential sediment yield. Identified sites should then be treated to reduce the amount of fine sediments entering the stream.

Stitz Creek

PROBLEM SITES AND LANDMARKS

The following landmarks and possible problem sites were noted. All the distances are approximate and taken from the beginning of the survey reach.

0'	Begin survey at confluence with the Eel River. Channel type is a B3 for the entire survey reach.
159'	Railroad bridge 75' high. Concrete channel with no natural substrate.
181'	Plunge 7' high. CCC/DFG site.
408'	Boulder/log jam 6.5' high; possible barrier.
798'	Log and debris accumulation (LDA) 4.5' high.
1102'	Waterfall 11' high x 13' wide; possible barrier.
1202'	Creek flows through culvert 8' diameter x 100' long.
1470'	Small tributary enters from the right bank.
1761'	LDA 30' wide x 13' long x 6' high.
1860'	LDA 56' wide x 30' long x 11' high.
1928'	LDA 30' wide x 15' long x 9' high; probable barrier.
1983'	LDA 19' wide x 18' long x 8' wide. End of survey due to multiple LDAs, however 1 + steelhead were found 30' above this point during electrofishing.

Stitz Creek

Drainage: Eel River

Table 1 - SUMMARY OF RIFFLE, FLATWATER, AND POOL HABITAT TYPES

Survey Dates: June 5 & 8, 1992

Confluence: T1N R1E S15

UNITS MEASURED	HABITAT TYPE	HABITAT PERCENT OCCURRENCE	MEAN LENGTH (ft.)	TOTAL LENGTH (ft.)	PERCENT TOTAL LENGTH	MEAN WIDTH (ft.)	MEAN DEPTH (ft.)	MEAN AREA (sq.ft.)	TOTAL AREA (sq.ft.)	MEAN VOLUME (cu.ft.)	TOTAL VOLUME (cu.ft)	MEAN RESIDUAL POOL VOL (cu.ft.)	MEAN SHELTER RATING
24	RIFFLE	40.00	45.63	1095.00	52.39	11.10	0.43	408.88	9813.10	160.43	3850.30	0.00	49.58
14	FLATWATER	23.33	33.00	462.00	22.11	8.75	0.55	271.92	3806.90	154.01	2156.10	0.00	38.21
22	POOL	36.67	24.23	533.00	25.50	13.25	1.04	324.12	7130.60	370.97	8161.40	216.90	51.59

TOTAL UNITS	TOTAL LENGTH (ft.)	TOTAL AREA (sq. ft.)	TOTAL VOL. (cu. ft.)
60	2090.00	20750.60	14167.80

Level III and LEVEL IV HABITAT TYPE KEY:

HABITAT TYPE	LETTER	NUMBER
RIFFLE		
Low Gradient Riffle	[LGR]	1.1
High Gradient Riffle	[HGR]	1.2
CASCADE		
Cascade	[CAS]	2.1
Bedrock Sheet	[BRS]	2.2
FLATWATER		
Pocket Water	[POW]	3.1
Glide	[GLD]	3.2
Run	[RUN]	3.3
Step Run	[SRN]	3.4
Edgewater	[EDW]	3.5
MAIN CHANNEL POOLS		
Trench Pool	[TRP]	4.1
Mid-Channel Pool	[MCP]	4.2
Channel Confluence Pool	[CCP]	4.3
Step Pool	[STP]	4.4
SCOUR POOLS		
Corner Pool	[CRP]	5.1
Lateral Scour Pool - Log Enhanced	[LSL]	5.2
Lateral Scour Pool - Root Wad Enhanced	[LSR]	5.3
Lateral Scour Pool - Bedrock Formed	[LSBk]	5.4
Lateral Scour Pool - Boulder Formed	[LSBo]	5.5
Plunge Pool	[PLP]	5.6
BACKWATER POOLS		
Secondary Channel Pool	[SCP]	6.1
Backwater Pool - Boulder Formed	[BPB]	6.2
Backwater Pool - Root Wad Formed	[BPR]	6.3
Backwater Pool - Log Formed	[BPL]	6.4
Dammed Pool	[DPL]	6.5

Stitz Creek   Drainage: Eel River

Table 2 - SUMMARY OF HABITAT TYPES AND MEASURED PARAMETERS   Survey Dates: June 5 & 8, 1992

Confluence: T1N R1E S15

UNITS MEASURED	HABITAT TYPE	HABITAT PERCENT OCCURRENCE	MEAN LENGTH (ft.)	TOTAL LENGTH (ft.)	% TOTAL LENGTH	MEAN WIDTH (ft.)	MEAN DEPTH (ft.)	MAXIMUM DEPTH (ft.)	MEAN AREA (sq.ft.)	TOTAL AREA	MEAN VOLUME	TOTAL VOLUME	MEAN RESIDUAL POOL VOL (cu.ft.)	MEAN SHELTER RATING	MEAN % RT. BANK VEGETATED	MEAN % LT. BANK VEGETATED	MEAN % CANOPY
12	LGR	20.00	56.42	677.00	32.39	10.29	0.34	1.10	497.40	5968.80	166.93	2003.10	0.00	37.50	78.75	74.58	84.17
11	HGR	18.33	36.55	402.00	19.23	12.36	0.46	2.10	339.30	3732.30	157.75	1735.20	0.00	59.09	71.36	77.73	77.27
1	CAS	1.67	16.00	16.00	0.77	7.00	1.00	2.40	112.00	112.00	112.00	112.00	0.00	90.00	70.00	80.00	85.00
5	GLD	8.33	37.80	189.00	9.04	9.50	0.60	2.00	352.30	1761.50	214.38	1071.90	0.00	14.00	61.00	54.00	83.00
5	RUN	8.33	25.20	126.00	6.03	8.30	0.52	1.40	169.98	849.90	89.28	446.40	0.00	54.00	66.00	69.00	85.00
4	SRN	6.67	36.75	147.00	7.03	8.38	0.53	1.80	298.88	1195.50	159.45	637.80	0.00	48.75	85.00	76.25	88.75
12	MCP	20.00	24.00	288.00	13.78	11.83	0.92	3.10	299.30	3591.60	325.46	3905.50	168.91	45.83	71.67	76.25	80.00
2	STP	3.33	40.00	80.00	3.83	10.50	0.95	2.30	427.50	855.00	397.25	794.50	294.00	82.50	77.50	77.50	80.00
1	LSL	1.67	12.00	12.00	0.57	6.50	0.80	1.70	78.00	78.00	62.40	62.40	7.80	60.00	85.00	65.00	95.00
1	LSR	1.67	20.00	20.00	0.96	8.00	0.90	1.60	160.00	160.00	144.00	144.00	96.00	75.00	95.00	90.00	90.00
6	PLP	10.00	22.17	133.00	6.36	19.00	1.38	3.90	407.67	2446.00	542.50	3255.00	342.18	47.50	74.17	68.33	75.00

TOTAL UNITS	LENGTH (ft.)	AREA (sq.ft)	TOTAL VOL. (cu.ft)
60	2090.00	20750.60	14167.80

Stitz Creek

Drainage: Eel River

Table 3 - SUMMARY OF POOL TYPES

Survey Dates: June 5 & 8, 1992

Confluence: T1N R1E S15

UNITS MEASURED	HABITAT TYPE	HABITAT PERCENT OCCURRENCE	MEAN LENGTH (ft.)	TOTAL LENGTH (ft.)	PERCENT TOTAL LENGTH	MEAN WIDTH (ft.)	MEAN DEPTH (ft.)	MEAN AREA (sq.ft.)	TOTAL AREA (sq.ft.)	MEAN VOLUME (cu.ft.)	TOTAL VOLUME (cu.ft)	MEAN RESIDUAL POOL VOL. (cu.ft.)	MEAN SHELTER RATING
14	MAIN	63.64	26.29	368.00	69.04	11.64	0.92	317.61	4446.60	335.71	4700.00	186.78	51.07
8	SCOUR	36.36	20.63	165.00	30.96	16.06	1.25	335.50	2684.00	432.68	3461.40	269.61	52.50

TOTAL MEASURED	TOTAL LENGTH (ft.)	TOTAL AREA (sq.ft.)	TOTAL VOL. (cu.ft.)
22	533.00	7130.60	8161.40

Stitz Creek Drainage: Eel River

Table 4 - SUMMARY OF MAXIMUM POOL DEPTHS BY POOL HABITAT TYPES Survey Dates: June 5 & 8, 1992

Confluence: T1N R1E S15

UNITS MEASURED	HABITAT TYPE	HABITAT PERCENT OCCURRENCE	<1 FOOT MAXIMUM DEPTH	<1 FOOT PERCENT OCCURRENCE	1-<2 FT. MAXIMUM DEPTH	1-<2 FOOT PERCENT OCCURRENCE	2-<3 FT. MAXIMUM DEPTH	2-<3 FOOT PERCENT OCCURRENCE	3-<4 FT. MAXIMUM DEPTH	3-<4 FOOT PERCENT OCCURRENCE	>=4 FEET MAXIMUM DEPTH	>=4 FEET PERCENT OCCURRENCE
12	MCP	54.55	0	0.00	7	58.33	3	25.00	2	16.67	0	0.00
2	STP	9.09	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00
1	LSL	4.55	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00
1	LSR	4.55	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00
6	PLP	27.27	0	0.00	0	0.00	2	33.33	4	66.67	0	0.00

TOTAL
UNITS
22

Stitz Creek

Drainage: Eel River

Table 5 - SUMMARY OF MEAN PERCENT COVER BY HABITAT TYPE

Survey Dates: June 5 & 8, 1992

Confluence: T1N R1E S15

UNITS MEASURED	HABITAT TYPE	MEAN % UNDERCUT BANKS	MEAN % SWD	MEAN % LWD	MEAN % ROOT MASS	MEAN % TERR. VEGETATION	MEAN % AQUATIC VEGETATION	MEAN % WHITE WATER	MEAN % BOULDERS	MEAN % BEDROCK LEDGES
12	LGR	3.75	12.50	19.58	0.83	5.83	0.00	0.83	47.50	0.00
11	HGR	1.36	19.55	10.45	4.55	6.82	0.00	1.82	53.64	1.82
1	CAS	0.00	15.00	40.00	20.00	0.00	0.00	0.00	20.00	5.00
5	GLD	0.00	6.00	16.00	3.00	10.00	0.00	0.00	40.00	5.00
5	RUN	0.00	19.00	22.00	0.00	10.00	0.00	2.00	47.00	0.00
4	SRN	23.75	18.75	12.50	0.00	16.25	0.00	0.00	31.25	0.00
12	MCP	5.00	10.83	26.67	8.33	6.67	0.00	0.00	41.67	0.83
2	STP	0.00	5.00	60.00	5.00	0.00	0.00	5.00	20.00	5.00
1	LSL	50.00	0.00	25.00	0.00	0.00	0.00	0.00	25.00	0.00
1	LSR	60.00	0.00	10.00	30.00	0.00	0.00	0.00	0.00	0.00
6	PLP	13.33	18.33	23.33	10.00	1.67	0.00	4.17	29.17	0.00

Stitz Creek

Drainage: Eel River

Table 6 - SUMMARY OF DOMINANT SUBSTRATES BY HABITAT TYPE

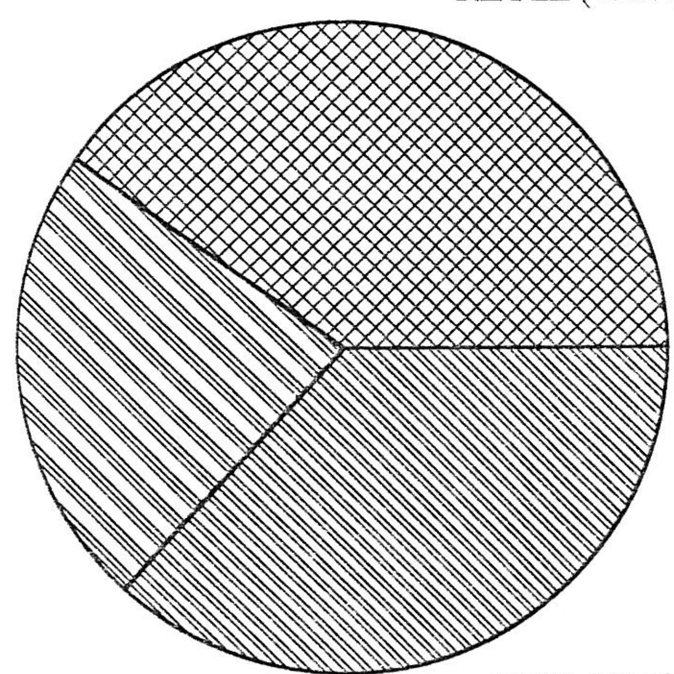
Survey Dates: June 5 & 8, 1992

Confluence: T1N R1E S15

UNITS MEASURED	HABITAT TYPE	# UNITS SILT/CLAY DOMINANT	% TOTAL SILT/CLAY DOMINANT	# UNITS SAND DOMINANT	% TOTAL SAND DOMINANT	# UNITS GRAVEL DOMINANT	% TOTAL GRAVEL DOMINANT	# UNITS SM COBBLE DOMINANT	% TOTAL SM COBBLE DOMINANT	# UNITS LG COBBLE DOMINANT	% TOTAL LG COBBLE DOMINANT	# UNITS BOULDER DOMINANT	% TOTAL BOULDER DOMINANT	# UNITS BEDROCK DOMINANT	% TOTAL BEDROCK DOMINANT
12	LGR	4	33.33	0	0.00	1	8.33	2	16.67	3	25.00	0	0.00	0	0.00
11	HGR	1	9.09	1	9.09	1	9.09	1	9.09	4	36.36	3	27.27	0	0.00
1	CAS	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	GLD	3	60.00	0	0.00	1	20.00	0	0.00	0	0.00	0	0.00	0	0.00
5	RUN	2	40.00	0	0.00	2	40.00	1	20.00	0	0.00	0	0.00	0	0.00
4	SRN	4	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
12	MCP	12	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
2	STP	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	LSL	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
1	LSR	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
6	PLP	6	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

STITZ CREEK

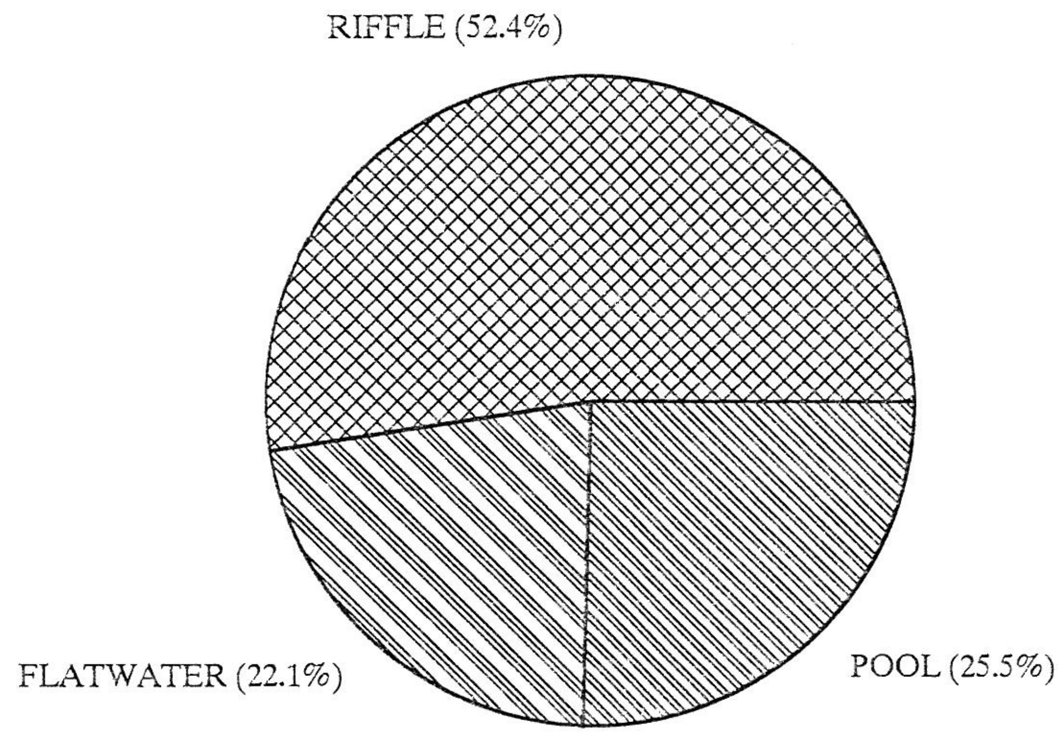
HABITAT TYPES BY PERCENT OCCURRENCE



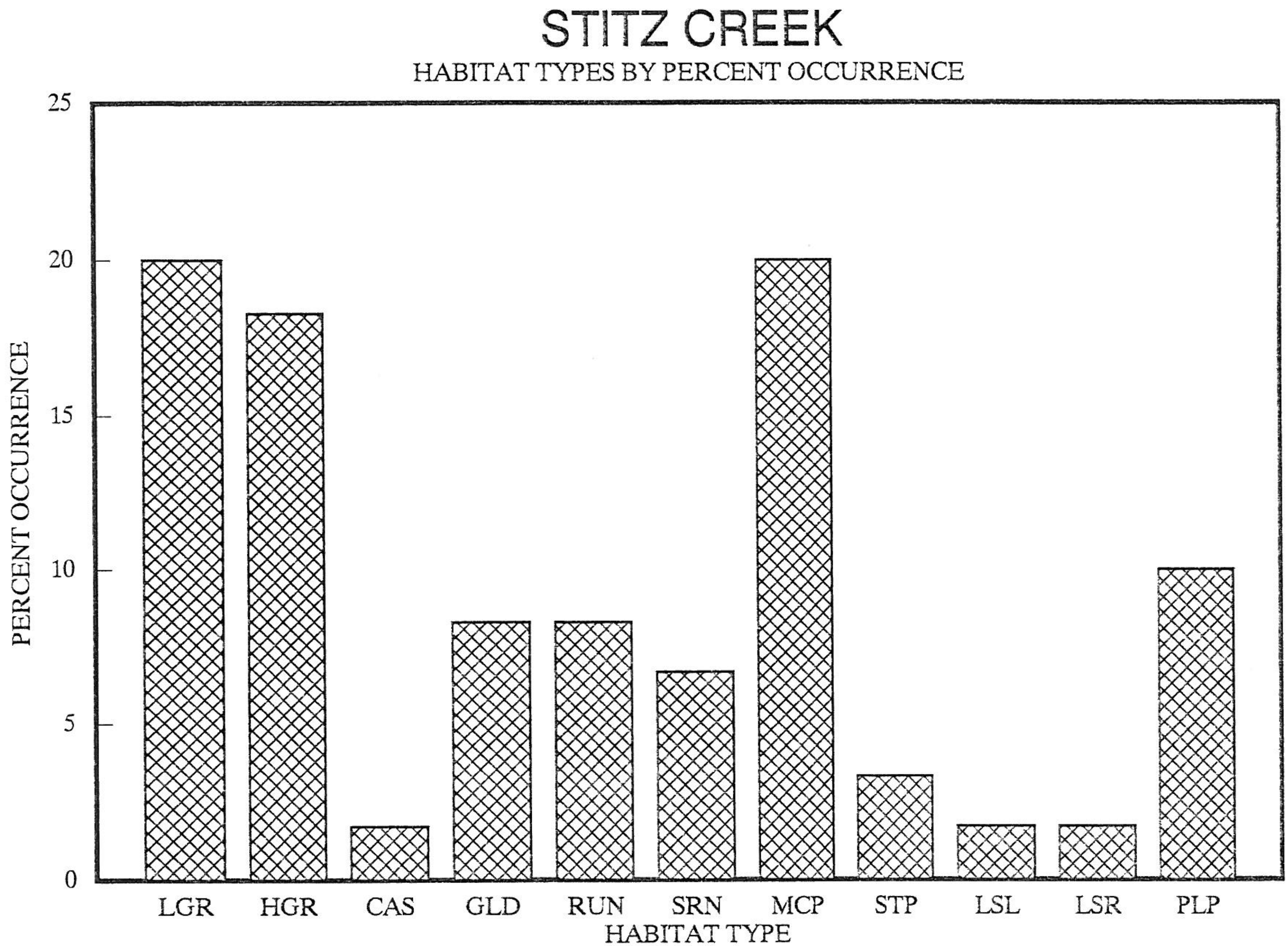
GRAPH 1

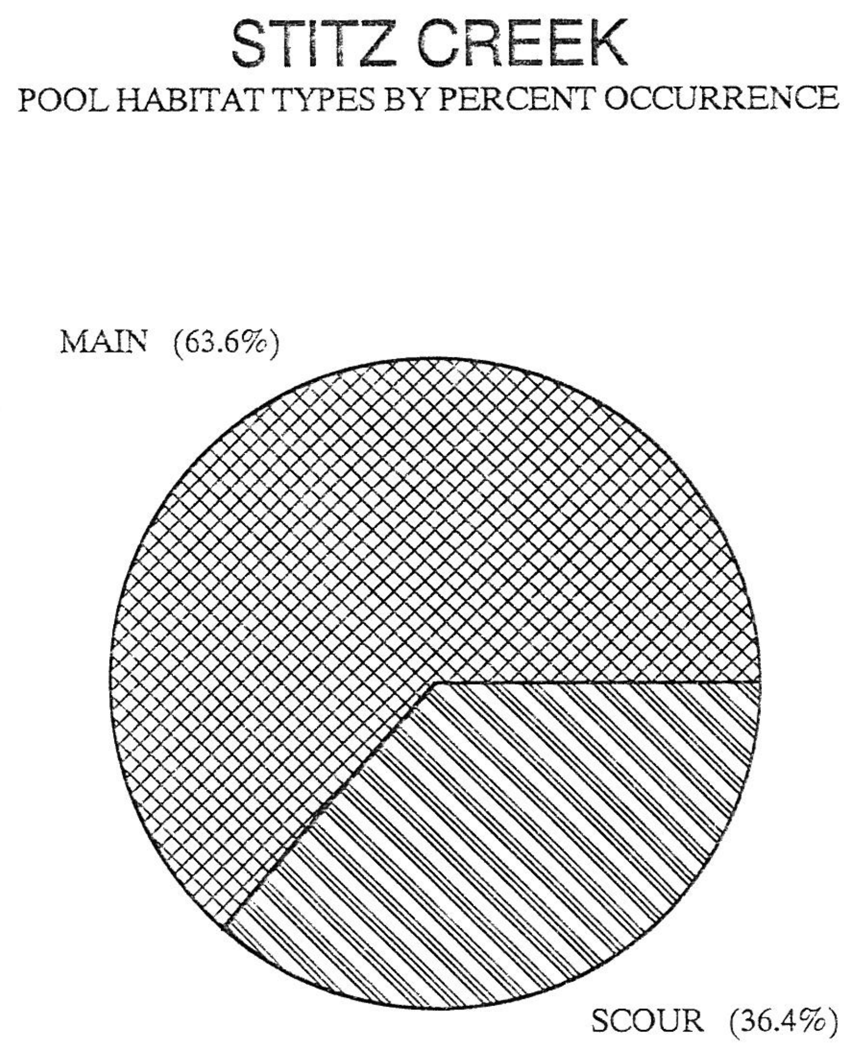
STITZ CREEK

HABITAT TYPES BY PERCENT TOTAL LENGTH



GRAPH 2

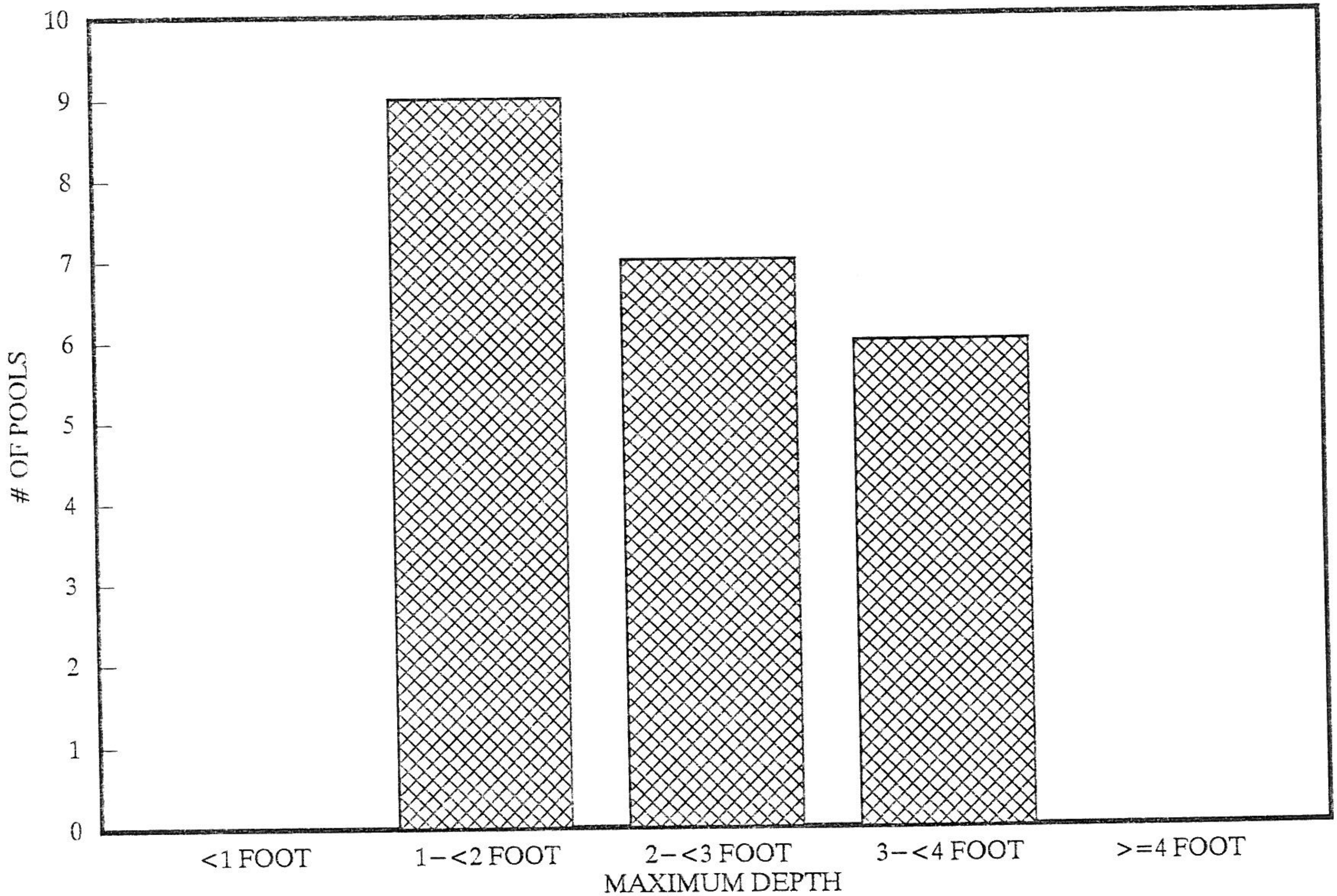

STITZ CREEK
HABITAT TYPES BY PERCENT OCCURRENCE
PERCENT OCCURRENCE
25
20
15
10
5
0
LGR
HGR
CAS
GLD
RUN
SRN
MCP
STP
LSL
LSR
PLP
HABITAT TYPE
GRAPH 3


STITZ CREEK
POOL HABITAT TYPES BY PERCENT OCCURRENCE
MAIN (63.6%)
SCOUR (36.4%)

GRAPH 4

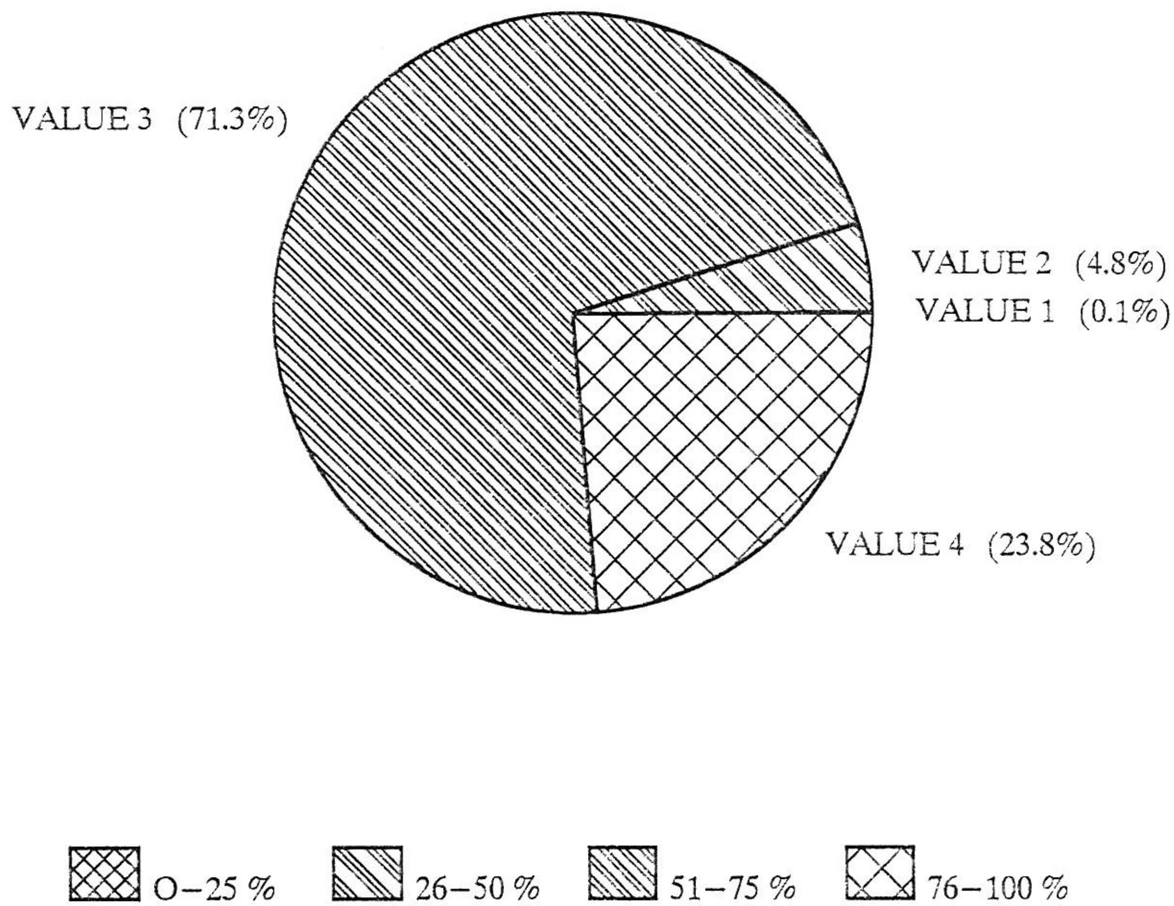
STITZ CREEK

MAXIMUM DEPTH IN POOLS



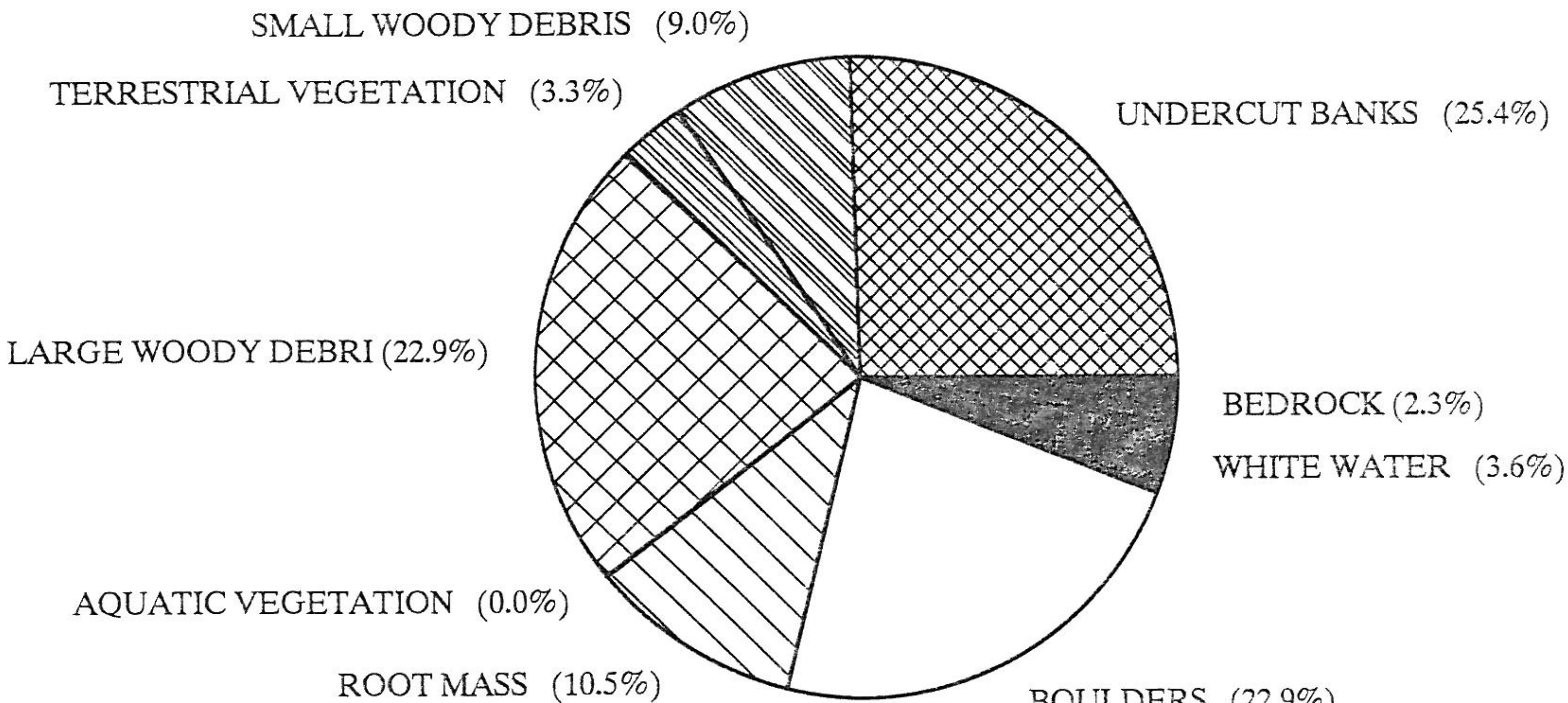
GRAPH 5

STITZ CREEK
PERCENT EMBEDDEDNESS



GRAPH 6

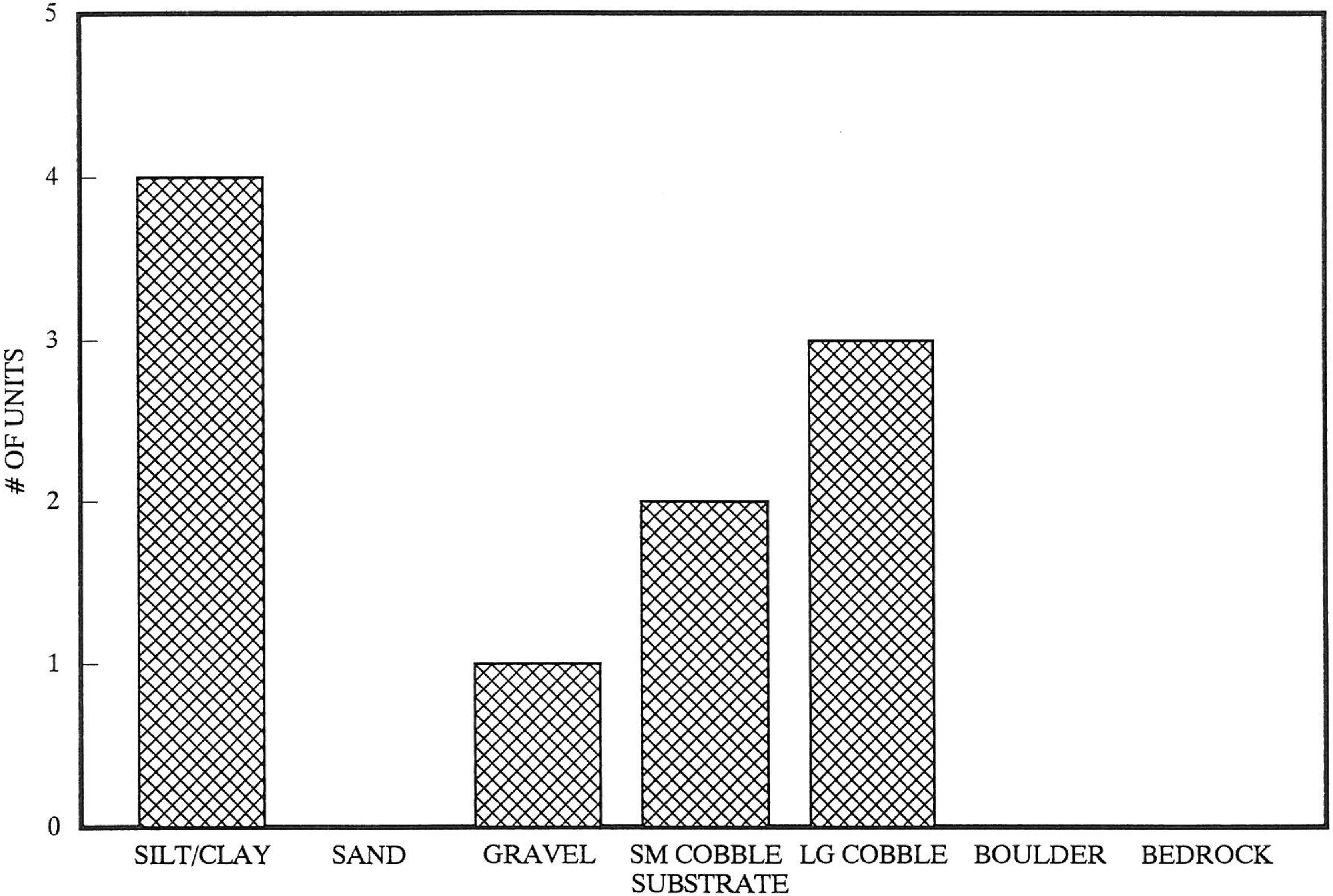
STITZ CREEK
MEAN PERCENT COVER TYPES IN POOLS



GRAPH 7

STITZ CREEK

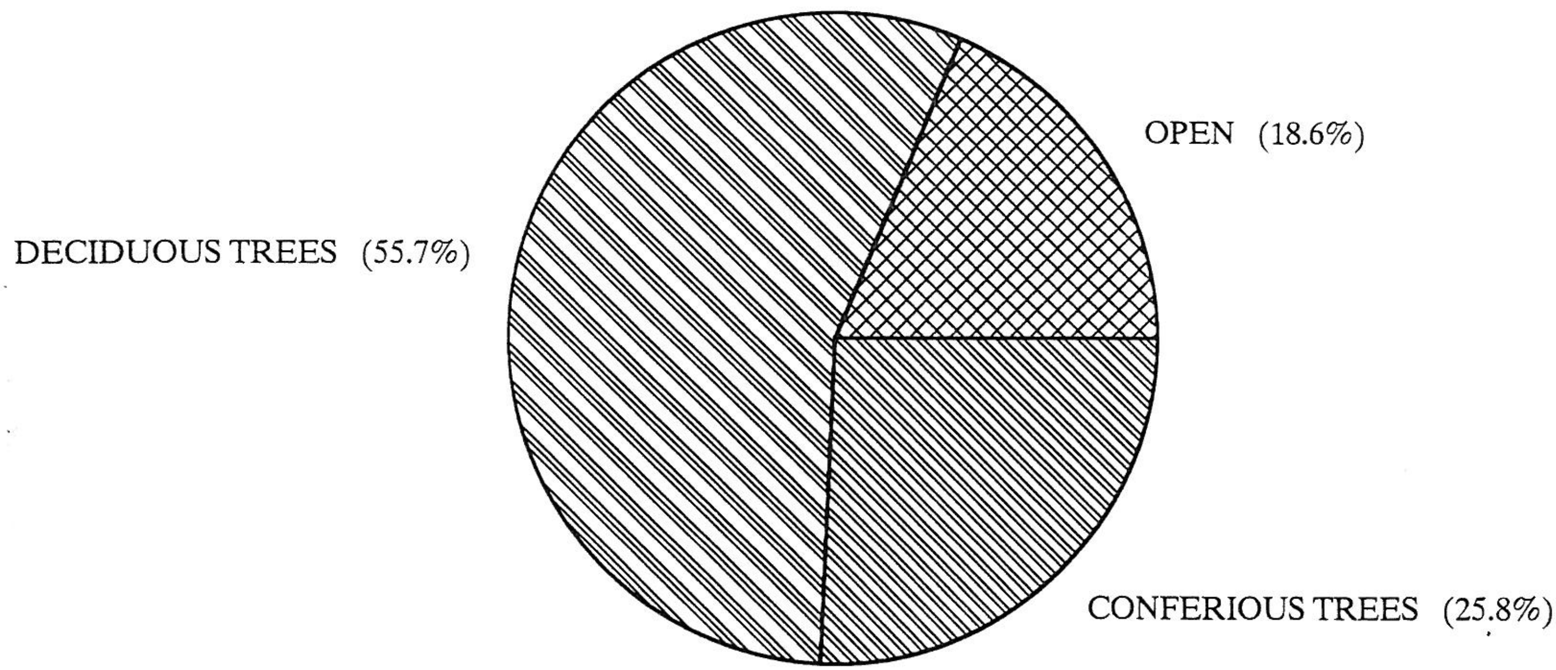
SUBSTRATE COMPOSITION IN LOW GRADIENT RIFFLES



GRAPH 8

STITZ CREEK

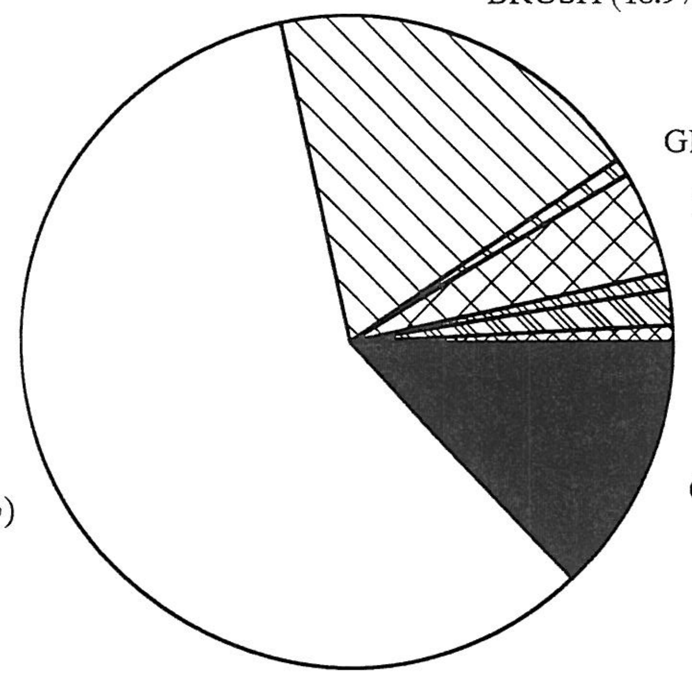
PERCENT CANOPY



GRAPH 9

STITZ CREEK

PERCENT BANK COMPOSITION



GRAPH 10


STITZ CREEK
FISH SPECIES BY LENGTH
OF FISH
2.5
2
1.5
1
0.5
0
<75
76–125
>125
FORK LENGTH OF FISH
STEELHEAD
SILVER SALMON
KING SALMON

GRAPH 11

St

Scotia Pacific Co, LLC.

8 February 2000

TO: John Clancy – NMFS
FROM: Robert Darby

Hi John,

Sorry this letter was not sent to you earlier but the crew that worked on the project was not available to ask questions of until just recently. Attached please find a diagram of the culvert to give you a brief example of what the conditions are. Here are a few brief notes about Stitz Creek

At the end of September 1999, a PALCO field crew did a brief presence absence survey above the Stitz Creek Culvert (approx. 3 Miles south of the town of Scotia). The survey consisted of a 250 ft stretch of creek above the culvert. This stretch had two pools considered likely to contain fish. Only three fish were encountered, two from one pool and one from the other. The first pool contained a 0+ rainbow trout (Approx 37 mm, steelhead or resident is unknown) and one cutthroat trout (approx 170mm). The other pool contained one cutthroat trout (220 mm). The area directly above the culvert had a debris torrent from a side tributary a year earlier. The amount of LWD in this immediate area is excessive (over 200 pieces in less than 500 ft). If any proposed work below the culvert required the use of LWD, wood from above the culvert should be considered. In addition, due to the amount and size of the LWD and the size of the culvert, natural movement or recruitment of LWD downstream to below the culvert is most likely not possible. The Culvert and the road which passes over it belong to County of Humboldt.

PALCO has very little historic data on this creek. However if there is an interest in any research or enhancement work on Stitz Creek, PALCO would like to be informed and would be willing to assist if possible.

I am sorry there is not more data available. I appreciate your interest and if I can be of any help in the future please let me know.

Robert Darby
Aquatic Biologist, Scotia Pacific Co., LLC
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(707) 764-4118 Fax

A Brief Look At Stitz Creek Culvert