Coastal Watershed Council

Draft Aptos Creek Watershed Assessment and Enhancement Plan

Coastal Watershed Council

Aptos Creek Watershed Assessment and Enhancement Plan

April 2003

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I. EXECUTIVE SUMMARY

Introduction

Major declines in salmon populations throughout the West Coast over the last few decades have prompted numerous restoration efforts in California. In order to promote sound, effective salmonid habitat restoration, a comprehensive watershed approach is needed. Prior to 2001, few watershed studies focused on Aptos Creek (Figure 1) or any of its major tributaries (Valencia Creek, Trout Gulch, Mangels Gulch and Bridge Creek). Therefore, there was a strong need to conduct a thorough evaluation of factors that may be adversely impacting salmonid populations within Aptos Creek.

Currently, coastal waterways in Central California and Southern California contain the smallest populations of coho salmon and steelhead. By preserving and restoring fish habitat within these areas, we can increase the likelihood that they will remain in this portion of their range thereby maintaining population and species diversity. Coho salmon and steelhead trout habitat are both present in Aptos Creek, although no coho have been observed in recent years. However, Aptos Creek is identified as one of nine watersheds targeted in the Draft Strategic Plan for Restoration of Endangered Coho Salmon South of San Francisco Bay, (CDFG, 1998).

Plan Objectives

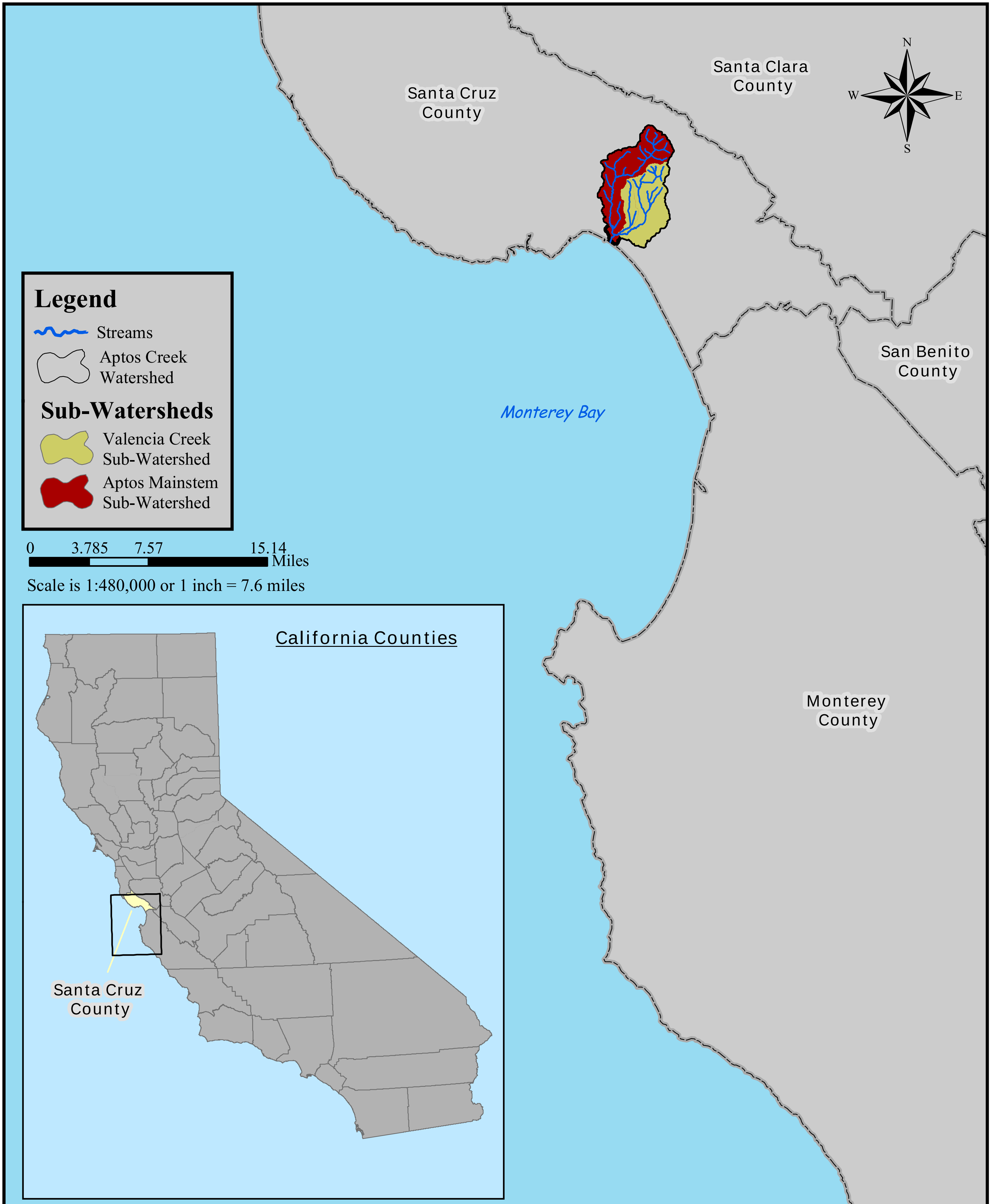
The Aptos Creek Watershed Assessment and Enhancement Plan, funded by the State Coastal Conservancy (SCC) and the California Department of Fish and Game (CDFG), was managed by the Coastal Watershed Council (CWC). Focusing primarily on Aptos and Valencia Creeks (where salmonid habitat is present), the assessment evaluated the following factors throughout Aptos Creek watershed,):

1) Fisheries habitat
2) Hydrology and water quality
3) Geomorphology
4) Riparian habitat

Based on assessment findings and restoration recommendations, projects designed to improve salmonid habitat were developed and prioritized. This Enhancement Plan is a tool for stakeholders, including watershed residents, to implement informed watershed restoration projects that will primarily benefit steelhead trout and coho salmon.

Planning Process and Methodology

A successful watershed enhancement plan is one that will be embraced by many stakeholders, especially watershed landowners. Although this Enhancement Plan is geared towards ready-to-implement salmonid habitat restoration projects, long term restoration will best be accomplished by informed, conservation-based



Swanson Hydrology and Geomorphology 115 Limekiln St. Santa Cruz, CA 95060 tel. 831-427-0288 fax. 427-0472	Aptos Creek Watershed Regional Location	Figure 1

land use practices. This will be most effectively carried out by voluntary, non-regulatory landowner participation.

To increase the validity and the breadth of this Enhancement Plan, we called upon several entities to review the assessment findings and develop the recommendations. The technical team was comprised of the following technical scientists and funding agency representatives:

Aptos Creek Watershed Assessment and Enhancement Plan Technical Team Members

Name	**Title**	**Entity Represented**
Maya Conrad	Project Manager	Coastal Watershed Council
John Dvorsky	Project Manager/Geomorphologist	Swanson Hydrology & Geomorphology
Jeff Hagar	Fisheries Biologist	Hagar Environmental Studies
Nicole Beck	Geochemist/Hydrologist	Swanson Hydrology & Geomorphology
Kathleen Lyons	Ecologist	Biotic Resources Group
Marty Gingras	Grant Manager/Fisheries Biologist	California Department of Fish & Game
Kate Goodnight	Grant Manager	State Coastal Conservancy

Other groups made essential contributions, including the community at large, a public advisory group, and a technical advisory group.

Public meetings occurred at the onset and conclusion of the project, where information about the Assessment and Plan was disseminated and opportunities for public comment were provided. Additionally, a public advisory group, or PAG, was convened to:

- Share their knowledge of the watershed;
- Learn about the Assessment methodologies;
- Provide input on the proposed work;

- Review findings and recommendations; and
- Brainstorm community-based or outreach-based restoration projects

A technical advisory committee (TAC), comprised of scientists with strong knowledge of watershed processes, convened at appropriate milestones to:

- Review and comment on assessment methodologies
- Provide additional scientific expertise
- Review assessment findings and recommendations
- Prioritize recommendations

Many of the TAC members also represent local resource agencies; their participation in the Assessment increases collaboration with concurrent projects and will hopefully facilitate future restoration efforts.

Major Findings and Recommendations

Assessment findings and recommendations were developed through a thorough interdisciplinary approach that included:

1) Historical data review
2) Field studies
3) Data analysis
4) Data synthesis
5) Technical review

A comprehensive list of findings and recommendations is included in Section III. These recommendations are provided to steer restoration efforts by local resource agencies, community groups and landowners over time.

The primary assessment findings and recommendations are divided by reaches within the watershed and are summarized here:

Watershed-wide (includes findings that apply to the entire Aptos watershed, including all tributaries):

Findings
The primary limiting factors within the Aptos watershed are:

1) Sediment
2) Lagoon water quality

3) Urbanization

Recommendations
- Reduce sediment delivery to the channel
- Provide landowner outreach materials for best management practices (e.g. "Stream Care Guide" produced by the County of Santa Cruz)
- Create landowner incentive programs to minimize sediment delivery and peak flows during storm events
- Emphasize the overall importance of maintaining baseflow in an urbanized watershed
- Conduct erosion-risk assessments on private and public roads and develop sediment reduction plans

Aptos Lagoon (includes the mouth of Aptos Creek at Seacliff State Beach upstream to Spreckel's Bridge):

Findings
- Coastal lagoons provide important rearing habitat for steelhead trout
- Food availability for steelhead is the primary limiting factor in Aptos lagoon
- Artificial (and illegal) breaching of the summer sandbar occurs
- Water quality is impaired, overall
- There is a lack of cover for fishes
- Lagoon enhancement can increase steelhead rearing habitat, decrease temperature and increase food availability

Recommendations
- Evaluate opportunities and constraints to expand the lagoon through a feasibility study
- Create public outreach materials including signage and brochures that emphasize importance of lagoons for salmonids
- Improve water quality and lagoon habitat
- Purchase adjacent land from any willing landowners for floodplain restoration

Spreckel's Bridge to Valencia Creek confluence (includes a short reach (0.1 mile) to the confluence of Valencia Creek at stream mile 0.3):

Findings
- This section contains relatively low-quality salmonid rearing habitat
- The grade control at Spreckel's Bridge is holding back a large volume of sediment and is a partial barrier during certain flows

- Several homes are within the flood plain

Recommendations

- Modify barrier at Spreckel's Bridge
- Public outreach about proper yard debris disposal and importance of maintaining riparian corridor
- Focus of any restoration efforts should incorporate flood control (no structures should be added to enhance this reach)

Lower Valencia Creek (includes the mouth of Valencia Creek to the Valencia Road culvert crossing):

Findings

- Valencia Creek contained good salmonid habitat prior to the severe 1982 storm event
- Sedimentation is a major issue within Valencia Creek
- Three fish barriers are limiting access to salmonid habitat (adjacent to Highway One, under Soquel Drive and under Valencia Road)
- Flow is a limiting factor
- Most of the sedimentation is caused by bank erosion due to human encroachment
- Runoff from impermeable surfaces is increasing the peak flow during rain events

Recommendations

- Attenuate the peak flow to reduce streambank erosion and turbidity
- Remove or modify three fish barriers located at Highway One and Soquel Avenue crossings
- Develop programs for residential water catchment such as roof runoff cisterns for irrigation purposes to reduce peak flow and increase groundwater infiltration
- Provide education and outreach for better land use practices (including brochures, public service announcements, workshops, etc.)
- Reduce bank erosion and sedimentation through best management practices

Upper Valencia Creek (from the Valencia Road crossing to the extent of anadromy[1]

Findings

- Steelhead habitat upstream of Valencia Road culvert is relatively high quality
- Land-use is primarily rural residential and some timber lands in the upper watershed

Recommendations:

- Modify Valencia Road culvert or replace with a bridge

[1] Extent of anadromy refers to the highest point upstream that salmonids can access in a stream or river.

- Assess and develop a sediment reduction plan for any unpaved roads near the creek
- Preserve natural flows

Trout Gulch (includes the entire Trout Gulch tributary)

Findings
- This subwatershed is highly developed (primarily residential)
- Only low quality salmonid habitat is present; no pools are present and the drainage is very sandy
- Although there is a high degree of sedimentation within this drainage, there is limited benefit to reducing sediment here due to the lack of habitat and because it releases low in the Aptos watershed

Recommendations:
- Focus should be on landowner outreach and should include best management practices recommended for Valencia Creek
- Coordinate with the County of Santa Cruz to improve Trout Gulch road-associated problems

Mangel's Gulch (includes the entire Mangel's Gulch tributary)

Findings
- A barrier exists near the confluence with Aptos Creek
- The creek is dry during much of the year

Recommendations
- Provide landowner outreach materials that include the best management practices recommended for Valencia Creek

Lower Aptos Creek (extends from the confluence of Valencia Creek to the lower boundary of Forest of Nisene Marks State Park)

Findings
- Good quality salmonid habitat was observed but fewer fish than expected were observed during Hagar's 2001 surveys
- Canopy cover is low in some places
- Large woody material provides important habitat

Recommendations:
- Conduct water quality monitoring
- Provide landowner outreach materials that include the best management practices recommended for Valencia Creek

- Leave large woody material in place; if modification of a jam is needed, have a qualified geomorphologist and fisheries biologist evaluate it first

Upper Aptos Creek (includes the Forest of Nisene Marks State Park to the extent of

anadromy)

Findings

- Sediment is the primary limiting factor
- Reach A5 (Figure 2) is the most productive reach and is an important reach for spawning, especially near Bridge Creek
- Bridge Creek and Reach A6 contain multiple large wood jams (naturally induced) that are partial barriers
- There is a high degree of recreational trail use in the lower park

- Several unimproved creek crossings and rock dams are present throughout reaches A3-A4

Recommendations:
- Keep bikes and pedestrian traffic out of creek and away from spawning areas during spawning season (November-April)
- Restore creek crossings and build bridges to limit bike, pedestrian and vehicular travel through creek
- Improve trail and road maintenance
- Focus restoration efforts on A3 and A4 where impacts from recreational use are greatest
- Provide outreach signage and brochures to educate recreational users about steelhead habitat

Next Steps- Prioritized Project List

The overarching goal of the Aptos Watershed Enhancement Plan was to develop restoration recommendations. Out of these recommendations, a list of projects was created to enhance the quantity and quality of salmonid habitat for both coho salmon and steelhead. This project list is not a comprehensive list, but was derived from the recommendations as a subset of projects that are either ready to implement or easy to develop.

The projects listed below incorporate several objectives that include:

- The project should increase fish population over time
- The project must be durable (it will last a long time)
- The project should be both feasible and cost-effective
- Habitat enhancement should be quantifiable

Based on the findings and recommendations and input from the TAC and PAG, the technical team developed a list of prioritized projects for the entire Aptos Creek watershed. This list has been developed to provide a watershed-scale perspective useful to planning restoration objectives. We hope that funders and restorationists alike will use this document to implement and make informed decisions about salmonid restoration within the Aptos Creek watershed.

The table below lists the projects, descriptions and priority (1= high). Several high priority projects (ranked 1 or 2) are detailed, including cost estimates, as conceptual plans in Section III to facilitate future implementation and are described more fully than the other projects. Potential project leads are discussed in Section III.

Table 1: Prioritized salmonid restoration projects for Aptos Creek watershed

Location	Project Title	Brief Project Description	Priority (1-5)
Lower Aptos Creek	Spreckels Road grade control modification	Modify the partial fish barrier at the grade control just upstream of Spreckels Bridge.	1
Lower Valencia Creek	Soquel Avenue culvert fish ladder	Engineering plans have been developed to install a fish ladder at this location. Funding and permitting are needed.	1
Upper Aptos Creek	Stormproof Aptos Creek Road	A road assessment & erosion reduction plan.	1
Lower Aptos Creek	Lagoon Enhancement feasibility study	Evaluation of lagoon enhancement feasibility through land acquisition and restoration.	2
Lower Valencia Creek	Highway 1 culvert modifications	Modification to improve fish passage & reduce future maintenance at 2 culverts downstream of Soquel Ave.	2
Upper Valencia Creek	Valencia Road culvert modification / bridge	Evaluate alternatives to current culvert. Options include; a span bridge, arch culvert, or modifications to existing conditions.	2
Watershed-wide	Aptos watershed roof runoff detention/surface water capture program	Develop an incentive program for a roof runoff collection system to detaining runoff and provide landscape irrigation.	2
Watershed-wide	Aptos watershed road runoff pretreatment & detention/surface water infiltration program	Install sediment traps for pretreatment, and a modified culvert system that can act as an efficient detention system.	2
Valencia watershed	Valencia watershed roads assessment (County/private)	Conduct a roads assessment and erosion reduction plan for private and County-maintained roads.	2
Aptos Creek (Forest of Nisene Marks S. P.)	Public outreach regarding salmonid habitat conditions (FNMSP & Lagoon)	Educational materials/signage at stream crossings & interpretive centers about salmon & how to minimize recreational impacts.	3
Lower Nisene Marks State Park	Trail management plan/maintenance guidelines for Forest of Nisene Marks State Park	Develop a program to reduce erosion, decommission illegal or duplicate trails, and keep users on designated trails	3
Lower Aptos, Mangel's Gulch	Water quality monitoring	Install continuous water quality samplers in and adjacent to Mangel's Gulch.	4
Aptos Creek near Kiosk	Aptos Creek trails and crossings upgrades to pedestrian bridges	Clearly define designated recreational crossings and install permanent pedestrian and bike crossings	4
Aptos Creek Road (reaches A4 & A5)	Remediate and upgrade existing stream crossings (2)	Install bridges to prevent any vehicular traffic fords at creek crossings and restore adjacent habitat.	5
Aptos Creek at Old Mill Site	Exotic vegetation management	Remove invasive exotic vegetation at problematic sites, such as the Old Mill site, & revegetate with native plants.	5
Watershed-wide	Erosion source treatment	Prioritize & treat erosion sources in Table 11 of the Aptos Geomorphic & Erosion Source Technical Report.	Not ranked
Valencia Creek watershed	Valencia hydrology/geomorphology assessment	Comprehensive, multi-year studies to more closely examine baseflow and sediment transport dynamics.	Not ranked

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II. APTOS CREEK WATERSHED ENHANCEMENT PLAN

INTRODUCTION

California salmon populations have declined by an estimated 90% during the last 50 years. As a result, the National Marine Fisheries Service listed many salmonid species throughout California as "threatened" or "endangered" under the federal Endangered Species Act during the last decade. Coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Oncorhynchus mykiss*) in Central Coast streams were federally listed as "threatened" in the mid 1990s. Additionally, coho salmon south of San Francisco Bay were listed by the State as endangered in the 1990s.

What caused such major declines? Cumulative land use impacts have degraded salmonid spawning habitat over the last century. Additionally, many environmental factors far beyond our control - ocean temperature and food availability changes, shifts in winter storm patterns and severity, and prolonged periods of drought, for example – have contributed to the population declines.

What can we do to stop the salmon and steelhead declines within the Central Coast region? Coho salmon and steelhead are "anadromous" fish meaning they spawn and grow in freshwater streams and rivers until they are too big to find sufficient food. They undergo a transformation called "smoltification" which allows them to enter the Pacific Ocean where they can forage for bigger and more abundant prey. After a couple of years, they return to their natal stream (where they were born) to spawn. While coho only spawn once and then die, steelhead can spawn and return to the ocean more than once. While we have no control over climatic changes and ocean conditions, we can improve degraded freshwater spawning and rearing habitat to help stabilize and potentially increase juvenile survival rates.

Are we saying that people shouldn't work and live near the creek? No. This Enhancement Plan is designed to be a voluntary, non-regulatory approach towards salmonid restoration. A successful watershed enhancement plan is one that will be embraced by many stakeholders, especially watershed landowners. Long term restoration will best be accomplished by informed, conservation-based land use practices. This will be most effectively carried out through:

- Implementation of restoration projects by willing landowners
- Conducting demonstration projects on public lands
- Public outreach and education
- Increasing coordination with regulatory agencies
- Creating landowner incentive programs for restoration measures
- Providing restoration funding and technical assistance for landowners

How do we approach habitat restoration? Watershed science is a complicated mesh of geology, hydrology, biology and sociology. However, over the last century, we have learned a great deal about how our land uses impact the natural environment. We can use what we've learned in similar watersheds and what we've recently learned in the Aptos watershed to understand big picture watershed processes. Consequently, several catchy terms like "best management practices" (practices like erosion control and riparian plantings that limit our impacts to the environment) and "adaptive management" (learning from our mistakes) have provided us with a myriad of science-based restoration tools to promote resource sustainability.

Purpose of the Plan

The purpose of the Watershed Assessment and Enhancement Plan is to synthesize both historic information and assessment data to create a comprehensive salmonid restoration plan. Prior to this assessment, few watershed studies existed for the Aptos and Valencia Creek areas.

Background

Aptos Creek watershed, including Valencia Creek, is located in southern Santa Cruz County approximately 8.5 miles south of the city of Santa Cruz and encompasses approximately 24.5 square miles. It is located within the Aptos-Soquel Hydrologic subarea, inside the larger Big Basin Hydrologic Unit. The watershed extends from the upper Santa Cruz mountains down to Seacliff State Beach at Rio Del Mar. The perennial stem of Aptos creek surfaces along the Santa Rosalia Ridge at approximately 2,502 ft from sea level. Approximately sixty percent of the watershed (mainstem Aptos Creek) includes the Forest of Nisene Marks State Park. From the headwaters in the Santa Cruz Mountains, Aptos Creek and its tributaries flow west through the town of Aptos and drain into the Monterey Bay National Marine Sanctuary (Figure 1).

The remaining 40% of the watershed is primarily privately owned, with the exception of Aptos Village Community Park (owned by the County of Santa Cruz) and the State Beach. Upper Valencia Creek watershed includes rural residential, timber and agriculture lands. The lower portions of the Aptos watershed are predominantly suburban and urban residential and commercial. Urbanization throughout the lower watershed has resulted in a highly altered channel that includes bank protection, channelization, riprap and other bank protection, road crossings and buildings within the floodplain.

Project Methods

Comprehensive field data were collected for the Assessment. However, it should be noted that there were data-gathering limitations due to lack of access to private lands and also the lack of historical data available. Also, time constraints and funding limitations restricted the breadth of information collected. Methods for data collection are summarized in this section. Copies of full assessment reports, including methods and results, are attached as appendices.

A. Salmonid Habitat Assessment and In-Channel Large Woody Debris (LWD) Surveys

Fisheries habitat was assessed by Hagar (**Appendix A**) between late August and early October 2001 using the California Salmonid Stream Habitat assessment methodology (1998). Surveys were completed in 8.5 miles of Aptos Creek from the mouth upstream to a point southeast of Whites Lagoon. Bridge Creek was surveyed from the Aptos Creek confluence upstream for 1.2 miles. A total distance of 5.2 miles in Valencia Creek was surveyed from the Aptos Creek confluence to approximately 1.7 miles upstream of Valencia Road. Trout Creek Gulch was surveyed from the Valencia Creek confluence to the road crossing 1.3 miles upstream. A short section of Mangels Gulch was surveyed but most of the creek was dry.

Prior to initiating field surveys, the watershed was segmented into discrete reaches (Figure 2) based on gradient, tributary inflow, stream channel type, natural barriers, and other available channel morphology data. Reach designations were confirmed or adjusted during the field surveys based on actual channel conditions.

Stream habitat types were inventoried in accordance with the California Salmonid Stream Habitat Restoration Manual (Flosi et al. 1998) with the following modifications:

- Habitat typing was conducted at a Level IV classification using a ten percent sampling protocol (Flosi et al. 1998).
- In each sample reach all habitat units were identified by type and length measured. First encounters for each habitat type, and a randomly selected 10% sample will be characterized in full detail.
- Maximum depth, pool tail crest depth and pool tail embeddedness were recorded for every pool encountered.
- Canopy density was recorded for every third habitat unit.
- Bank composition and vegetation components were not included since detailed information on these features was collected in the geomorphic and erosion/deposition assessment (Task 2) and riparian and overstory description and mapping task (Task 4).

As an additional layer of information and to aid in interpreting the habitat assessment data, visual observations of fish were also recorded during the habitat assessment. In conjunction with the habitat assessment, large woody debris occurring within the channel was tabulated by size using the protocol outlined in the CDFG Salmonid Stream Habitat Restoration Manual (Flosi et. al., 1998). Information describing the impact LWD has on channel structure, pool formation and habitat complexity within each reach was also collected.

B. Geomorphic and Erosion/Deposition Assessment

The goal of the geomorphic data collection and analysis was to characterize erosion sources and channel conditions to a level that would allow for development of a sediment budget approximation. Swanson Geomorphology and Hydrology (SH&G) assessed the information in the context of existing fish habitat to develop sound recommendations for sediment reduction that would give the greatest benefit to fisheries (**Appendix B**).

<u>Characterization of Dominant Erosion Sources</u>
Identifying the dominant sources of erosion in the Aptos Creek Watershed involved several steps including:

- **Existing Data Review and Collection**
  Landslides were mapped in the Forest of Nisene Marks State Park as part of a study conducted to look at seismically-induced landslides and estimates of landsliding using local and regional erosion rates were made.
- **Aerial Photo Interpretation**

Erosion scars were located, characterized, and digitized into a GIS database using historic and recent aerial photos. Each erosion site was characterized by process (e.g. – debris flow, landslide, road failure, etc.), age-estimated, and assessed as natural or anthropogenic (e.g. – adjacent to roads, land use related, etc.).

- **Erosion Map**
  An erosion map, incorporating local geology, was generated depicting erosion sources mapped from existing data and aerial photos.
- **Field Reconnaissance**
  The erosion map and sample subunits were used to locate and sample grain-size at identified erosion sites. Additional erosion sources were identified and sampled (depending on the type of erosion and number of samples collected to date) and added to the erosion map

Evaluation of Channel Conditions

Channel conditions were evaluated throughout the Aptos Creek Watershed through pebble counts (Wolman, 1954) and cross-section surveys at selected reaches within the watershed. The grain size information was compared throughout the watershed to determine reaches where depositional and erosion of fine grain sediments within the channel are occurring. Streambank erosion rates were estimated along the same reaches that were surveyed for fish habitat conditions. Additionally, sites with bank erosion were identified during the habitat surveys. This information was used to compute an erosion rate per unit of stream length assuming a retreat rate based on an activity rating.

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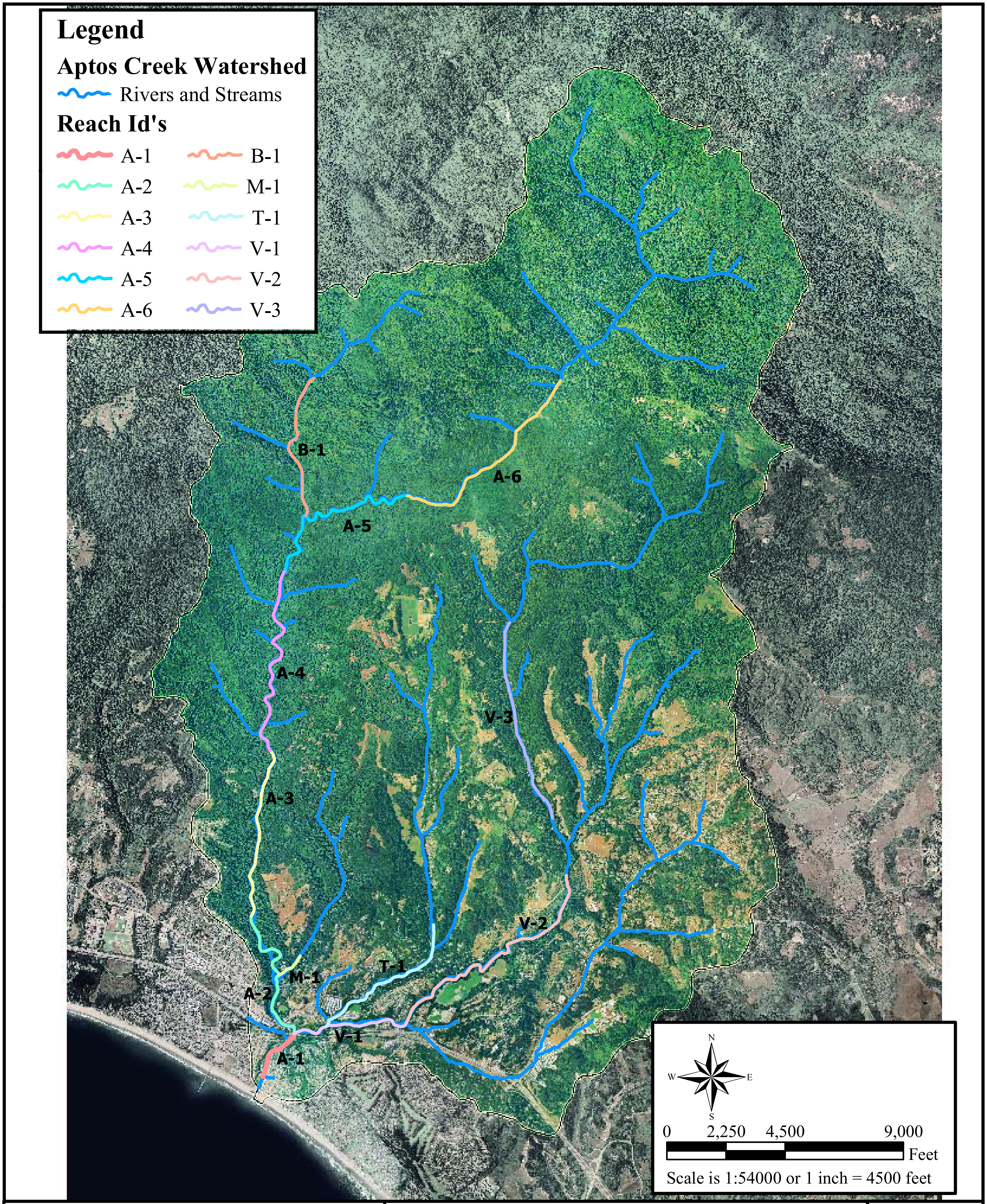

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Reach Id's
Aptos Creek Watershed
Assessment and Enhancement Plan

Figure 2

C. Hydrologic and Water Quality Assessment

Continuous Discharge Measurements & Synoptic Flow/Seepage Rate Studies

Four flow monitoring stations were established by SH&G that consisted of continuously recording water level pressure transducers and staff plates (Figure 3). The locations were in the lower watershed of each major tributary (Valencia Creek, Trout Creek, and Aptos Creek) to understand flow contributions from each (**Appendix C**), and an additional site just downstream of the confluence of the three major tributaries (Aptos Creek at Spreckles Bridge) (Figure 2). Water level was recorded at 30-minute intervals and downloaded every 30 to 40 days.

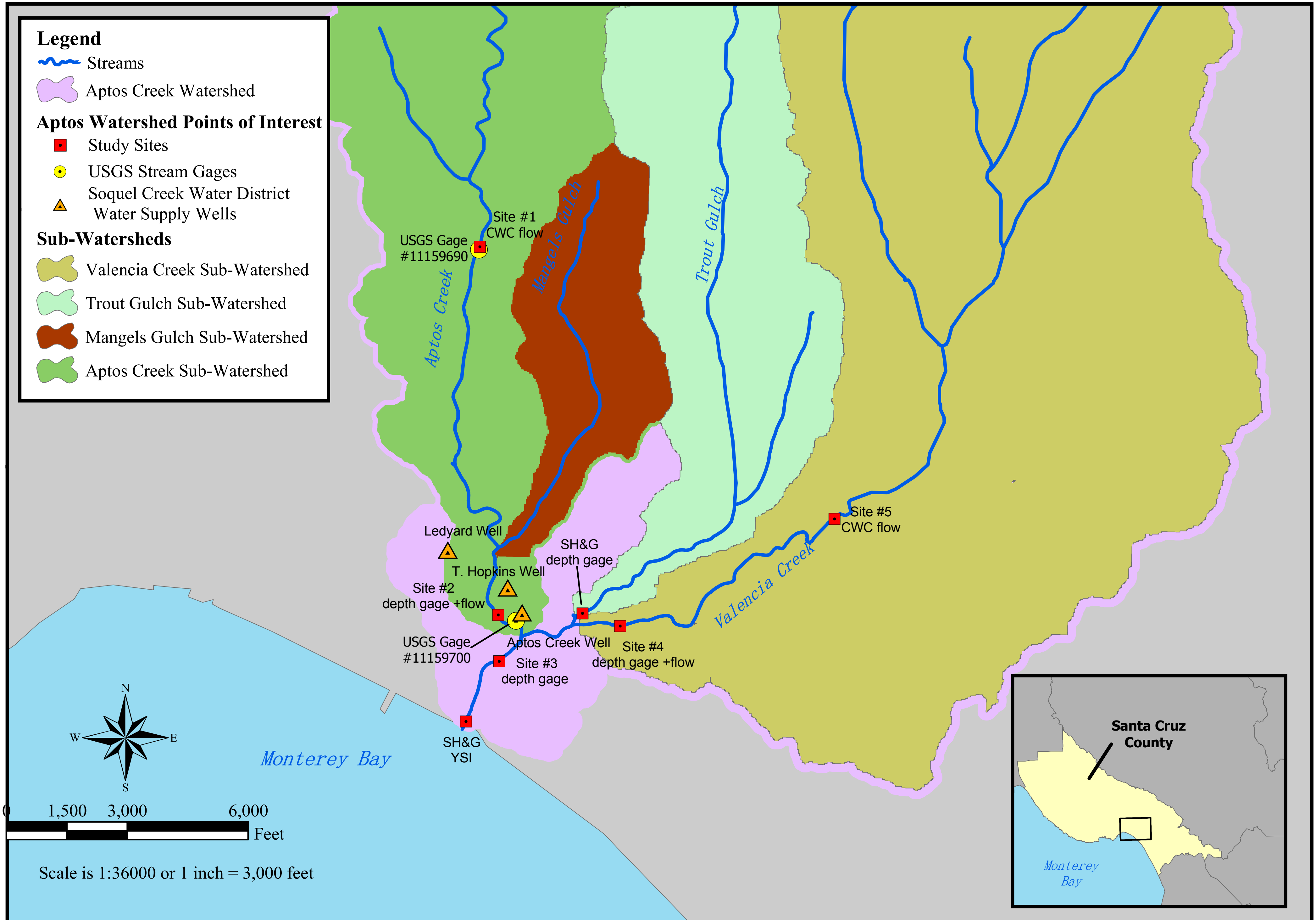
The water level readings were translated to discharge measurements following the development of rating curves for each site. In-field stream flow measurements were conducted by CWC staff, CWC volunteers and/or SH&G personnel at each of the continuous depth recording sites.

Flow measurement stations were established in two locations within Aptos and Valencia Creeks approximately 0.5 miles apart. One synoptic flow study consisted of stream flow measurements conducted at the downstream site within one hour of an upstream flow measurement The two stream flow measurements for the upstream and downstream sites were then compared to determine the rate at which water was lost or gained over the given stream reach.

Water Quality Studies

The water quality study for the Aptos Creek Watershed Assessment consisted of the installation of a real-time water quality data logger in the Aptos Lagoon from August through November 2001. The following water quality data was collected every 30 minutes:

1. **Depth** used for hydrologic behavior analyses and to determine the location of the recordings within the water column.
2. **Dissolved Oxygen** provides an indication of biological rates and basic functionality of the lagoon waters.
3. **pH** varies as function of biological activity and aquatic habitat quality.
4. **Salinity** provides information regarding the degree of chemical stratification.
5. **Water temperature** is an imperative element of aquatic habitat.
6. **Conductivity** measures total dissolved solids (TDS).



Swanson Hydrology and Geomorphology 115 Limekiln St. Santa Cruz, CA 95060 tel. 831-427-0288 fax. 427-0472	Aptos Creek Watershed Lower Watershed Points of Intersest	Figure 3

D. Riparian Survey

The focus of the riparian survey was to identify the primary vegetation habitat features along each watercourse within the watershed (**Appendix D**). This was accomplished by the Biotic Resources Group through the following:

1. Aerial photos of the project area were interpreted to ascertain the general type and distribution of riparian and in-stream wetlands within the watershed.
2. Mapping was refined through field checking. Field surveys were conducted during July and August 2002. Field surveys were conducted along Aptos Creek, Bridge Creek, Trout Gulch, Mangels Gulch and Valencia Creek.
3. The watercourses were walked and the vegetation communities documented.
4. The plant species composition within each polygon was documented as per *series* protocols *Sawyer et al.* (e.g., alder/willow riparian forest, coast redwood/tanoak riparian forest). Areas devoid of woody riparian vegetation were also identified and mapped.

5. Within each *series*, the vegetation characteristics were documented by establishing a minimum of three *releve* sample plots. The following measurements were obtained at each sample plot: canopy cover (i.e., measurement of percent cover, dominant plant species, from the toe of the channel and from the middle of the channel), average height of riparian trees, plant species composition (trees, shrubs and herbaceous plant species) and the occurrence of invasive, non-native plant species.
6. The current distribution of riparian vegetation (including gaps in the corridor) was compared to available historic data. Where changes are detected, these areas was demarcated onto the project base maps.
7. Areas that need management were identified during the field surveys. These include areas of significant botanical resources (i.e., location of special status species, locally unique species or area of botanical interest); degraded areas in need of revegetation and areas containing invasive, non-native plant species.

8. The riparian areas within the watershed were evaluated for the known and potential occurrence of special status plant species and invasive nonnative species.

E. Large Woody Material Recruitment Inventory

Large Woody Material (LWM) recruitment surveys were conducted by CWC using a modified California Department of Fish and Game protocol (Leicester 2002) to augment instream large woody debris data collected for the fisheries habitat assessment (**Appendix E**). A total of 10.5 miles were surveyed on Aptos and Valencia Creeks during fall 2002. Surveys were conducted every 1000-2000 feet to evaluate potential for recruitment of large wood from the riparian corridor into the stream.

A modified LWM Inventory form, based on the form developed by Flosi and others (1998), was utilized that included the following categories:

- Perched live and dead trees (leaning over the creek)
- Riparian 1 (deciduous-dominant riparian)
- Riparian 2 (upslope riparian within 75 feet of bankfull)
- Riparian 1 and 2 slopes (measured in percent)

The modified form was based on Leicester's work in Gazos Creek (2002) but was modified to record data outside of the bankfull area only.

Project Participants

A successful watershed enhancement plan is one that will be embraced by many stakeholders, especially watershed landowners. Although this Enhancement Plan is geared towards ready-to-implement salmonid habitat restoration projects, it is our feeling that long term restoration will best be accomplished by informed, conservation-based land use practices. This will be most effectively carried out by voluntary, non-regulatory landowner participation. Therefore, we called upon the community at large and two ad hoc groups to participate in the assessment process.

Two public meetings were held at the Aptos Village Community Park center and at Valencia Hall during the beginning of the Assessment and towards the end of the project. Mailings were sent out before the meetings to over 1500 landowners and residents within the watershed and press releases were distributed to local papers. Technical team members presented methods, findings, and recommendations to the group and responded to questions. Approximately twenty-five people attended each meeting.

During the first public meeting, attendees were invited to join the Public Advisory Group (PAG). Six individuals, primarily landowners within the Aptos watershed, volunteered to participate in the PAG. The group convened twice during the project to review assessment materials, review findings and recommendations, and to provide input. The PAG recommendations are included in Section III, Community Priorities.

Public Advisory Group

Ms. Deborah Chirco-MacDonald, Resident	Lower Aptos Creek
Ms. Susan Ferrel, Resident	Lower Aptos Creek
Mr. Ryan Hilburn, Cal Polytechnical Institute	Upper Valencia Creek
Mr. Mondy Lariz	NCC Federation of Fly Fishers
Mr. Dan Miller, Resident	Mangel's Gulch
Ms. Doreen Stein, Resident	Lower Valencia Creek
Laurie McCann, Facilitator	Good Work! Facilitation Services

The Aptos PAG is a very active group with many great ideas about how to increase public involvement and conservation knowledge within the watershed. It is our hope that the PAG will continue beyond the life of this assessment and provide an important avenue for community outreach and restoration participation.

Finally, resource agency technical advisors were requested to participate in the Technical Advisory Committee (TAC) to review assessment methods, findings and recommendations and to provide oversight to the technical team. The TAC members convened twice throughout the project and provided comments. Additionally, TAC members ranked restoration recommendations based on their knowledge of the area, technical expertise and the information presented to them.

Technical Advisory Committee

Mr. Jon Ambrose, Fisheries Biologist	National Marine Fisheries Service
Ms. Laura Brown, District Manager	Soquel Creek Water District
Ms. Portia Halbert, Biologist	Santa Cruz District State Parks
Ms. Jane Henson, Water Resource Planner	County of Santa Cruz
Ms. Jennifer Nelson, Fisheries Biologist	Ca. Dept. of Fish and Game
Dr. John Ricker, Environmental Health	County of Santa Cruz
Mr. Dominic Roques, Soil Scientist	Reg. Water Quality Control Board
Ms. Kristen Schroeder, Resources Planner	County of Santa Cruz

Concurrent Projects

Several other efforts are currently occurring within the Aptos Creek watershed. A draft General Plan/Environmental Impact Report for the Forest of Nisene Marks State Park has recently been released for public comment. To review the Draft Plan, visit the Santa Cruz District State Parks website (www.santacruzstateparks.org). The Central Coast Regional Water Quality Control Board is currently developing sediment numeric targets for total maximum daily loads (TMDLs) for Aptos and Valencia Creeks. The County of Santa Cruz recently conducted an inventory of all stream crossings that may impede fish movement. Among those surveyed were Valencia Creek at Soquel Drive and Valencia Creek at Valencia Road near the historic Valencia Hall. Finally, the Santa Cruz District Department of Parks and Recreation received funding earlier this year to evaluate roads and develop road-related best management practices within their parks. The Aptos Creek Road, which transects the Forest of Nisene Marks, and associated roads, will be inventoried in 2003 and 2004 and an erosion reduction plan will be developed.

Table 2: Concurrent Projects within Aptos watershed

Project	Lead Agency	Purpose	Timeline
Forest of Nisene Marks State Park General Plan	Santa Cruz State Parks	To establish a general plan for recreational use of the State Park.	Draft recently completed
Aptos Creek and Valencia Creek sediment TMDLs	Central Coast Regional Water Quality Control Board	To develop numeric targets of acceptable levels of sediment within the creeks.	In progress
Santa Cruz County roads Fish Crossing barrier evaluation	County of Santa Cruz	To determine road crossings that impede fish movement in the creek	Work recently completed
Santa Cruz State Parks road inventory	Santa Cruz State Parks	To evaluate all roads within the Santa Cruz State Parks and develop erosion reduction plans	2003-2004

WATERSHED CONDITIONS

A. Historical and Existing Land-use Conditions

Prior to 1844, the steep canyons and slopes of the Aptos watershed provided little value for the native people in the Monterey Bay Region. As urban and agricultural development in the Aptos area began, the coastal terraces were utilized for livestock and then eventually agriculture. Early harvesting of timber in the upper watershed initially began during the years of 1883 through 1923 (Figure 3). During this time, over 150,000,000 board feet of redwood forest in the Aptos watershed was clear cut logged (www.santacruzstateparks.org) utilizing a railway system that extended from either end of Santa Cruz County up into the headwaters of Aptos Creek.

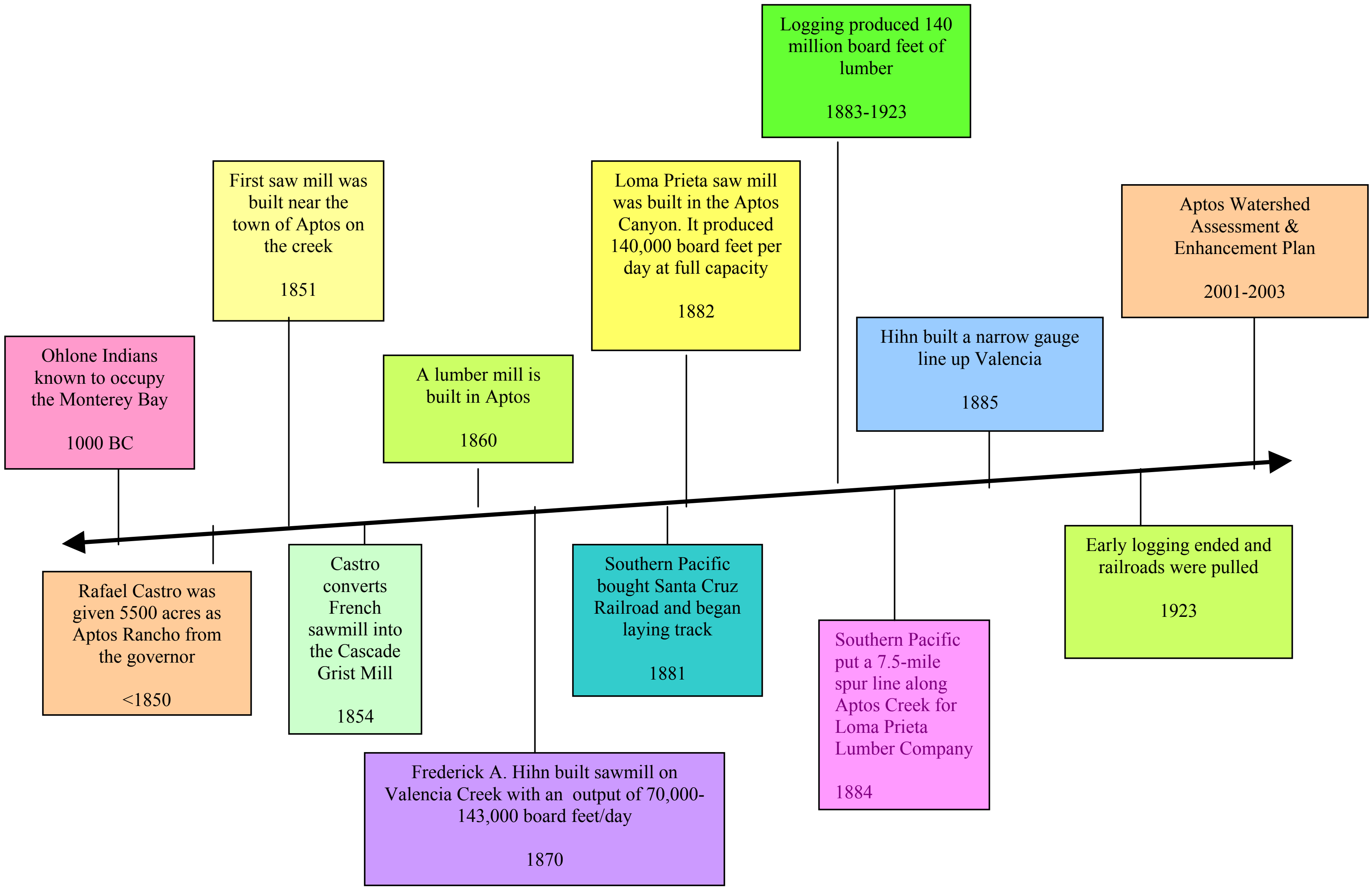
After this period of logging, the forest within Aptos Creek regenerated over the next thirty years. By the early 1960s, the majority of the Aptos Creek watershed was established as the Forest of Nisene Marks State Park for public recreation. While some timber production and agriculture (including orchards) still occurs within upper Valencia Creek, the primary land use is rural residential. Within the lower watershed, both Aptos Creek and Valencia Creek have experienced rapid residential and commercial development since the 1970s.

Few watershed studies have been conducted within the Aptos Creek watershed to date. Prior work includes intermittent California Department of Fish and Game Stream Inventory surveys. Additionally, the Coastal Watershed Council conducted a volunteer water quality monitoring program within Aptos Creek from 1999 until the beginning of the watershed assessment in 2001.

Interdisciplinary work commenced for the Aptos Creek watershed assessment from fall 2001 through fall 2002. The results for the work are summarized in the following sections according to discipline:

- B) Fisheries habitat
- C) Geomorphology
- D) Hydrology and water quality
- E) Riparian
- F) Large woody material

Figure 4. Aptos Creek Historical Land-Use



B. Fisheries and Fisheries Habitat

Through historical data review, Hagar found that Aptos Creek has provided essential steelhead habitat and potential coho salmon habitat (**Appendix A**). The California Department of Fish and Game (CDFG) has considered Aptos Creek as an important steelhead spawning and nursery stream since the 1930s. Aptos Creek is near the southern extent of the known range of coho salmon in North America. In southern San Mateo County and northern Santa Cruz County, coho populations are currently found primarily in Gazos, Waddell and Scott Creeks. Coho runs disappeared from most streams south of San Francisco Bay during the late 1960s, 1970s and early 1980s and were last reported in Aptos Creek in 1973. Nonnative coho were stocked in many coastal streams, including Aptos Creek during the 1960s.

A Santa Cruz County fish sampling assessment conducted in 1981 (Harvey and Stanley Associates, Inc. 1982), prior to the large storm event in 1982, found relatively high numbers of smolt-sized trout in both upper Aptos and Valencia Creeks and good quality habitat in several locations within both creeks. Limiting factors included substrate, cover, and spawning in Aptos Creek and pool depth, substrate and flow in Valencia Creek.

During the assessment, Hagar found poorer quality habitat conditions in Valencia Creek with respect to pool depth, substrate conditions, and relative fish numbers, compared to the 1981 study (**Appendix A**). Abundance of rearing trout downstream of Valencia Road was about 70% of that at the best site in Aptos Creek in 1981. This contrasts to the present survey where abundance of rearing trout in that reach of Valencia Creek was only about 10% at best, of that in upper Aptos Creek (based on visual observations). Changes in trout density as a result of the floods of 1982 may have resulted from degraded habitat conditions that persist today.

Estimates trout estimates abundance from 1981 and 1996 appear to be well below estimates from the 1960s, however, the earlier estimates are not well documented. A 1997 stream inventory conducted by CDFG (1997) in the Aptos Creek watershed documented the following significant findings:

- Temperature conditions were near the upper optimal limit for juvenile salmonids in Valencia, Aptos and Bridge Creeks.
- Numerous rock dams constructed within the creek prevented upstream movement of juvenile fish in Aptos Creek
- Trash was dumped in the creek
- Riparian trees were cut and left outside of the State Park
- Valencia Creek would benefit from more large woody debris
- A sediment inventory for Valencia, Trout and Aptos Creeks was needed

Habitat Assessment Results

Six reaches of Aptos Creek and one reach of Bridge Creek were surveyed (Figure 2). Valencia Creek was segmented into three reaches and 1.3 miles of Trout Gulch was surveyed as one reach. Mangels Gulch was primarily dry during the survey and has a migration barrier 680 feet upstream of Aptos Creek confluence; therefore, it was not surveyed.

The results of habitat surveys and fish observations were evaluated to identify key factors that potentially limit fish populations in the watershed including habitat type and stream dimensions, shelter characteristics, substrate conditions, bank and canopy conditions, stream temperature, and barriers to fish movement. The discussion of results that follows is organized around these key features.

Habitat Type and Stream Dimensions

Habitat conditions varied considerably between sub-watershed areas and between reaches within sub-watersheds (Appendix A). Aptos reach 1 was atypical in that approximately half its length included the lagoon. The other half was highly influenced by Valencia Creek and consisted primarily of wide shallow glide type habitat dominated by sand substrate. Most of Valencia Creek and Trout Creek consisted of narrow, shallow channels with predominantly sand substrate and no pools. Valencia Creek had lower flow and a narrower wetted channel (mean width) than Aptos and Bridge Creeks. Habitat conditions improved in upstream Valencia Creek with lower amounts of sand substrate and better habitat present. Only three pools were identified in Valencia Creek, all in the uppermost reach (reach 3). A single pool was found in the 7,018 feet of Trout Creek that were surveyed. Depth was less for all habitat types in Valencia and Trout Creeks than in Aptos and Bridge Creeks, even in the smaller, upper reaches of Aptos Creek.

As would be expected, estimated discharge and average wetted width in Aptos Creek decreased higher in the watershed, as did pool habitat quantity (% by length) and pool depth. Pools were most extensive in reach 3 of Aptos Creek where they were typically long and deep with steep bedrock sides. The pools were generally sufficiently deep to support older age classes of resident trout and juvenile steelhead and coho. The great majority of pool habitat (75% to 85% by length) in reaches 2, 3, and 4 of Aptos Creek had mean depths over 1 foot and maximum depths of at least 2 feet (Figures 4 and 5). A significant number of pools in these reaches had maximum depths of 3 feet or more (29% of pools in reach 2, 44% in reach 3, and 40% in reach 4). In the upper two reaches of Aptos Creek and in Bridge Creek, pools were less extensive and more shallow (Tables 2 and 3). Pools in Aptos reach 6 and Bridge Creek were only 18% and 9% of the habitat by length and the majority had mean depth of less than 1 foot and maximum depth of 2 feet or less. This type of habitat would presumably support fewer fish past their first year than the lower reaches.

Scour against bedrock was the primary pool formation factor in Aptos Creek but wood, in the form of logs or roots, was a relatively important pool formation factor in reaches 2 and 3 (41% and 30% of pools, respectively). Since bedrock pools were longer on average than wood-formed pools, they made up a much greater proportion of the stream length than wood formed pools. The contribution of wood-formed pools to habitat should not be discounted. However, since much of the useful habitat in a pool is at the head of the pool , much of the longer bedrock pools may not be used for rearing. In other words, a relatively short wood formed pool may have nearly as much useable habitat as a long bedrock pool. It is surprising that even in reach 6, where a substantial amount of large woody debris was available, it was less important than other factors in pool formation. This is primarily because the available wood was suspended above the channel or was concentrated in debris jams.

Flatwater habitat was relatively extensive in all reaches of Aptos Creek. Riffle habitat was relatively scarce in the lower five reaches of Aptos Creek. Flatwater habitat dominated both Valencia and Trout Creeks with lesser amounts of riffle habitat. Flatwater in Valencia and Trout Creeks was shallower and more dominated by sand than in Aptos Creek.

Shelter Characteristics

There are numerous potential predators (e.g., birds, mammals and reptiles) on juvenile salmonids inhabiting streams and the presence of adequate cover, or shelter, (e.g., riparian vegetation, undercut banks, cobbles, or boulders) can greatly influence survival rates. The proportion of each habitat unit that was influenced by some type of shelter was estimated as a percentage of the total surface area of the unit. A shelter complexity rating of low, medium, or high was also estimated for each habitat unit based on the areal coverage, structural complexity, and utility of cover present. Percent coverage was generally moderate to low in all reaches of Aptos and Bridge Creeks. A relatively high percentage of habitat units were rated as "low" in shelter complexity in the lower 3 reaches of Aptos Creek and in Bridge Creek and the proportion of pools rated as "low" was relatively high in reaches 2, 3, and 4. Even many of the pools that were rated "moderate" in terms of shelter complexity did not have extensive areas of shelter. A high proportion of pools in reaches 2 through 5 and in Bridge Creek had shelter coverage of only 20% or less. Woody debris was present as a cover component in at least a quarter to a third of the pools but was present in nearly two thirds of the pools in Aptos reach 3 and in Bridge Creek.

The most extensive cover types included terrestrial vegetation (primarily in reaches 1 and 2) and Cobbles and boulders (more important in the higher gradient, upper watershed reaches). Bedrock ledges were particularly prevalent in reach 3 and 5. Large woody debris was more extensive in reach 3 than other reaches. In Valencia Creek small woody debris and overhanging terrestrial vegetation were the most prevalent cover types lower in the creek while substrate roughness and surface turbulence became more important in the upper reaches. In pool habitats, small woody debris and overhanging terrestrial vegetation were common in the lower part of Aptos Creek while bedrock ledge, substrate roughness, and large woody debris were dominant in the upper reaches.

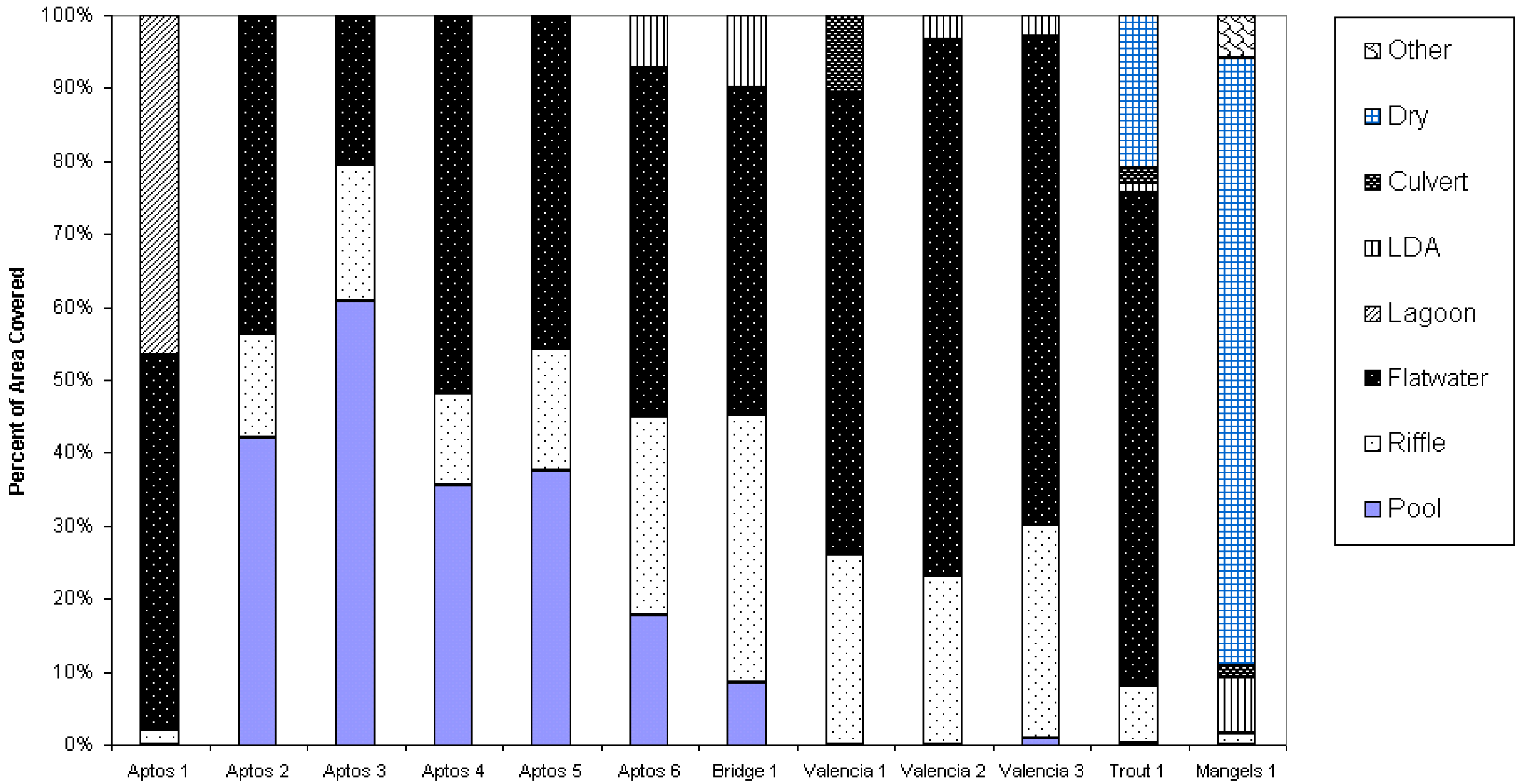


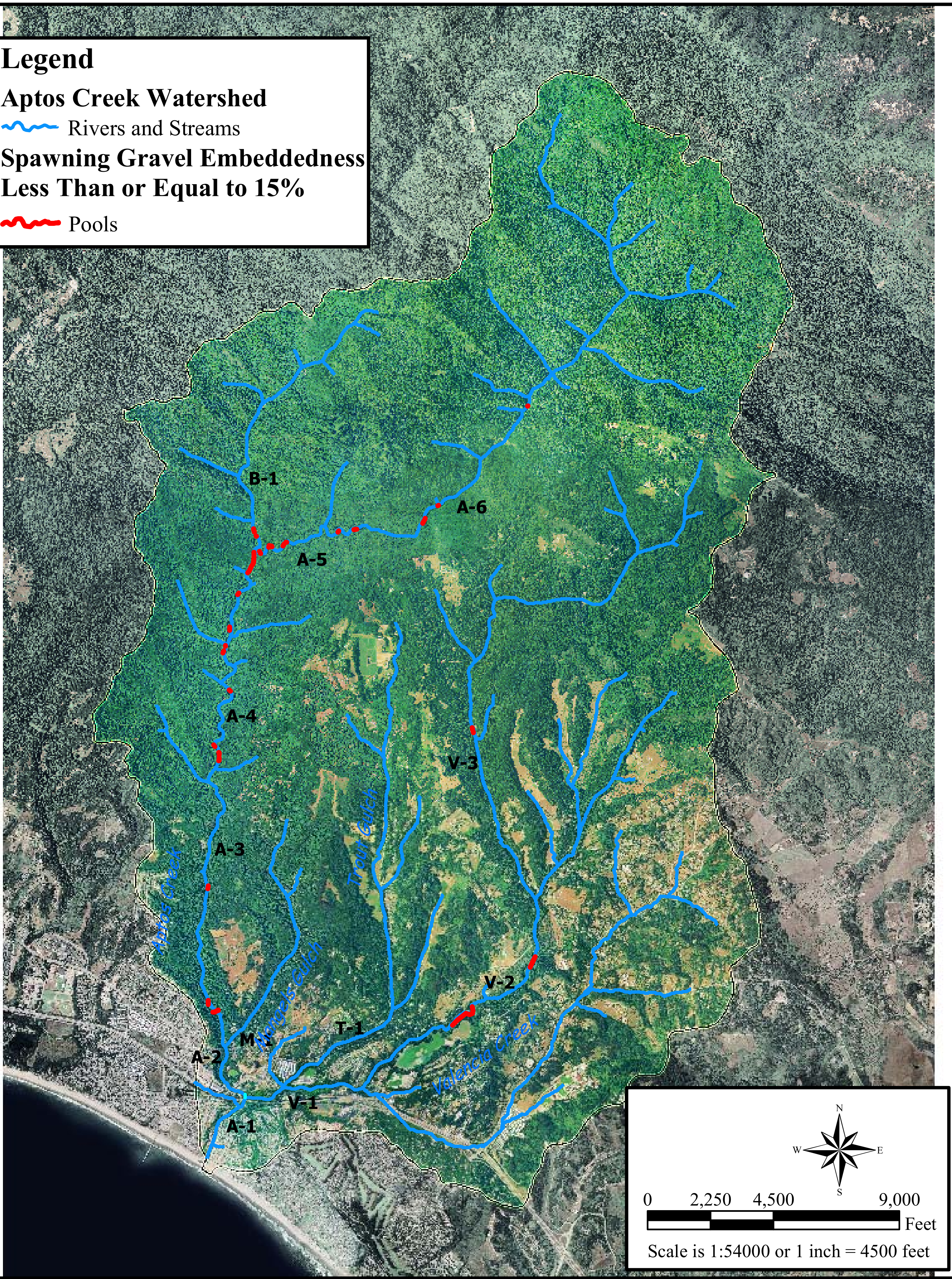
Figure 5: Percent occurrence of primary habitat types within reaches of Aptos Creek surveyed during the fall of 2001.

Substrate Condition

Substrate conditions influence spawning and egg incubation, cover for juveniles, and production of aquatic invertebrates important in the aquatic food chain. Steelhead and coho salmon rely on relatively loose, clean gravel substrate with low amounts of fine sediments for reproduction. Larger substrate such as cobbles and boulders can provide hiding areas for juveniles of many species including trout. Fine sediments (silt and sand) present in excessive amounts fill spaces between the larger substrate elements and reduce its ability to support invertebrate production, spawning, and escape cover. Embeddedness, the degree that large cobbles and rocks are surrounded by fine sediment, is estimated in pool tails and in other areas with suitable conditions for spawning. Fish density, particularly for juvenile trout and salmon, is generally reduced as embeddedness increases. Excessive amounts of fine sediment may also fill in pools and other deep areas and reduce their utility as habitat for adult fish. Habitat conditions in Aptos and Bridge Creeks were influenced by high levels of sand in the substrate (Figure 8). Sand was the dominant substrate in 59% to 70% of habitat units in reaches 2 through 6 and was dominant in all units in reach 1 (downstream of the Valencia Creek confluence). Sand was the subdominant substrate in an additional 10% to 17% of habitat units in reaches 4, 5, and 6 (Figure 9). In Bridge Creek, sand was the dominant substrate in 95% of habitat units and subdominant in the other 5%.

In Aptos Creek riffle habitats, sand was still the dominant substrate in reach 1, half the units in reach 2, and two-thirds of the units in Bridge Creek. Sand was the subdominant component in 17% to 30% of riffle habitat units in reaches 4, 5, and 6 of Aptos Creek. In Bridge Creek, sand was the dominant substrate in 2 of 3 riffles surveyed and was subdominant in the third. Valencia Creek was even more heavily influenced by sand than Aptos Creek. Sand was the dominant substrate in 100% of habitat units in the two lower reaches (Aptos Creek to Valencia Road). Sand was also dominant in 94% of the habitat units in reach 3 (upstream of Valencia Road). As a result, there were no pools in reaches 1 and 2 and pools made up slightly less than 1% of the length of reach 3. Gravel was present only as a subdominant size class and was never estimated at more than 5% in any habitat unit.

Areas with suitable substrate and hydraulic conditions for spawning were relatively scarce throughout the watershed. In Aptos Creek, reach 4 had the greatest concentration of spawning areas although reaches 2, 3, and 5 also had some areas with good spawning conditions. The low frequency of suitable spawning areas resulted primarily from high levels of sand in the substrate. The presence of large quantities of sand was evident in the embeddedness data. In Aptos Creek, over 50% of all pool tails had embeddedness of more than 30% in reaches 2, 3, and 4. Embeddedness was lower in reaches 5 and 6 with, respectively, only 36% and 33% of sampled units having embeddedness greater than 30% (Table 8). The least embedded spawning areas were in reach 5 where 75% of all potential spawning areas had embeddedness of 15% or less. Although the amount of potential spawning area identified in Bridge Creek was very small (2 areas totaling only 23 square feet), embeddedness was low.



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Spawning Gravel Embeddedness Less Than or Equal to 15%
Aptos Creek Watershed
Assessment and Enhancement Plan

In Valencia Creek, pools were present only in reach 3, where 2 of the 3 pool tails assessed had embeddedness ratings of 30% or greater. Also, due to extensive sand substrate, areas with suitable conditions for spawning were not identified in reach 1 of Valencia Creek and were extremely limited in reaches 2 and 3. No embeddedness estimates were made in Trout Creek; there were no sites identified in the entire reach that had potential as spawning sites.

Bank and Canopy

The ideal vegetative condition for salmonids is a moderately dense canopy (55%-85%) with occasional small openings. Canopy was highly variable in Aptos and Bridge Creeks, ranging from 10% or less to 95% or more in each reach. No clear differences between reaches were distinguishable. Valencia Creek had higher levels of canopy closure than Aptos and Bridge Creeks with an average canopy coverage of at least 60%. Habitat units with relatively open canopies were fairly well dispersed through the watershed. A more open canopy can enhance aquatic productivity and trout growth rates as long as associated temperature increase is not extreme.

Temperature

Temperature determines the distribution of many native fish species and salmonids in particular. Stream temperature generally fluctuates on a daily basis in parallel with air temperature and reaches maximum levels in streams of Central California in July and August. Temperature becomes lethal for both steelhead and coho as it approaches and exceeds about 25°C (77°F). Though there is much variation, temperatures below 18°C (64°F) are generally regarded as optimum for rearing steelhead although temperatures up to 21°C (70°F) may be suitable if food is sufficiently abundant. For coho salmon, optimum temperature is commonly cited in the range of 11°C to 15°C (52°F-59°F) and extended periods with temperatures exceeding 18°C (64°F) may significantly limit coho populations.

Temperature monitoring was not conducted as part of this study. Temperature grab samples ranged from 13°C to 15°C (55°F-59°F) in Aptos Creek during surveys in late August, and 12°C to 15°C (54°F-59°F) in Valencia Creek in early October (air temperature ranged up to 20.5°C (69°F) in August and 23°C (73°F) in October). Coastal Watershed Council and CDFG have collected temperature data during 1999 and 2000. Data collected by CDFG indicate that temperature conditions in Aptos Creek in 1999 were comparable to other Central Coast streams supporting coho salmon including Waddell Creek and Scott Creek.

Barriers to Fish Movement

Full levels of production for anadromous salmonids in Central California coastal streams relies on the ability of adult steelhead to enter the streams and easily access spawning and rearing habitat in the upper reaches and for smolts to return to the ocean. Even obstacles that are not complete barriers can impair populations by delaying migration rates and exposing fish to potential predation or poaching. Partial barriers may also limit instream movement of rearing juveniles; rearing juveniles need to disperse from spawning areas to rearing habitat. In some streams, seasonal movement may be important to avoid sections that go dry during summer months or to avoid lower gradient mainstem reaches during extreme high flows. If the only refuge areas are downstream, barriers may result in failure of re-colonization and loss of fish populations from otherwise suitable habitat upstream. The following sections detail migration obstacles in each of the surveyed stream reaches.

Aptos Creek Mainstem

There are no significant obstacles to migration of adult steelhead and coho salmon in the lower five reaches of Aptos Creek, although there are a few locations where adult upstream migration may be impaired at lower levels of flow. The first of these is immediately upstream of Spreckels Road and consists of a concrete weir spanning the creek (Section III). At the time of the survey the weir rose about 1.5 feet above the downstream water surface with a relatively shallow depth of flow up to about 1 foot deep immediately downstream of the weir. The water upstream of the weir is often uniformly wide and shallow. The shallow downstream pool combined with shallow flows upstream, may make passage difficult during low flows.

The other two locations in Aptos Creek, reaches 1-5, where adult passage may be impaired are caused by accumulations of large woody debris (LDAs) and these did not appear to present significant obstacles to passage of healthy adult steelhead or coho. The first had an elevation change of only about 2.5 feet and at higher flows this would be reduced. An unobstructed side channel was also available that would likely provide passage at higher flows. The second LDA had a more substantial elevation change of about 5.5 feet but there was relatively good flow under the debris and adults would likely be able to pass through the jam at moderate flows. Additionally, rock dams in Nisene Marks may inhibit fish movement during low flows.

Upstream of Reach 5, LDAs increase in frequency (Figure 15). Some of these accumulations likely shift under varying flow conditions and may become more or less of an obstacle at different times. The first LDA encountered at the break from reach 5 to reach 6 appeared to be a relatively significant obstacle and had an overall drop of about 6 feet without apparent passage through any side channel. Although a migrating adult may be able to pass some of these obstacles, or pass many of them under ideal flow conditions, these large LDAs' cumulative effect is likely to severely limit the frequency of access to upper parts of the reach and reduce the number of individuals that can successfully pass. It is perhaps significant that the density of young-of-year steelhead dropped off fairly sharply after the first significant LDA, at the break between reach 5 and 6

Bridge Creek

There were a total of 5 passage obstacles in the lower 3/4 mile of Bridge Creek. The first four, two LDAs and two cascades, were likely only obstacles to passage of adult steelhead or coho during low flow conditions. The last, an LDA, was judged to be a complete barrier for upstream migration of both adults and juveniles having a drop of about 6 feet with sediment filling the upstream channel and no jump pool below. Juvenile trout were seen up to the barrier but none were seen upstream of it.

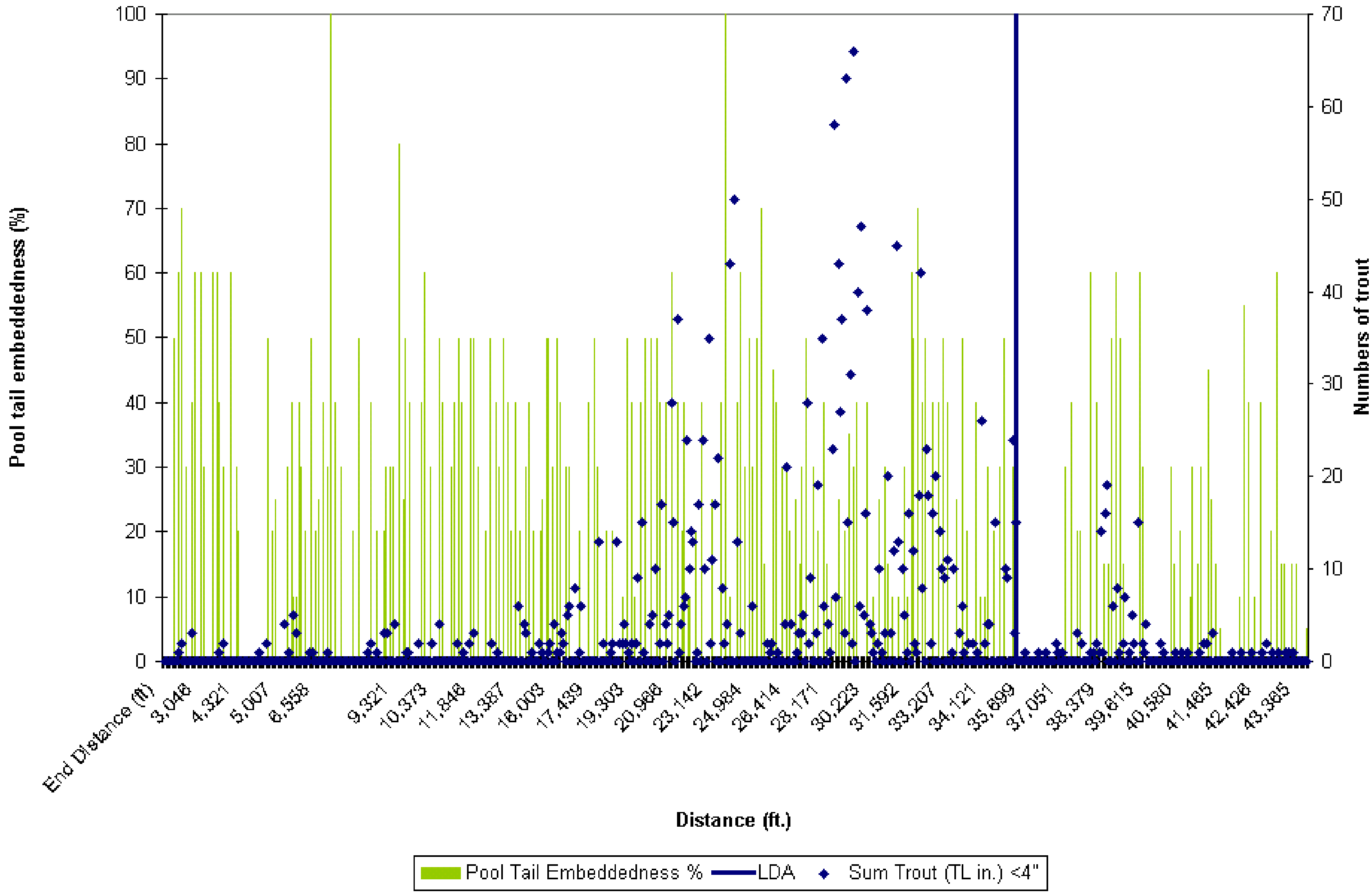


Figure 6: Longitudinal occurrence of young-of-year steelhead in relation to Large Debris Accumulation (LDA) determined to be a complete barrier to upstream migration of adult steelhead. Fish numbers are based on visual observations, representing an index, rather than absolute # of fish present**.**

Valencia Creek Mainstem
A total of eight passage obstacles were identified in Valencia Creek, four of which were culverts. The first three obstacles, all culverts, occurred within the lower quarter mile of the creek. The first two culverts presented low to moderate passage difficulty. They were about 240 feet and 180 feet in length, 10 feet in width, and had gradients between 1% and 2%. Both were fitted with a baffle system on one side, presumably to aid fish passage, but most of the baffle sections had filled with sediment and debris, rendering the systems useless. Both culverts are likely passable at moderate and higher flow levels. The third culvert, at Soquel Drive, is a more significant barrier and probably precludes upstream migration of adult steelhead or coho at most flow levels. The lower end of the culvert is perched approximately 4 feet above the downstream bed. This culvert has been considered for remediation. Swanson Hydrology and Geomorphology has developed designs for each of these culverts to improve fish passage (Section III).

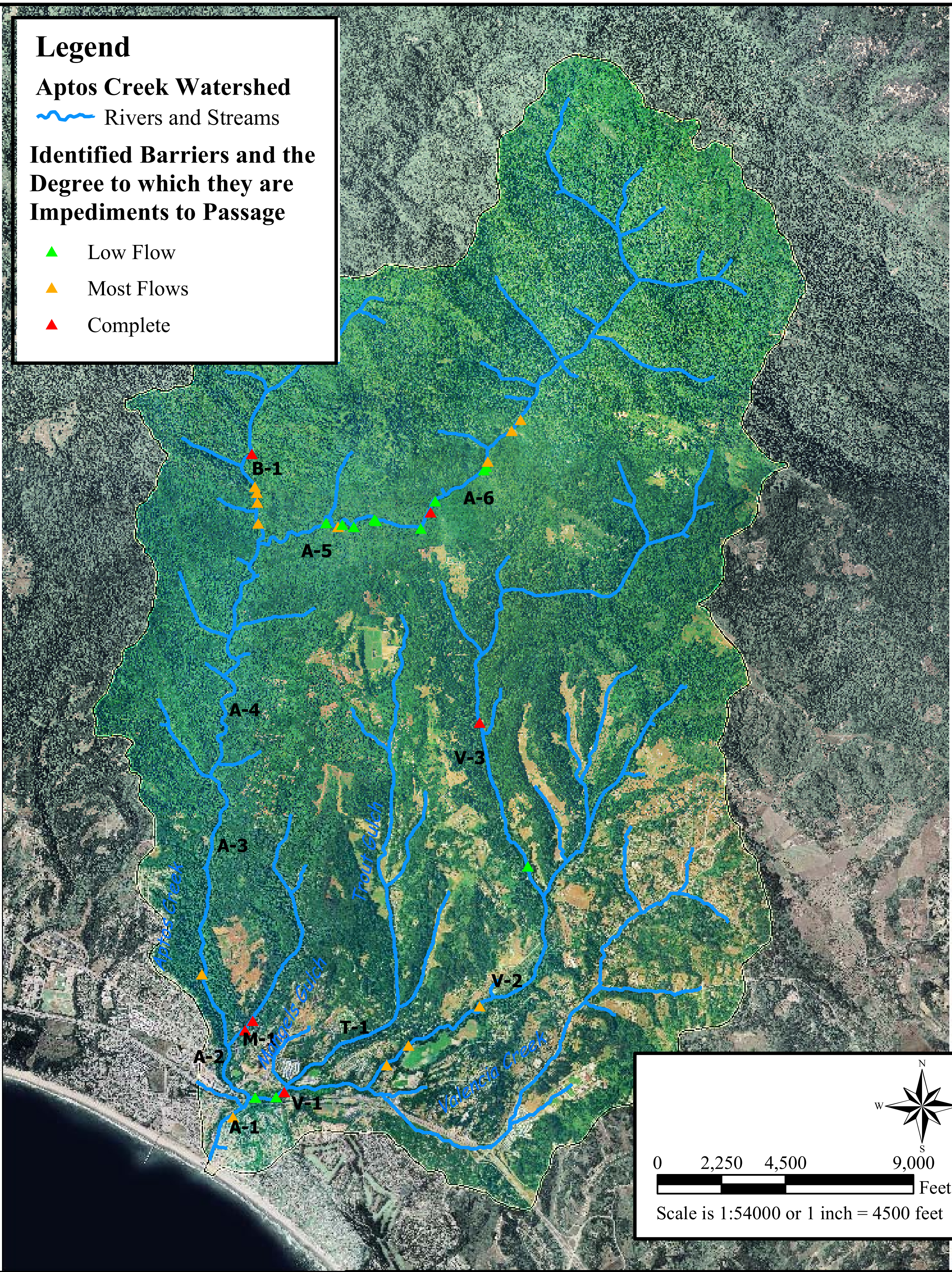
Three natural obstacles in reach 2, including a 3-foot cascade and two debris jams, present relatively minor obstacles to adults but probably prevent upstream movement of juveniles under a wide range of flows.

The seventh obstacle in Valencia Creek is the culvert at Valencia Road, approximately 3.4 miles upstream from the Aptos Creek confluence (Figure 2). Although fitted with baffles to improve the potential for migration, the culvert is quite steep (gradient of about 4%) and the lower end is perched about 2 feet above the stream bed. Since this culvert is fairly high in the watershed, flows sufficient for passage may be relatively infrequent. The culvert was recently evaluated using FishXing analytical methods and software. Coastal Watershed Council staff observed a 6-8 inch trout enter this culvert and swim part way through it using the baffle system in early November 2002 (Maya Conrad, Coastal Watershed Council, personal communication, January 2003).

The final obstacle recorded in Valencia Creek is a large debris jam about 1.2 miles upstream from the Valencia Road crossing. The debris jam is sufficiently large and complex that it was judged to prevent upstream migration of both adults and juveniles at most, if not all, flow levels. This jam would likely limit anadromous fish in most years.

Trout Creek
No significant obstacles to migration were identified in Trout Creek in the lower 1.3 miles that were surveyed.

Mangels Gulch
Two complete barriers to upstream migration of adults and juveniles were identified in the lower part of Mangels Gulch. The first was a 13-foot cascade with associated debris jam located approximately 680 feet upstream from the Aptos Creek confluence. The second was the culvert under Aptos Creek Road that was perched about 5.5 feet above the streambed with no plunge pool below.



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Identified Barriers and the Degree to which they are Impediments to Passage
Aptos Creek Watershed
Assessment and Enhancement Plan

Assessment of Limiting Factors

Salmonid populations may be limited in abundance or distribution by several limiting factors, even in pristine systems. This assessment focuses on the factor or factors that are most likely to limit steelhead and coho salmon production in the Aptos Creek watershed and which are subject to some type of remediation. Steelhead and coho salmon populations are generally depressed along the California Central Coast. A logical approach to restoring populations would involve determination of factors that limit a given population so that restoration funds can be most efficiently focused on those factors that are likely to make a difference to a given population. Often important limiting factors are readily apparent (e.g., barriers). In other cases they are more obscure.

Common factors that limit production of steelhead and salmon in Central California coastal streams typically include migration obstacles; excessive stream temperatures; loss of stream flow during key periods; lack of instream cover; excessive fine sediment accumulations; toxic water quality conditions (gasoline spills, waste disposal, swimming pool discharges, etc.); human disturbance of spawning habitat; and excessive legal or illegal harvest.

Although challenging to implement, the greatest potential for increasing production of steelhead in the watershed would come from improvements in Valencia Creek since it appears to have experienced far greater decline in productivity than Aptos Creek. The primary factors believed to be most limiting in the Aptos Creek watershed are:

1) Sediment;
2) Salmonid migration access;
3) Lack of summer flow; and
4) Rearing cover

Aptos Creek is in relatively good shape due to the protected status of much of its watershed although improvement in habitat conditions could certainly lead to increased fish production there as well.

Migration Obstacles

Migration obstacles may limit use of Bridge Creek by steelhead and may limit the ability of steelhead to access upper reaches of Aptos Creek (upstream of reach 5). Migration obstacles in both Bridge Creek and upper reaches of Aptos Creek are caused either by logjams or cascades that, except for possible continuing influence of past timber harvests, are natural in origin. Although some appear to present more difficult passage than others and a few appear to preclude passage under most conditions, it is likely that they shift over time and therefore present temporary obstacles. A more thorough evaluation, under higher flow conditions, would be needed to more completely assess these obstacles. In any case, they are not likely the primary limiting factors in Aptos or Bridge Creeks.

Migration obstacles are a potentially significant limiting factor in the Valencia Creek watershed. The four mainstem culverts all limit to varying degrees the ability of adult steelhead to access spawning areas and the free movement of juvenile steelhead within rearing areas. Three of the culverts, including one that is probably impassable under most flows, are in the lowest part of the watershed and therefore influence a large proportion of potentially useable habitat. Both the culvert under Soquel Drive and the culvert under Valencia Road failed to meet passage criteria for all species of adult salmonids and all age classes of juveniles under all flow conditions (Ross Taylor and Associates 2003). Although they are a primary limiting factor, removal of barriers in Valencia Creek may have limited benefits for steelhead use of the watershed since significant sediment problems also exist (see below).

Temperature

Based on CDFG monitoring, temperature does not appear to be a limiting factor for either steelhead or coho in Aptos Creek, Bridge Creek or Valencia Creek (see earlier discussion of temperature tolerance).

Stream Flow

The magnitude of streamflow is important to rearing salmonids since greater levels of streamflow may increase the area of riffles and production of food organisms, increase the transport of these organisms to areas of the stream inhabited by rearing trout, and for sediment transport and channel forming processes. During summer months conditions become particularly critical with some reaches becoming intermittent or dry. The Aptos and Bridge Creek watersheds are almost completely protected from development and have no significant diversions. Hydrographs within these reaches would be considered unimpaired. Other stream reaches in the basin, including Valencia Creek, Trout Creek, and Mangels Gulch have hydrographs that have been altered by development within the watersheds including water diversions and altered runoff patterns.

Habitat surveys indicated that summer flows appear to be non-existent in Mangels Gulch and this condition is the primary factor limiting steelhead. Although some spawning may occur in tributary streams that dry in summer, with juveniles moving to the mainstem to rear, the substrate in Mangels Creek is dominated by sand and is not suitable for spawning.

Trout Creek also had very low flow during the habitat survey and the channel was dry in some areas. Although the extensive deposits of sand substrate in the channel are probably the primary limiting factor in Trout Creek, low stream flow would be considered an important secondary factor. No trout were observed in Trout Creek.

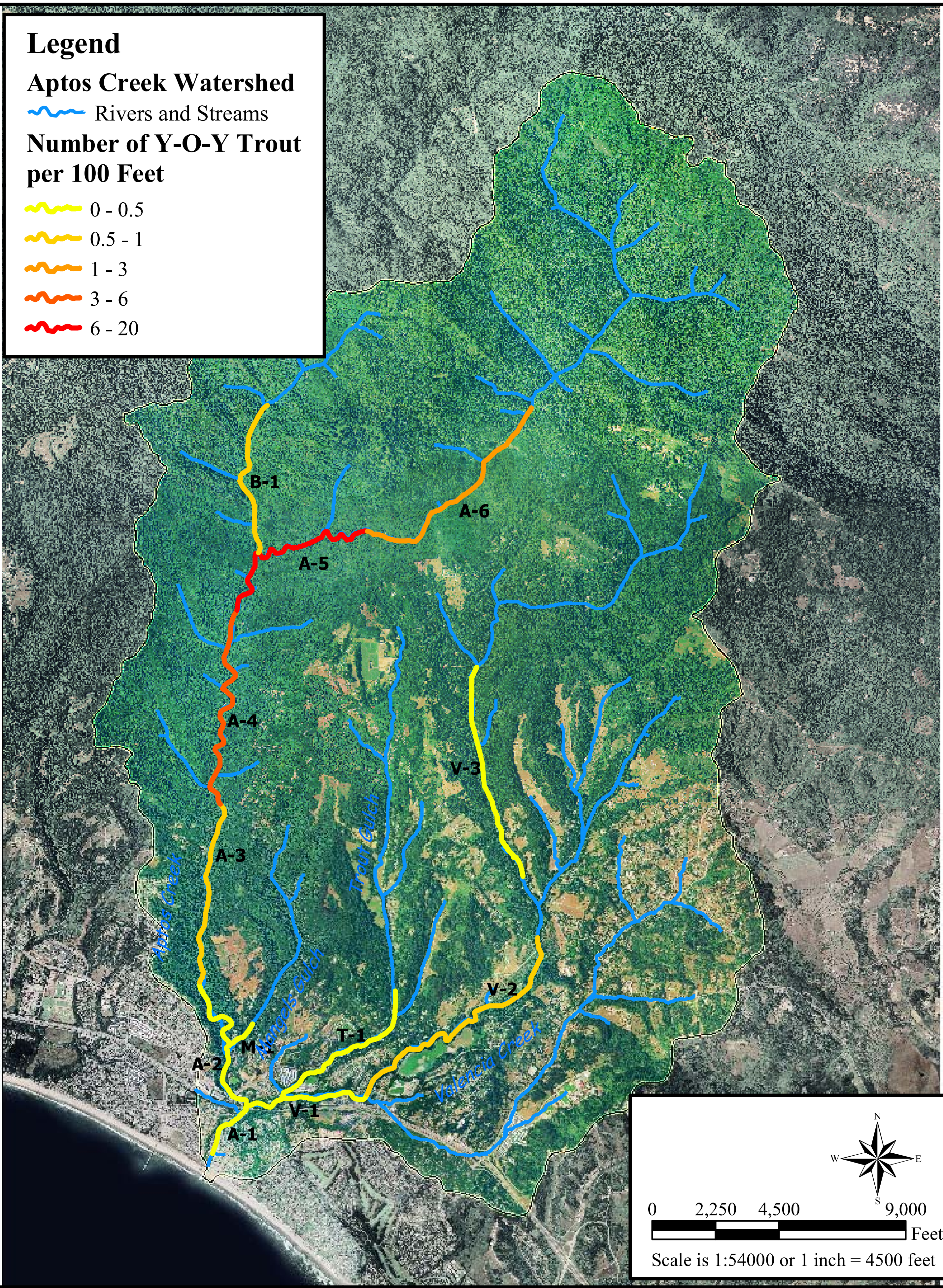
Low streamflows and narrow, shallow channel conditions were also observed in Valencia Creek, particularly upstream of the Valencia Road culvert. Although trout were present in this reach, the low streamflow levels likely limit their abundance although this is probably secondary importance to the high amounts of sand sediment and access issues.

Rearing Capacity

In Aptos Creek there is abundant habitat for steelhead in their first year of growth in both flatwater and pool habitat types. There is also a significant amount of deep pool habitat available for older trout; however, much of this habitat may be of limited value due to the relative scarcity of food producing riffle habitat. Since available abundance data indicates relatively good density of 1+ and older steelhead in Aptos Creek, particularly in the upper reaches, there may not be significant food limitations. Better information on abundance and habitat utilization by 1+ and older fish would be needed to fully evaluate this issue.

Habitat surveys indicated that most reaches of Aptos and Bridge Creeks have shelter conditions that are generally within the range consistent with good steelhead production in comparable streams, although the extent and complexity are at the low end of the range. Pool habitats are quite frequent and generally provide good depth conditions. Much of the pool habitat, particularly in Aptos Creek, is in bedrock formed pools, which do not develop extensive undercut banks and do not recruit large woody debris to the same extent as habitats with softer banks. Rearing juvenile trout may be less susceptible to predation if cover was more extensive. Although steelhead population assessment was not conducted as part of this survey, visual observations and results of previous surveys indicate that both young-of-year and 2nd year and older steelhead/rainbow trout are distributed throughout Aptos Creek and are reasonably abundant.

In many coastal streams, lagoons at the stream mouth can provide important rearing habitat. Lagoons can provide conditions that support rearing of large numbers of juvenile salmonids (Smith 1990, Hagar Environmental Science 2002). Growth rates in lagoons can exceed that in tributary streams and steelhead can reach smolt size in a single season rather than the two years or more it would take in stream habitats (Smith 1990). The Aptos Creek lagoon is compromised in its ability to support steelhead and coho salmon in some important ways. First, it has been reduced in size and compressed between vertical concrete walls for much of its length. It is also enriched by undetermined but presumably unnatural nutrient loading (see Appendix C, Hydrology and Water Quality Report). Artificial breaching of the lagoon during summer months can lead to conditions that are unsuitable for salmonid juveniles. The degree to which rearing steelhead use the lagoon has not been the subject of any concerted studies and the importance of lagoon rearing for sustaining steelhead runs in Aptos Creek is unknown. Although, water quality monitoring conducted during the course of this study indicated that there may be suitable habitat in the lagoon for rearing juveniles, it could likely be greatly improved by identifying and controlling sources of nutrient enrichment and other pollutants, controlling artificial breaching, and restoring more natural bank conditions.



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Number of Y-O-Y Trout per 100 Feet
Aptos Creek Watershed
Assessment and Enhancement Plan

Sediment

Sediment is likely the major factor limiting salmonid production on both a watershed and individual reach scale. Evidence from past sampling indicates that Valencia Creek has had higher densities of rearing trout and lower levels of fine sediments than currently occur and that conditions changed relatively dramatically after sediment deposition during the high flow winter of 1982. Production of trout in Valencia may have been reduced by an order of magnitude relative to Aptos Creek since surveys were last conducted in 1981. The greatest increase in steelhead production on a watershed scale would come from restoring the greatly diminished productive capacity of Valencia Creek. Available evidence indicates that, while both Aptos and Valencia Creeks have high rates of sediment loading, Aptos Creek appears to be better able to flush out fine sediments and recover from extreme events. Valencia Creek, perhaps due to high rates of anthropogenic sediment mobilization and altered hydrology due to increased impermeable surfaces from development in the watershed, appears to accumulate fine sediment and recovers very slowly (see Appendix B, Geomorphology Technical Report).

Fine sediments also likely diminish the productive capacity of Aptos and Bridge Creeks though not to the same degree as in Valencia Creek. Abundance of young-of-year steelhead was highest in Aptos Creek in reach 5 where the most extensive areas of low embeddedness also occurred. Densities of young-of-year steelhead were also relatively high in reach 4 and reach 6 but were lowest in reaches 2 and 3 where embeddedness estimates were generally higher. As in Aptos Creek, abundance of young-of-year steelhead in Valencia Creek was greatest in areas where spawning areas were observed and where embeddedness ratings were lowest. No trout were seen in Trout Creek and this corresponded to some of the highest levels of fine sediments observed.

Any increase in sediment loading in Aptos Creek has the potential to reduce steelhead productivity and, in the worst case, could induce a threshold response resulting in dramatic declines in the capacity of the watershed to support steelhead such as has apparently occurred in Valencia Creek.

Water Quality

Water quality issues are a potential concern in the lower, more urbanized parts of the watershed due to contamination from pesticides, herbicides, fertilizers, paint, oil and gas, chlorine from swimming pools and spas, sewage, and other contaminants. More remote parts of the watershed may be subject to contamination related to illegal activities such as methamphetamine production and marijuana cultivation (rat poisons, etc.). Although no obvious water quality problems were identified during the habitat survey, there was a section of Aptos Creek downstream of Mangels Gulch where no fish were observed. Contamination from sources indicated above would tend to be episodic and difficult to detect.

Disturbance

Recreationists including runners, mountain bikers, and hikers intensively use Nisene Marks State Park. Most of Aptos Creek within the Park is accessible to Park users. In the lower part of the Park, trails run along and across the creek in several places. Road crossings also occur at two locations. Creek crossings are frequently at pool/riffle transitions in areas suitable for spawning steelhead and coho salmon. Use of crossings by hikers and bikers could disturb spawning activity and damage eggs and pre-emergent fry in the substrate. Hiking off trail, in or along the creek, could also disturb spawning activity.

In numerous locations, Park users have piled cobbles across pool tail areas. These cobble dams obstruct free movement of juvenile trout and salmon and may obstruct adults migrating early in the season or at lower flows. In some parts of Valencia and Trout Creeks, landowners adjacent to the creek have modified stream banks or riparian vegetation to the possible detriment of steelhead and salmon. It is difficult to judge the potential impact of any of these activities although none of them is likely to act as a major limiting factor. Nevertheless, the disturbance may be susceptible to greater control through educational programs and reduction in the level of disturbance would be beneficial.

Exploitation

Existing fishing regulations allow fishing for steelhead in Aptos Creek from the mouth to the Steel Bridge between November 16 and February 28. Fishing is restricted to Wednesdays, Saturdays, Sundays, legal holidays, and the season opening and closing days. Only barbless hooks may be used and all caught fish must be released. The rest of the stream, upstream of Highway 1, is closed to fishing all year. The level of angler use, legal or illegal, is not consistently monitored and is unknown. Although the habitat survey did not specifically address this issue, nothing was encountered during the habitat survey that would indicate high levels of legal or illegal fishing.

Coho Salmon

Coho salmon have declined dramatically in streams south of San Francisco Bay. Coho salmon were present in Aptos Creek as recently as 1973 (Anderson 1995). Nearly the entire Aptos Creek watershed is maintained in natural condition as State Park lands and supports a relatively healthy steelhead population. Therefore, the disappearance of coho from Aptos Creek cannot be linked to human activities in the watershed such as residential development, water extraction, timber harvest, or road construction, which may be a factor in other streams. It is more likely that the major factors currently limiting coho in Aptos Creek are external to the watershed or are the result of natural environmental events that have impacted coho to a far greater degree than steelhead.
It is likely that ocean conditions are a significant factor in abundance of coho south of San Francisco Bay. Anderson (1995) points out that the sharp decline or extirpation of coho south of San Francisco Bay in the late 1970's and early 1980's was coincident with a warming trend along the Washington-California coast from 1976 to 1983 and with the severe drought in 1976-1977. Certainly, declining abundance of species at the extremes of range and contraction in range is expected (and widely demonstrated in terrestrial species) in response to long-term climate change. Still, coho maintain populations in nearby Central Coast streams that are, presumably, also impacted by these conditions (e.g., Waddell Creek and Scott Creek).

Due to its rigid 3-year female brood lineages, coho may have been eliminated from Aptos Creek as a result of very poor conditions in a few years. For example, 1972 was a very dry year with flow rarely exceeding 2 to 3 cfs through the winter and declining to about 0.5 cfs during the summer. This would have been a poor year for spawning and reproduction and would have influenced the return of the brood year lineage spawning in 1975, 1978, and 1981. The drought of 1976-1977 could have resulted in poor spawning and recruitment thus impacting the other two female lineages, spawning in 1979 and 1980. The extreme winter of 1982 resulted in near complete loss of rearing habitat and may have seriously reduced the abundance of rearing juveniles from the 1981 brood year that would have spawned in 1984, as well as wiping out eggs or fry and eliminating rearing habitat for the 1982 year class that would have spawned in 1985.

It may be that the primary factor currently limiting coho in Aptos Creek is simply that there is no spawning population. Coho, like other Pacific salmon, will inevitably stray to suitable habitat given sufficient time and the proximity of a viable population. The nearest viable populations occur in Scott and Waddell Creeks. The likelihood that fish will stray from these populations is influenced by their ocean behavior, response to currents and food sources, and abundance. It may be that reintroduction of coho would be a necessary prerequisite to establishing a population in the near term. The Aptos Watershed Assessment and Enhancement Plan is focused on habitat management and restoration. Reintroduction of coho salmon is an issue that will be addressed by others in other forums, such as the coho salmon recovery team convened by the National Marine Fisheries Service. Until fish are present in the stream it is difficult to predict precisely what may be influencing their abundance there. Beyond limitations imposed by lack of a spawning population and ocean conditions, coho would likely be limited by many of the same factors limiting steelhead as discussed in the preceding section, particularly sediment.

C. Geomorphology

The geology of the Aptos Creek watershed is dominated by the presence of the northwest-trending San Andreas Fault, a transverse fault that is characterized by lateral movement of the North American and Pacific Plates (**Appendix B**). The San Andreas Fault and associated Rosalia Ridge skirts the northeastern boundary of the watershed. The San Andreas Fault is considered to be very active in the study region, producing large magnitude seismic events, the most recent being the October 17, 1989 Loma Prieta earthquake. The epicenter of this 7.1 magnitude earthquake occurred within the Aptos Creek Watershed in the Forest of Nisene Marks State Park. Other geologically important features include the Zayante Fault and the Glenwood Syncline. The Glenwood Syncline, which falls between the Zayante and San Andres fault system, is a dominant feature through Bridge Creek and upper Aptos Creek. The Glenwood Syncline appears to be consequent with a large portion of the landslides mapped in the Forest of Nisene Marks.

The Purisima Formation is the dominant rock type, comprising 62% of the entire watershed. By subwatershed, the Purisima occurs in 69% of Aptos Creek, 92% in Mangels, 82% in Trout, and 51% in Valencia (Table 3). A significant proportion of the geologic units in the Aptos Creek Watershed consist of Quaternary deposits from the Pleistocene and Holocene (0-2 million years B.P.). Between 5 and 30 percent of the surficial geologic units are mapped as Quaternary deposits. In many cases, these relatively young deposits are unconsolidated and highly erodible when disturbed. They primarily occur within the Trout and Valencia Creek watersheds.

A variety of landslides ranging from shallow debris flows to rotational slumps over a hundred feet deep are found in the Santa Cruz Mountains and the Aptos Creek Watershed. Landsliding (or mass wasting) is the dominant geomorphic process in the Aptos Creek watershed. Landslides often terminate at and impinge upon stream channels, sometimes feeding a seemingly endless supply of sandy material directly into the channels. In the worst cases, chronic sediment loading from landslides can eliminate pools, riffles and coarse substrate for hundreds of feet below the point of delivery. An important mechanism to store delivered sediment and attenuate sediment delivery downstream relates to the presence of large woody material and debris jams (Keller and Talley, 1979; Keller et al., 1981).

Mapped landslides make up a substantial proportion of the overall sediment budget for Aptos watershed. The large slides are deep failures that often extend from ridge top to the canyon floor and stream. The speed of the active mass can range from inches per year to tens of feet per day. As a large slide moves along a distinct failure plane, the landmass on the upper part of the slide is lowered and depleted, while the lower toe area expands and bulges into the stream canyon or valley. As the stream incises or if a road is cut along the canyon wall, the landslide toe is eroded and the mass buttressing the slide above is removed, causing the slide to move further down slope. This lower zone of

Geologic Unit	Abreviation	Entire Watershed		Aptos Creek Sub-Watershed		Mangels Gulch Sub-Watershed		Trout Gulch Sub Watershed		Valencia Creek Sub Watershed	
		Area (acres)	Percent	Area (acres)	Percent	Area (acres)	Percent	Area (acres)	Percent	Area (acres)	Percent
Eolian Lithofacies	Qae	891	5.7	0	0.0	0	0.0	0	0.0	891	14.8
Fluvial Lithofacies	Qaf	219	1.4	0	0.0	0	0.0	0	0.0	219	3.6
Alluvial Deposits	Qal	387	2.5	103	1.3	46	8.4	127	8.5	109	1.8
Aromas Sand	Qar	580	3.7	0	0.0	0	0.0	106	7.1	474	7.9
Basin Deposits	Qb	58	0.4	0	0.0	0	0.0	0	0.0	58	1.0
Beach Sand	Qbs	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Lowest Emergent Coastal Terrace Deposit	Qcl	152	1.0	17	0.2	0	0.0	0	0.0	2	0.0
Coastal Terrace Deposits	Qcu	117	0.7	42	0.5	0	0.0	0	0.0	56	0.9
Quartz Diorite	qd	14	0.1	14	0.2	0	0.0	0	0.0	0	0.0
Older Flood Plain Deposits	Qof	282	1.8	13	0.2	0	0.0	9	0.6	190	3.2
Terrace Deposits	Qt	151	1.0	4	0.1	0	0.1	24	1.6	91	1.5
Colluvium	Qtl	858	5.5	0	0.0	0	0.0	0	0.0	858	14.3
Middle Sandstone Member	Tbm	315	2.0	315	4.1	0	0.0	0	0.0	0	0.0
Butano Sandstone	Tbu	179	1.1	179	2.3	0	0.0	0	0.0	0	0.0
Lambert Shale	Tla	2	0.0	2	0.0	0	0.0	0	0.0	0	0.0
Purisima Formation	Tp	9,816	62.5	5,344	69.2	499	91.6	1,224	82.2	3,071	51.0
San Lorenzo Formation	Tsl	997	6.3	997	12.9	0	0.0	0	0.0	0	0.0
Santa Margarita Sandstone	Tsm	13	0.1	13	0.2	0	0.0	0	0.0	0	0.0
Vaqueros Sandstone	Tvq	662	4.2	662	8.6	0	0.0	0	0.0	0	0.0
Zayante Sandstone	Tz	21	0.1	21	0.3	0	0.0	0	0.0	0	0.0

Table 3: Land surface area within each geologic unit by subwatershed. The geologic units with the highest percentage of land surface within each subwatershed are highlighted in gray. The Purisima Formation covers approximately 2/3rds of the entire Aptos Watershed.

canyon slopes where incision dominates is called the "inner gorge". The inner gorge is generally steeper than the hillslope above.

Road building is a common and often dominant theme in land use disturbance. From timber harvests to driveways and public thoroughfares, roads are required for access to nearly every land use. Roads are also by far the most destructive element in the landscape in terms of excessive fine sediment generation per unit area. Roads constructed along canyon floors and steep inner gorge slopes cause channel realignment resulting in direct delivery of sediment to streams. Erosion from road surfaces, ditches, shoulders and other human-induced land clearing contribute mostly fine-grained sediment. Paved and unpaved roads modify local hillslope drainage patterns, concentrate flow and increase runoff rates. In terms of managing sediment loads to reduce aquatic habitat impairment, fine sediment source reduction from roads will be the most effective treatment . In the Aptos Creek watershed alone there are approximately 148 miles of paved and dirt roads, not include private roads and driveways.

Bank erosion and reworking of old floodplain deposits in Aptos Creek also contributes significantly to the amount of fine sediment in the channel. These sources contribute fine sediment directly to the channel and have a significant impact on aquatic habitat conditions. Reworking of old floodplain deposits that might have been delivered to the stream channel due to historic and intensive logging operations may be especially important in the Valencia and Trout Creek watersheds due to urbanization impacts that affect the hydrologic regime. To what extent reworked floodplain deposits have an impact on aquatic habitat conditions is largely unknown.

One model, developed by Douglas (1985) describes a conceptual relationship between land use changes, relative sediment yield, and channel stability. At the onset of urban development, this model suggests the sediment yield would be very heavy due to increased runoff from impervious surfaces, resulting in increased gullying, undercutting, and bank erosion. The impact on channel stability would be rapid aggradation and some bank erosion. Assuming no net increase in urbanization, the Douglas model predicts that a watershed would proceed through a period of stabilization that would last on the order of 25 years. During this period, sediment yields would be moderate as channels adjusted to the new hydrologic condition and readily available sediment supplies were exhausted. Reduced sediment yields during this transitional period would result in channel degradation and severe bank erosion. Eventually, the channel is expected to reach a stable urban condition with low to moderate sediment yields and a relatively stable channel. This whole channel evolutionary process is expected to take 50-75 years due to lags in land use change and channel response. The timing would be highly dependent upon the size of the watershed, the rate of urbanization, and the time it takes for land use conditions to stabilize. Estimates of impervious surfaces in the Valencia Creek watershed suggests that a total of 8% of the land surfaces are either paved or contain roof tops.

Table 4 lists the estimated sediment yield for the Aptos Creek Watershed by sediment source and location. The total estimated sediment yield for the Aptos Creek Watershed is approximately 60,500 tons/year. Averaged over the whole watershed, the expected yield is approximately 2,465 tons/mi^2/year. Each subwatershed has an expected yield of 2,670, 1,940, 2,380, and 2,300 tons/mi^2/year for Aptos, Mangels, Trout, and Valencia, respectively. These values fall within the expected range of sediment yields generated for other watersheds in coastal California.

Valencia, Trout, and Mangels may be significantly impacted by recent urbanization of the watershed which has had a cumulative impact on the channel conditions. As watersheds urbanize, an increasing percentage of the land surface becomes impervious to rainfall due to more roads, rooftops, and driveways. The increase in impervious surfaces creates a hydrologic regime that is flashier[2], with higher peak flow values. This is especially evident during low magnitude precipitation events. In undisturbed watersheds, low magnitude precipitation events produce very little runoff due to soil storage and percolation to groundwater. In urbanized watersheds, even small amounts of rainfall produce a significant amount of runoff from impervious surfaces that are delivered quickly to stream channels. This has been shown to increase bank erosion (Booth and Henshaw, 2001) and create unstable geomorphic conditions as the channel attempts to adjust to a new hydrologic regime.

In the winter of 1982 a series of storms battered the California coast and caused extensive damage throughout Santa Cruz County. These storms may have been the “straw that broke the camel’s back” for Valencia Creek, an event that the system has yet to recover from. Eyewitnesses reported severe damage to Valencia Creek, including complete unraveling of the banks of the lower stream channel and 2 to 5 feet of aggradation by predominantly sand-sized material (Dr. Jerry Smith, personal communication). If this account is accurate, it is likely that the system may still be adjusting to the massive sedimentation event while simultaneously reacting to increased pressure from urbanization and a continually changing hydrologic regime.

The sediment budget numbers can also be manipulated to obtain a rough estimate of the amount of material that is being delivered to the stream channel from either natural or anthropogenic sources. This requires some knowledge of the land uses occurring in a particular subwatershed and an educated estimate of the percent of the total yield that is expected to be caused by human impacts, as opposed to naturally occurring erosion processes. Table 5 outlines the percentages that were determined to be appropriate for each source for each individual watershed. Sediment delivered to the channel from roads was assumed to be entirely anthropogenic, whereas the other categories were proportioned according to observed land use impacts in the watershed. Aptos Creek was assumed to be the least influenced by human interactions with the landscape. Much of the watershed is protected within a state park and a large number of the landslides occurring within the watershed have been documented to be a result of the Loma Prieta earthquake. The results from this analysis are shown in Table 6.

[2] A “flashy” hydroligc regime refers to a rapid rise and fall in stream water levels associated with precipitation.

	Sub-Watershed	Feature Length (miles)	Erosion Rate (tons/mi^2/yr)	Delivery Efficiency	Sediment Delivery Rate to Streams (tons/mi/yr)	Sediment Yield (tons/yr)	Totals by Erosion Type (tons/yr)	Total Sediment Yield (tons/yr)	Total Sediment Yield (tons/mi2/yr)
Inner Gorge Paved Roads	Aptos Creek	3.4	78.1	100%	78.1	263	1,293	**60,521**	**2,465**
	Mangels Gulch	2.0	78.1	100%	78.1	159			
	Trout Gulch	1.8	78.1	100%	78.1	143			
	Valencia Creek	9.3	78.1	100%	78.1	728			
Inner Gorge Dirt Roads	Aptos Creek	1.6	600	100%	600	560	581		
	Mangels Gulch	0.1	600	100%	600	21			
	Trout Gulch	None Mapped							
	Valencia Creek	None Mapped							
Hillslope Paved Roads	Aptos Creek	23.6	78.1	42%	33	773	4,052		
	Mangels Gulch	13.8	78.1	42%	33	452			
	Trout Gulch	14.1	78.1	42%	33	463			
	Valencia Creek	72.1	78.1	42%	33	2364			
Hillslope Dirt Roads	Aptos Creek	6.0	600	42%	252	1523	1,566		
	Mangels Gulch	None Mapped							
	Trout Gulch	None Mapped							
	Valencia Creek	0.2	600	42%	252	43			
Bank Erosion	Aptos Creek	24.7	70	100%	70	1729	8,184		
	Mangels Gulch	2.1	170	100%	170	357			
	Trout Gulch	6.0	327	100%	327	1962			
	Valencia Creek	21.1	196	100%	196	4136			
	Sub-Watershed	**Feature Area (Sq. miles)**	**Erosion Rate (tons/mi^2/yr)**	**Delivery Efficiency**	**Sediment Delivery Rate to Streams (tons/mi^2/yr)**	**Sediment Yield (tons/yr)**			
Mass Wasting	Aptos Creek	11.6	7996	20%	1599	18538	26,772		
	Mangels Gulch	1.2	1605	20%	321	395			
	Trout Gulch	2.3	2316	20%	463	1078			
	Valencia Creek	9.4	3593	20%	719	6761			
Urban and Rural Lands	Aptos Creek	11.6	1548	42%	650	7536	18,073		
	Mangels Gulch	1.2	1935	42%	813	999			
	Trout Gulch	2.3	1935	42%	813	1892			
	Valencia Creek	9.4	1935	42%	813	7646			

Table 4: Estimated sediment yield for each erosion source, by major subwatershed.

Table 5: Estimates of natural versus anthropogenic sediment yields from Aptos Creek Watershed.

Subwatershed	Sediment Yield (tons/yr)	Sediment Yield (tons/mi2/yr)	Natural (tons/yr)	Athropogenic (tons/yr)
Aptos	30,922	2,668	22,581	8,341
Mangels	2,383	1,938	1,507	875
Trout	5,538	2,379	2,004	3,534
Valencia	21,678	2,304	8,609	13,068

Table 6: Percent of erosion that was considered to be anthropogenic for each erosion source.

Subwatershed	Erosion from Roads	Bank Erosion	Mass Wasting	Urban and Rural Lands
Aptos	100%	30%	30%	30%
Mangels	100%	50%	50%	50%
Trout	100%	70%	60%	80%
Valencia	100%	70%	60%	80%

D. Hydrology and Water Quality

Hydrology

The mainstem of Aptos Creek (including Bridge Creek) drains an area of 11.2 mi^2, much of which occurs within the Forest of Nisene Marks State Park (Table 7). To the east, Valencia Creek drains 9.41 mi^2 of both rural and developed lands. Trout Gulch is relatively small, draining 2.33 $mi^{2\ of}$ rural residential lands and discharges into Valencia Creek just upstream of Soquel Drive. Mangels Gulch, the smallest named tributary, drains 0.85 mi^2 of rural residential lands.

The differences in current land use between the mainstem of Aptos Creek and Valencia Creek drainage allows for a comparison of hydrologic and channel conditions, with some consideration given to the geologic differences of the two watersheds (**Appendix C**). Valencia Creek has been significantly impacted by historic and recent logging, rural residential and urban development, and stream-side development, whereas the majority of Aptos Creek watershed has remained relatively undisturbed since 1964 when the Forest of Nisene Marks State Park was established, although significant logging occurred on these lands prior to the 1960s. The differences in the channel substrate and the hydrologic conditions observed within each of these watersheds are due, in large part, to the variations in the surrounding land uses.

Table 7: Characteristics of the main tributaries of Aptos Creek Watershed.

Sample Site Sub-Shed	Sub-Shed Areas (mi^2)	Main Tributary Length	Elev. Peak of Sub-Shed (ft)	Area and (%) of Impervious Surfaces	Predominant Land Use
Aptos/ Bridge Creek	11.2	7.2	2624	0.23 mi^2 (1.9%)	Predominantly dense forest canopy with few residential parcels and open spaces in lower sub-watershed area.
Mangels Gulch	0.85	2.0	860	0.04 mi^2 (0.5 %)	Scattered rural residential parcels throughout entire sub-watershed.
Trout Gulch	2.33	4.0	979	0.12 mi^2 (5.3 %)	Rural residential and large open spaces throughout entire sub-watershed.
Valencia Creek	9.41	7.3	1928	0.72 mi^2 (7.7 %)	Densely residential in lower sub-watershed with rural residential in upper east sub-watershed.
Aptos Mainstem	24.2	20.5	2624	1.1 mi^2 (4.5 %)	Residential / Open space

The hydrology of any stream is strongly influenced by the local climate, the watershed area, the basin land gradient and the local geology. In urbanized areas, the local hydrology will also be heavily influenced by human activities that have resulted in impervious surfaces, such as roads, rooftops and storm sewer systems. Creek side landowners often desire efficient flood conveyance to prevent flooding. Urbanized areas frequently develop ways to route the water off of property for quick delivery into the adjacent channel. This greatly increases the peak flow (discharge) within the streams and decreases the duration of the runoff, converting the local streams to “flashier” systems than they originally were. Changes to the hydrologic regime can result in increased water velocities, increased erosive power within the stream channel and elevated sediment transport. Due to these factors, many streams subjected to development in their surrounding watersheds experience channel incision and cross-sectional changes due to increased flows.

Substrates in Valencia Creek are dominated by sandy sediments that are easily mobilized during most flow events. Valencia Creek most likely had a significant sediment delivery and aggradation event during the extremely high flows in the winter of 1982 (see Appendix B). We assume the change in channel morphology in the last few decades has been in response to land use impacts. While minimal detailed hydrologic data on Valencia Creek are available, current stream channel conditions and storm event observations suggest Valencia Creek is now a relatively “flashy” system with increased peak flows and decreased durations due to the last few decades of development. In contrast, and as a result of of a more stable channel morphology and the lack of overwhelming sediment loads, the Aptos Creek system appears to be more resilient than Valencia Creek to catastrophic sediment inputs.

The United State Geologic Survey (USGS) maintained two different stream flow gages on the Aptos Creek tributary (Appendix C); one gage was utilized from 1959 to 1972, the other was in operation from 1972 to 1985. There are no historical data for any of the other named tributaries. The peak flow of record (3,980 cubic feet per second) occurred on January 4, 1982 and had an estimated recurrence interval of 33 years. Based on available data from adjacent Soquel Creek, it is reasonable to assume that no flow has exceeded 3,980 cfs during the past 40 years. The historic streamflow record suggests that Aptos Creek contains surface flow during all months, even in drought years (Table 8). Valencia Creek was purported to have dried up in some sections during drought years, though this condition is likely exacerbated by the presence of deep sandy substrate on the bed of lower Valencia that causes much of the water to flow subsurface.

Based on flow measurements conducted within Aptos and Valencia Creeks (Jan 17th and late February 2002) and visual observations throughout the study, a reasonable estimate of the annual surface water flow budget of Aptos Creek Watershed may be 20-30% from the Valencia Creek Watershed and the remaining 70-80% of the flow observed in the mainstem is generated within Aptos Creek watershed. During storm runoff events the surface water contribution from Valencia and Aptos Creek watersheds may be more equal, but surface water volumes recede in Valencia Creek relatively rapidly following the end of storm runoff. While climatic variability and other factors may result in each runoff event not following the same relative contributions of water as stated above, these estimates provide a first-order approximation of the distribution of surface water within the Aptos Creek Watershed.

Table 8: Monthly exceedance probabilities and estimated peak discharges for USGS Gages 11159690 Aptos Creek near Aptos, CA (WY 1971-1985) and 11159700 Aptos Creek at Aptos, CA (WY 1958-1971). Exceedance probabilities are calculated by sorting all available mean daily flow values by month. Exceedance probabilities give information about how often a certain flow value is exceeded. For example, in August during a dry year, the flow exceeds 0.77 cfs 50% of the time and 0.67 cfs 90% of the time.

Month	Exceedance Probability	Wet	Average	Dry	Drought	Month	Exceedance Probability	Wet	Average	Dry	Drought
Oct.	95	2.1	0.94	0.69	0.51	Nov.	95	3.3	1.2	0.77	0.51
	90	2.1	1.0	0.70	0.55		90	3.4	1.3	0.78	0.56
	80	2.3	1.0	0.72	0.57		80	3.8	1.4	0.82	0.64
	70	2.3	1.0	0.74	0.60		70	4.3	1.5	0.85	0.67
	60	2.4	1.1	0.75	0.61		60	5.0	1.7	0.90	0.70
	50	2.6	1.2	0.77	0.61		50	6.4	1.8	0.95	0.70
Dec.	95	6.0	1.6	1.1	0.82	Jan.	95	15	2.3	1.5	0.91
	90	6.4	1.7	1.1	0.85		90	16	2.5	1.5	0.92
	80	7.5	1.8	1.2	0.86		80	20	2.7	1.6	1.0
	70	8.5	2.0	1.2	0.87		70	24	3.0	1.7	1.0
	60	10	2.5	1.2	0.92		60	30	3.4	1.7	1.0
	50	13	2.8	1.3	0.95		50	39	4.1	1.8	1.1
Feb.	95	22	3.6	2.2	1.0	Mar.	95	19	4.0	2.0	1.0
	90	24	3.9	2.2	1.1		90	20	4.4	2.1	1.1
	80	27	4.8	2.3	1.2		80	23	4.9	2.2	1.3
	70	32	5.4	2.4	1.3		70	26	5.6	2.3	1.4
	60	39	6.0	2.6	1.3		60	30	6.7	2.3	1.5
	50	48	6.7	2.8	1.4		50	35	8.1	2.4	1.6
April	95	12	2.9	1.6	1.1	May	95	5.8	1.8	1.2	0.82
	90	13	3.2	1.6	1.1		90	6.1	1.9	1.2	0.91
	80	14	3.8	1.7	1.1		80	6.7	2.2	1.3	1.0
	70	17	4.1	1.7	1.2		70	7.3	2.5	1.3	1.0
	60	21	4.7	1.9	1.2		60	8.0	2.8	1.3	1.0
	50	24	5.3	2.1	1.2		50	8.9	3.0	1.3	1.0
June	95	3.7	1.4	0.84	0.36	July	95	2.7	1.1	0.70	0.29
	90	3.8	1.5	0.85	0.38		90	2.8	1.2	0.73	0.48
	80	4.2	1.6	0.89	0.42		80	3.0	1.3	0.76	0.53
	70	4.6	1.7	1.0	0.55		70	3.1	1.4	0.79	0.54
	60	4.8	2.0	1.0	0.63		60	3.2	1.4	0.80	0.55
	50	5.0	2.2	1.1	0.70		50	3.4	1.6	0.84	0.58
Aug.	95	2.0	1.0	0.63	0.45	Sept.	95	1.8	0.87	0.63	0.46
	90	2.1	1.0	0.67	0.48		90	1.9	0.90	0.66	0.46
	80	2.2	1.0	0.68	0.48		80	2.0	1.0	0.69	0.47
	70	2.4	1.1	0.72	0.49		70	2.1	1.1	0.70	0.48
	60	2.4	1.2	0.75	0.49		60	2.1	1.1	0.70	0.49
	50	2.6	1.3	0.77	0.49		50	2.2	1.2	0.73	0.51

Water Quality

A brackish environment and abundant food sources make lagoons and estuaries the most productive systems per unit area on the Earth's surface. The natural seasonal transition of Central California coastal lagoons is from a tidally influenced river mouth in the winter months to an inundated brackish/freshwater system in the summer when a sandbar forms at the mouth. While the natural physical closure of the Aptos lagoon continues today, urban development around the lagoon has severely constricted the area to a width of approximately 70 feet between two vertical cement levees that extend from the high water line of the ocean upstream approximately 300 ft. Oceanward of a pedestrian bridge, the channel meanders along the Rio Del Mar Beach prior to discharging into the Monterey Bay.

During summer closure, the physical and chemical system goes through a dramatic shift as circulation is decreased, resulting in increased water temperatures, elevated biological activity (photosynthesis and respiration) and exacerbated chemical cycling. In order to monitor the transformation of the physical, chemical and biological components of the lagoon during the summer months, SH&G installed a high-resolution ancillary water quality data logger (YSI) 100 ft upstream of the pedestrian bridge on August 21, 2001. The YSI recorded water temperature, water depth, dissolved oxygen (DO), salinity, pH and conductivity on 30-minute intervals until October 21, 2001. Figure 7 shows graphically the data collected from the bottom waters from late August through October 2, 2001. The YSI was then moved higher in the water column and continued to record data until October 21, 2001.

The Aptos Lagoon accepts all of the point source and non-point source pollution that is introduced into the local waterways. The fertilization of surface waters with nutrients results in a significant increase in biological growth of algae and phytoplankton, known as eutrophication. When the lagoon mouth is open, water circulation allows the system to handle excess nutrient inputs without a severe eutrophic response. As sand deposition increases and freshwater discharges decrease in the spring and summer, a sandbar forms at the mouth and isolates the lagoon from the ocean. The salt water trapped within the lagoon is denser than the freshwater inflows, thus forming the bottom layer of the water column. Photosynthesis produces biomass and oxygen in the surface waters. The amount of algae (biomass) produced is directly dependent upon the supply of nutrients, nitrogen (N) and phosphate (P). The larger the nutrient supply, the greater the algal bloom. The algae subsequently sink to the bottom and are respired by bacteria, consuming oxygen in the process. Anoxic conditions (devoid of dissolved oxygen) develop in the bottom and pore waters (water in the surface sediments) as a result of bacterial breakdown of sinking organic detritus, such as algae.

The temperature and salinity differences between the surface and bottom water physically and chemically isolate these two water bodies from one another. This isolation prevents oxygen that is produced in the surface water by photosynthesis during the daylight hours to be available for respiration in the bottom waters Once the entire reservoir of oxygen

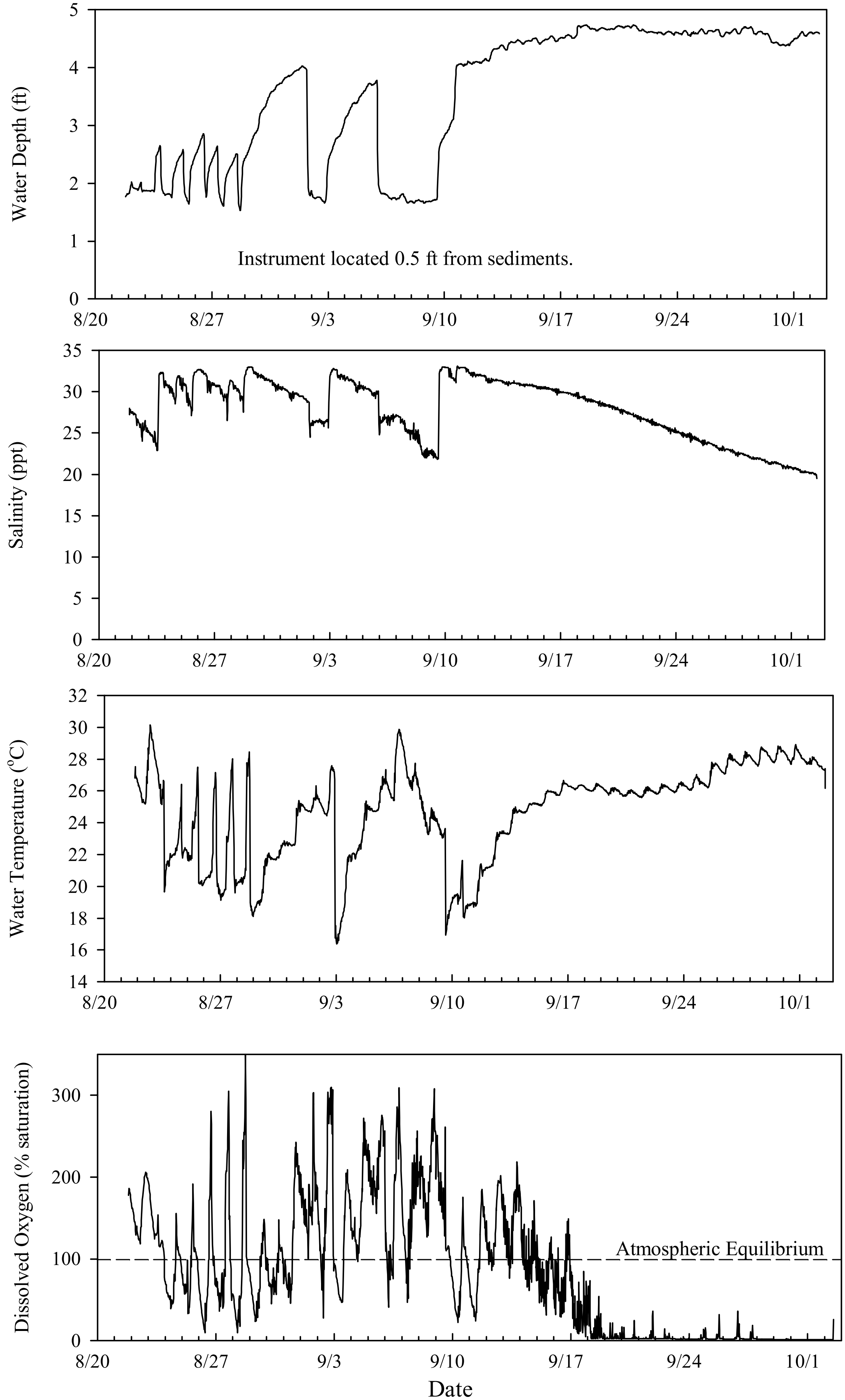

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Figure 7: Water quality data collected by YSI in Aptos Creek Lagoon, August 21 - October 2, 200. Instrument is located in bottom waters.

has been consumed in the bottom waters, heterotrophic bacteria will continue to oxidize organic matter by utilizing oxygen alternatives. The oxygen alternatives include sulfate (HSO_4^-), the most abundant substitute, nitrate (NO_3^-), and manganese oxide (MnO_2). When reduced, sulfate forms hydrogen sulfide (HS^-), which is toxic to fish and invertebrates. While no measurements of the HS^- levels were conducted within Aptos Lagoon during the sustained closure in the fall of 2001, it is a reasonable assumption that HS^- may have been produced sometime during 25 days of anoxic conditions. These reduced conditions can also result in high concentrations of ammonia in the water column, also toxic to aquatic organisms in high doses.

The Santa Cruz County Environmental Health Department has collected monthly water samples from a number of the local streams that transport nutrients directly to the coastal lagoons. Figure 8, a comparison of the average monthly N loading rates to four local lagoon systems, Aptos Lagoon, Soquel Lagoon, San Lorenzo Lagoon and Pescadero Marsh, depicts the relatively low levels of N delivery to Aptos Lagoon relative to the values in San Lorenzo. The majority of the nutrient data collected by local agencies has been limited to biologically available nitrate. In the mainstem of Aptos Creek, values of nitrate have been fairly low for human health standards, but high enough to induce algae growth. The lack of simultaneous biologically available P data for the tributaries limits our interpretation of the degree to which eutrophication in the lagoon is caused by inflowing waters. Water samples collected within the four local lagoons indicate that Aptos Lagoon is enriched with biologically available nutrients, particularly phosphate. Other water quality data has suggested that there may be an additional source of nutrients to the lagoon that is not coming from the local tributaries.

The Santa Cruz chapter of the Surfrider Foundation monitors the fecal coliform levels at the mouth of Aptos Creek and at various locations within the watershed once a week. The fecal coliform and *enterococcus* bacteria levels observed at the mouth of Aptos Creek watershed are consistently elevated relative to the other local coastal monitoring stations (>200 MPN). The *enterococcus* bacteria are a subgroup of the fecal *streptococci*. Studies in marine waters and freshwater indicate that *enterococci* are the most efficient bacterial indicator of water quality. *Enterococcus* is a bacterium found in the human intestine and therefore a good indicator of human waste, i.e. septic system and sewer system pollution. Fecal coliform is a specific kind of coliform bacteria found primarily in the intestinal tracts of mammals and birds. These bacteria are released into the environment through human and animal feces. The presence of fecal pollution may come from storm water runoff, pets and wildlife, and human sewage. The source correlation of nutrient and fecal coliform pollution suggest that observed elevated levels of fecal coliform would correspond with elevated nutrient levels as well. The occurrence of high fecal coliform, *enterococcus* bacteria and nutrient concentrations in the Aptos Lagoon, especially during storm runoff events, further suggests that coliform levels could be used as an indication of nutrient-enrichment.

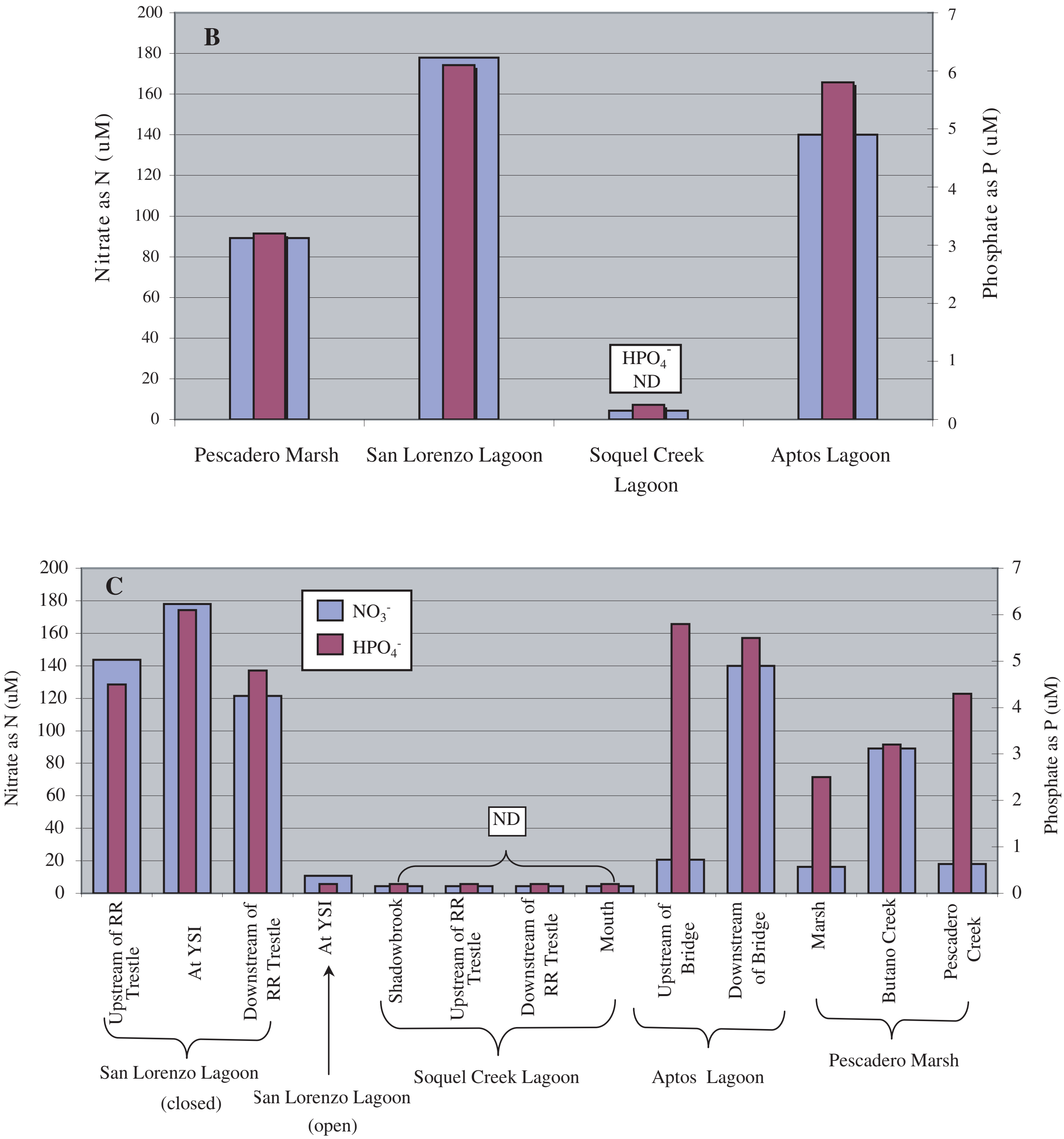

Figure 8: Comparison of maximum values of nitrate and phosphorus in Central California lagoons during the Fall of 2001. **C**: Concentration of NO_3 and HPO_4 in Central California coastal lagoons.

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E. Riparian Habitat

The watercourses within the Aptos watershed are predominantly naturally vegetated and are comprised of seven distinct riparian plant community types (Table 9). This assemblage of riparian plant community types result from differences in watercourse topography and substrate, stream flow characteristics and current and past land uses. Many parcels support residential land uses, including orchards and small farms and some lands are also in timber production within upper Valencia watershed. Since the turn of the century, the planting of non-native trees and groundcovers has occurred along the stream courses within the watershed.

Within the Aptos Creek watershed, coast redwood (*Sequoia sempervirens*) is a common component of the riparian forest. Other common riparian trees within the watershed include tanoak (*Lithocarpus densiflorus*), big leaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*), box elder (*Acer negundo*) and black cottonwood (*Populus balsamifera* ssp. *trichocarpa*).

Table 9. Riparian plant community types identified within the Aptos Creek Watershed

Plant Series	Common Plant Species	Creeks where Documented	Sample Plots*
Redwood/Tanoak Riparian Forest	Redwood, tanoak, snowberry, western raspberry, thimbleberry, sword fern, chain fern, redwood sorrel	Trout Gulch Upper Valencia Creek Bridge Creek	UVC-1, 3, 4
Maple/Tanoak/Redwood Riparian Forest	Big leaf maple, tanoak, redwood, sword fern, lady fern, redwood sorrel, California blackberry, chain fern, thimbleberry, hazelnut	Valencia Creek Mangels Gulch Aptos Creek	VC-1, 2, 4 AC-4, 5
Alder/ Maple/ Redwood Riparian Forest	Red alder, big leaf maple, redwood, creek dogwood, stinging nettle, thimbleberry, hazelnut	Valencia Creek	VC-3, 5 AC-4
Alder/Box Elder Riparian Forest	Red alder, box elder, creek dogwood, yellow willow, lady fern, common horsetail, English ivy	Valencia Creek	VC-6, 7
Alder/Cottonwood/ Redwood Riparian Forest	Red alder, black cottonwood, arroyo willow, redwood, pampas grass, Himalaya berry, panicled bulrush. English ivy, California blackberry, stinging nettle, thimbleberry	Aptos Creek Trout Gulch	AC-1, 2, 3
Willow/Dogwood Riparian Forest	Arroyo willow, yellow willow, creek dogwood, panicled bulrush, chain fern, hazelnut,	Trout Gulch Upper Valencia Creek	TG-1, UVC-2, VC-3
Herbaceous Riparian	Rabbitsfoot grass, rush, sedge	Tributary to Trout Gulch	None

No special status plant species were found or are expected to occur in the Aptos watershed riparian corridors. However, several nonnative invasive plant species were observed within the watershed and prioritized as to their threat to the riparian resources of the watershed include:

<u>High Threat</u>

- French broom (*Genista monspessulana*)
- Pampas grass (*Cortederia jubata*)
- Periwinkle (*Vinca major*)
- Poison hemlock (*Conium maculatum*)
- Cape ivy (*Delaireia odorata*)
- English ivy (*Hedera helix*)
- Acacia *(Acacia* sp.)
- Giant Reed (*Arundo donax)*
- Black Locust (*Robinia pseudoacacia)*

<u>Moderate to Low Threat</u>

- Italian thistle (*Carduus pynocephalus*)
- Monterey pine (*Pinus radiata*),
- Blue gum eucalyptus (*Eucalyptus globulus*),
- Harding grass (*Phalaris* spp.),
- Mexican eupatorium (*Eupatorium adenophorum)*,
- Bull thistle (*Cirsium vulgare)*
- Himalaya berry (*Rubus procerus),*
- Wandering Jew (*Tradescantia* sp.)
- Forget-me-Not (*Myosotis latifolia)*

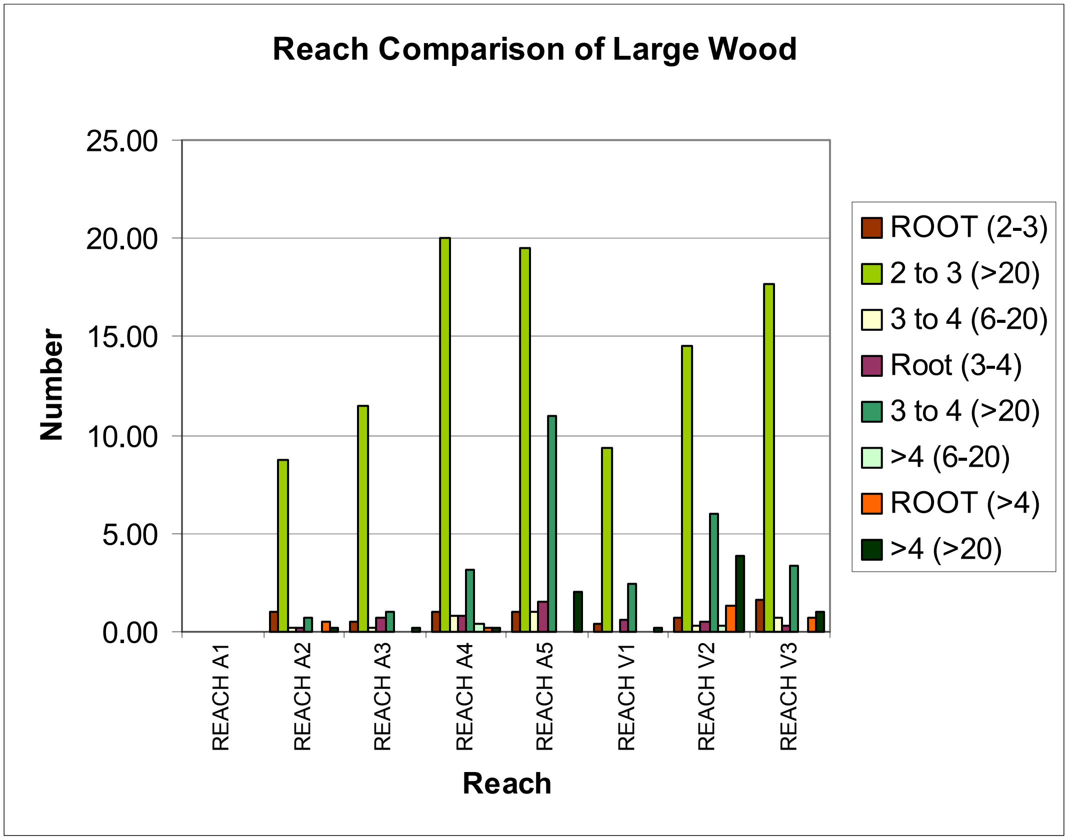
Other non-native plant species observed in the riparian areas include: hellebore and garden nasturtium; these two species occur in the riparian areas of the watershed but are not currently considered of management concern.

The riparian forests within the watershed lands offer opportunities to remove and/or control the spread of these invasive pest plant species and allow natural revegetation of native understory species.

F. Large Woody Material Recruitment Inventory

Throughout the Central California coast, including the Aptos watershed, most old growth redwood (*Sequoia sempervirens*) was harvested during the last 150 years and is no longer available for in-channel habitat, reducing both wood quantities and quality available to adjacent streams or rivers. Large woody material (LWM) creates important fish habitat such as pools, provides refuge during winter storm events and temporarily stores sediment. The majority of Aptos watershed surveyed contains very little old growth (**Appendix E**.). However, upper Aptos Creek and Valencia Creek (especially reaches A5 and V2) support mature coniferous trees that have a high likelihood of entering the channel due to tree size and steep slopes.

Figure 9. Reach comparisons of large wood in Aptos and Valencia Creeks



Aptos reaches 4 and 5 and Valencia reaches 2 and 3 contained the highest proportion of mature-old growth coniferous trees (>2' DBH), in both riparian sections one and two. These areas are important for recruitment of LWM that has a likelihood of remaining in the channel and providing long-term benefits for salmonid habitat and sediment storage. If larger diameter (>3' DBH) wood that spans the channel is left in place once it enters the stream, wood can act as "catcher" logs, creating more complex habitat. Comparisons were made between reaches by averaging the number of pieces of wood by number of surveys per reach. Figure 9 exhibits the lack of old growth wood in all reaches. Overall, Reaches A5 and V2 have the highest numbers of large wood, compared to other reaches surveyed. Reaches A5, V2 and V3 have the largest amounts of large wood (>4 feet diameter, > 20 feet length).

The lack of old growth wood within most of the Santa Cruz Mountains, including Aptos watershed, signifies increased importance in preserving instream wood and allowing natural LWM recruitment to occur for salmonid habitat and to attenuate sediment transport throughout Aptos and Valencia creeks.

FINDINGS, RECOMMENDATIONS AND LIMITING FACTORS

Major Findings and Recommendations

Assessment findings and recommendations were developed through a thorough interdisciplinary approach that included:

1) Historical data review
2) Field studies
3) Data analysis
4) Data synthesis
5) Technical review

After draft hydrology and water quality, geomorphology, fisheries habitat and riparian assessment reports were completed, the technical team peer-reviewed assessments, synthesized findings and developed recommendations. The TAC and PAG then reviewed findings and recommendations, provided input and prioritized recommendations.

The assessment findings and recommendations were divided into reaches based on salmonid habitat and fluvial geomorphic characteristics (Figure 2).

Watershed-wide (includes findings that apply to the entire Aptos watershed, including all tributaries):

Findings

The primary limiting factors within the Aptos watershed are:

- Sediment
- Lagoon water quality
- Urbanization

Sediment is thought to be the most significant limiting factor for salmonid habitat throughout the watershed. Lagoon water quality has been repeatedly reported as poor; if improved, more steelhead rearing habitat would be available. Finally, urbanization of approximately 40% of the watershed (including Valencia, Trout Gulch and Mangels Gulch) has significantly increased during the last thirty years. Increased areas of impervious surfaces are directly related to urbanization and can negatively impact fish habitat by accelerating flow rates, erosion and sedimentation and reducing habitat.

In terms of coho habitat, it is important to recognize that the two most important limiting factors for coho salmon are 1) ocean conditions and 2) no adult spawners are returning to Aptos Creek. Clearly, these factors are beyond the scope of this project. Therefore, the focus for our recommendations emphasizes the restoration of freshwater habitat that will benefit juvenile steelhead, and potentially coho, survival rates.

Recommendations

- Reduce sediment delivery to the channel
- Provide landowner outreach materials for best management practices (e.g. "Stream Care Guide" produced by the County of Santa Cruz)
- Create landowner incentive programs to minimize sediment delivery and peak flows during storm events
- Emphasize the overall importance of maintaining baseflow in an urbanized watershed
- Conduct assessment of private and public roads and develop sediment reduction plans

Aptos Lagoon (includes the mouth of Aptos Creek at Seacliff State Beach upstream to Spreckel's Bridge):

Findings

- Coastal lagoons provide important rearing habitat for steelhead trout
- Food availability for steelhead is the primary issue in Aptos lagoon
- The lagoon repeatedly exhibits high levels of fecal coliform (higher than other Santa Cruz County lagoons such as San Lorenzo and Soquel)
- High nutrient levels (higher than nearby lagoons) are present
- Based on coliform testing, high levels of fecal coliform are coming from the lower watershed (downstream of Valencia Creek confluence)
- Artificial breaching of the summer sandbar occurs which can negatively impact salmonids utilizing the lagoon for rearing habitat
- The lagoon primarily consists of sandy, exposed habitat (this is not necessarily limiting for steelhead- steelhead use this type of habitat in the Carmel River lagoon)
- The lagoon lacks complexity
- The lagoon was suboxic (low oxygen levels) or anoxic (without oxygen) at several points in the water column during lagoon closure at the site of the water quality probe
- Water quality is impaired, overall
- There is a lack of cover for fishes
- Trash is present within the lagoon area
- Lagoon enhancement can increase steelhead rearing habitat, decrease temperature and increase food availability

Recommendations

- Conduct a lagoon assessment and enhancement plan to evaluate opportunities and constraints to expand and restore the lagoon
- Create public outreach materials including signage and brochures that emphasize importance of lagoons for steelhead

- Manage lagoon function and reduce artificial breaching
- Determine and reduce the sewage source
- Control nonnative invasive plants
- Provide more vegetative and in-channel cover
- Reclaim the access road on the north side of lagoon
- Buy adjacent land from any willing landowners for floodplain restoration

Spreckel's Bridge to Valencia Creek confluence (includes a short reach (0.1 mile) to the confluence of Valencia Creek at stream mile 0.3):

Findings
- This section contains relatively low quality salmonid habitat
- The grade control at Spreckel's Bridge is holding back a lot of sediment and is a partial fish barrier during certain flows
- Several homes are within the flood plain

Recommendations
- Modify barrier at Spreckel's Bridge
- Public outreach about proper yard debris disposal and importance of maintaining riparian corridor
- Create more of a defined channel (barrier modification may catalyze this)
- Focus of any restoration efforts should incorporate flood control (no structures should be added to enhance this reach)

Lower Valencia Creek (includes the mouth of Valencia Creek to the Valencia Road culvert crossing):

Findings
- Valencia Creek contained good salmonid habitat pre-1982 storm event
- Sedimentation is a major issue within Valencia Creek
- The 1982 storm caused extensive unraveling of hillslopes; the channel has been unable to adjust due to the high level of urbanization
- Three fish barriers are limiting access to salmonid habitat (adjacent to Highway One, under Soquel Drive and under Valencia Road)
- Flow is a limiting factor
- Most of the sedimentation is caused by bank erosion due to human encroachment
- Channel incision and bank failure is prevalent within the lower watershed
- Canopy estimates for Valencia are approximately 80% (this is good for salmonid food production and stream shading)
- The creek probably dries up during some dry years
- The amount of sediment in the channel limits the availability of surface water
- Runoff from impermeable surfaces is increasing the hydrographic peak during rain events
- Runoff from impermeable surfaces is not entering into baseflow

- Long term infiltration recharge will decrease the "flashiness" of Valencia Creek and increase baseflow (landowner incentive for this is that wells will last longer and there will be less erosion)
- The most effective restoration in this reach will be long term outreach to minimize cumulative urban impacts

Recommendations

- Attenuate the peak flow to reduce streambank erosion and increase groundwater infiltration
- Remove or modify three fish barriers
- Develop programs for residential water catchment such as roof runoff cisterns for irrigation purposes
- Reduce bank erosion and sedimentation
- Provide best management practice materials (BMPs) for new roads to encourage incorporation of water retention into infrastructure (such as a reverse French drain, grease and oil traps)
- Reduce sedimentation before emphasizing flow increases (increasing the flow will not significantly increase the surface water availability)
- Provide BMP materials for new developments to encourage water detention devices
- Coordinate with the Soquel Water District and County of Santa Cruz to develop a rebate program for roof runoff cisterns

- Provide education and outreach for better land use practices (including brochures, public service announcements, workshops, etc.). Make sure to include why better management practices will benefit landowners
- Create best management opportunities for single-family residences, housing developments and County roads separately
- Control nonnative invasive plants to decrease bank erosion
- Use Public Advisory Group to develop outreach recommendations
- Develop erosion control plans for slides adjacent to the creek
- Work with non-regulatory entities such as the Santa Cruz Resource Conservation District and the Natural Resources Conservation Service to develop incentive programs
- Conduct private and County roads assessment
- Conduct a multi year, comprehensive hydrologic and geomorphic assessment for Valencia Creek

Upper Valencia Creek (from the Valencia Road crossing to the extent of anadromy[3]

<u>Findings</u>
- Young-of the-year steelhead were found in Hagar's 2001 habitat surveys
- Stream has better habitat upstream of Valencia Road culvert
- Primarily rural residential and some timber lands in the upper watershed
- Santa Cruz County had fish passage evaluation performed on Valencia Road culvert in 2002; determine extent of barrier based on their work

<u>Recommendations:</u>
- Modify Valencia Road culvert or place a bridge
- Assess and winterize any unpaved roads near creek
- Preserve natural flows

Trout Gulch (includes the entire Trout Gulch tributary)

<u>Findings</u>
- This subwatershed is highly developed (primarily residential)
- Only low quality salmonid habitat is present; no pools are present and the drainage is very sandy
- Few steelhead were observed during surveys
- The creek dries up in many locations during the dry season
- A high degree of downcutting is present
- Although there is a high degree of sedimentation within this drainage, there is limited benefit to reducing sediment here due to the lack of habitat and because it releases low in the Aptos watershed

[3] Extent of anadromy refers to the highest point upstream that salmonids can access in a stream or river.

Recommendations:

- Recommendations should focus primarily on landowner outreach and should include best management practices recommended for Valencia Creek
- Induce infiltration recharge in upper part of subwatershed. By inducing deeper recharge, ground water and lower watershed baseflows will benefit during the dry season.
- Coordinate with the County of Santa Cruz to improve Trout Gulch road-associated problems

Mangel's Gulch (includes the entire Mangel's Gulch tributary)

Findings

- A barrier exists near confluence to Aptos Creek
- The creek is dry during much of the year

Recommendations

- Conduct water quality monitoring
- Provide landowner outreach materials that include best management practices recommended for Valencia Creek

Lower Aptos Creek (extends from the confluence of Valencia Creek to the lower boundary of Forest of Nisene Marks State Park)

Findings

- Good quality salmonid habitat was observed but fewer fish than expected were observed during Hagar's 2001 surveys (see Appendix A)
- Canopy cover is low in some places
- Large woody material provides important habitat

Recommendations:

- Conduct water quality monitoring
- Provide landowner outreach materials that include best management practices recommended for Valencia Creek
- Leave large woody material alone; if modification of a jam is needed, have a qualified geomorphologist and fisheries biologist evaluate it first

Upper Aptos Creek (includes the Forest of Nisene Marks State Park to the extent of anadromy)

Findings

- Sediment is the primary limiting factor

- Reach A5 (Figure 2) is the most productive reach for steelhead, especially near Bridge Creek (a lot of YOY were present during 2001 surveys and low embeddedness was observed compared to other reaches)
- Reaches A3 and A4 also have sedimentation problems but lack of cover is the primary limiting factor
- Reach A3 contains a lot of downed wood but only a small portion has actually fallen in the channel at this time
- Bridge Creek and Reach A6 contain multiple large wood jams (naturally induced) that are partial barriers
- Reach A5 is an important reach for spawning
- There is a high degree of recreational trail use in the lower park
- Several unimproved creek crossings are present in reaches A3-A4 which can negatively impact spawning and rearing habitat, as well as migration
- Bridge Creek is probably accessible to steelhead in some years, but not all
- The Old Mill site in reaches A4 and A5 contains a large periwinkle patch (*Vinca* sp.) that should be controlled
- Unimproved heavy equipment stream crossings adjacent to bridges are present in Reach 4 and Reach 5. Fish were observed at the crossing in Reach 5
- Several informal channel-spanning rock dams have been built
- The CDFG has funded a comprehensive rural road inventory for Santa Cruz District State Parks. The Aptos Creek Road will be included in this inventory.

Recommendations:

- Keep bikes and pedestrian traffic out of creek during spawning
- Build bridges at creek crossings to limit bike and pedestrian travel through creek
- Improve trail and road maintenance
- Focus restoration efforts on A3 & A4 where impacts from recreation are greatest
- Promote rock paths across the creek that allow fish passage
- Leave natural log jams in Reach A6 and Bridge Creek alone (alteration would be extremely difficult due to lack of access)
- Restore sites adversely affected by heavy equipment creek crossing sites and develop bridges that allow heavy equipment access
- Coordinate with State Parks to improve road management techniques
- Conduct roads assessment and sediment reduction plan for the entire State Park
- Limit recreational uses in spawning areas during spawning season. Focus recreational traffic on a few trails and restore/revegetate the spurs (e.g. downstream area of the Steel Bridge).
- Provide outreach signage and brochures to educate recreational users about salmonid habitat
- Manage periwinkle at Old Mill site and other nonnative colonization areas

Data Gaps

Data gaps became evident during the Aptos Assessment due to lack of access on private lands, limited duration of the assessment and limited resources. In order to guide future studies, the following data gaps were identified during the synthesis of findings and development of recommendations. We hope these data gaps will be addressed in the future as funding and resources become available.

1) The effects of private wells and regulated wells on groundwater and surface water are not well understood. Future studies should focus on the groundwater/surface water interaction and potential long-term effects of groundwater extraction.
2) Determine source of pollution to lagoon.
3) The number of septic systems within the watershed is not known. A better understanding of how septic systems are functioning throughout the watershed will aid in water quality improvement and also illuminate understanding of groundwater recharge through septic contributions.
4) How much sediment is stored within Valencia Creek and what time scale is required to stabilize it?
5) Better information on abundance and habitat utilization by 1+ year and older steelhead is needed.
6) What is the lagoon volume and is the volume decreasing over time due to sedimentation?
7) Further hydrologic studies of Valencia Creek are needed to determine the rating curve.
8) What is the rearing capacity for steelhead in the lagoon?
9) Identification of chronic fine sediment sources.

III. ACTION PLAN

COMMUNITY PRIORITIES

During both public meetings, participants were invited to respond to the following questions:

- What would you like to see within the watershed in 15-20 years?
- What are your concerns?
- What watershed goals are important for you?

Responses were varied, but most individuals emphasized a desire to improve the habitat for both fish and also humans. Participants' responses are included below:

<u>What would you like to see within the watershed in 15-20 years?</u>

- Healthy septic systems along watershed
- More steelhead and coho salmon; big fish
- Less sedimentation in creek from bank failures (County roads)
- Biking and hiking trails for all
- Minimize activities that cause erosion
- Leave it alone; keep it the same as it is now
- Clean, drinkable water
- Plenty of shade (riparian canopy)
- Gravel stream bottom (no sediment burden)
- Clear water, year-round flow
- Better than now with improved habitat for critters
- A place where local residents can enjoy, respect, & take pride in the creek

<u>What are your concerns?</u>

- Barriers to fish passage
- Logging that affects watershed
- Maintaining a good business climate
- County road maintenance
- Junk in the creek
- Destruction of trails by bikes and horses (silt in the creek)

<u>What watershed goals are important for you?</u>

- Restoration of viability for natural inhabitants (fish and local wildlife)
- Keep new developments from contributing to creek degradation
- Prevent the creek from becoming a concrete tube
- Fish habitat
- Having a place to hear the sound of flowing water
- Leaving it alone; do not change anything
- Maintaining forest conditions

- ♦ Fuels management, access for fire protection, maintaining fuel breaks
- ♦ Elimination of nonpoint source pollution
- ♦ Year-round flow

PAG Recommendations

The Public Advisory Group (PAG) developed a set of recommendations in addition to those listed in Section II. The PAG felt these recommendations were important for the community as a whole and could make a difference for long-term restoration.

- ➢ Education: school groups, neighborhood groups, existing events (e.g.: Monterey Bay Salmon & Trout project's STEP, Aptos High EnviroGroup)
- ➢ Neighborhood action groups: creek clean ups, non-native plants removal
- ➢ Best Management Practices: workshops, cost-sharing, demo projects, technical assistance
- ➢ Media outreach: website, PSA's, local radio, cable TV, Gary Patton's radio program on land use.
- ➢ Land Use Policies: advocate for better ones, enforce existing ones (e.g., construction in the riparian corridor)
- ➢ Engage Local Elected Officials: County, State and Federal.
- ➢ Educational signage, kiosks & pamphlets regarding watersheds and salmonids: Design/produce/distribute to
  - o Homeowners ("streamside care" brochure)
  - o Tourists/Recreational users
  - o Kids

  - Docents
- Engage local businesses: offer free advertising, pr opportunities, tithing, Aptos Chamber of Commerce
- Continue/increase watershed coordination
- Form Aptos watershed group
- Conduct Surfrider's "Flows to Bay" stencil project in Aptos watershed
- Teach about hazards of small rock dams
- Encourage stepping stone dams
- Make it real to the kids – give them something positive and "hands-on" to do
- Establish permanent Adopt-a-Creek sections
- Conduct several restoration demonstration projects with explanation of purpose
- Demonstrate best management practices (BMPs) for landownners
- Refer to Forest of Nisene Marks State Park General Plan for additional recommendations
- Coordinate with mountain bike groups
- Coordinate with Wildlands Restoration group for nonnative plant removal
- Sponsor Invasive Plant Removal Day (already a Cal. Native Plant Society group in existence)
- Create Interpretive Center

RESTORATION GOALS AND OBJECTIVES

The overarching goal of the Aptos Watershed Enhancement Plan was to develop restoration recommendations and projects to enhance the quantity and quality of salmonid habitat available. Out of the recommendations described above, a list of projects was created to enhance the quantity and quality of salmonid habitat for both coho salmon and steelhead. This project list is not a comprehensive list, but was derived from the recommendations as a subset of projects that are either ready to implement or easy to develop.

The projects listed below incorporate several objectives that include:

- The project should increase fish population over time
- The project must be durable (it will last a long time)
- The project should be both feasible and cost-effective
- Habitat enhancement should be quantifiable

Based on the findings and recommendations and input from the TAC and PAG, the technical team developed a list of prioritized projects for the entire Aptos Creek watershed. This list has been developed to provide a watershed-scale perspective useful to planning restoration objectives. We hope that funders and restorationists alike will use this document to implement and make informed decisions about salmonid restoration within the Aptos Creek watershed.

PRIORITIZED PROJECT LIST

The technical team developed a list of prioritized projects to enhance both steelhead trout and coho salmon based on the recommendations and input from the TAC and PAG. This list has been developed as a guide to aid restoration objectives on a watershed level. It is our hope that funders and restorationists alike will use this document to implement and make informed decisions about salmonid restoration within the Aptos Creek watershed.

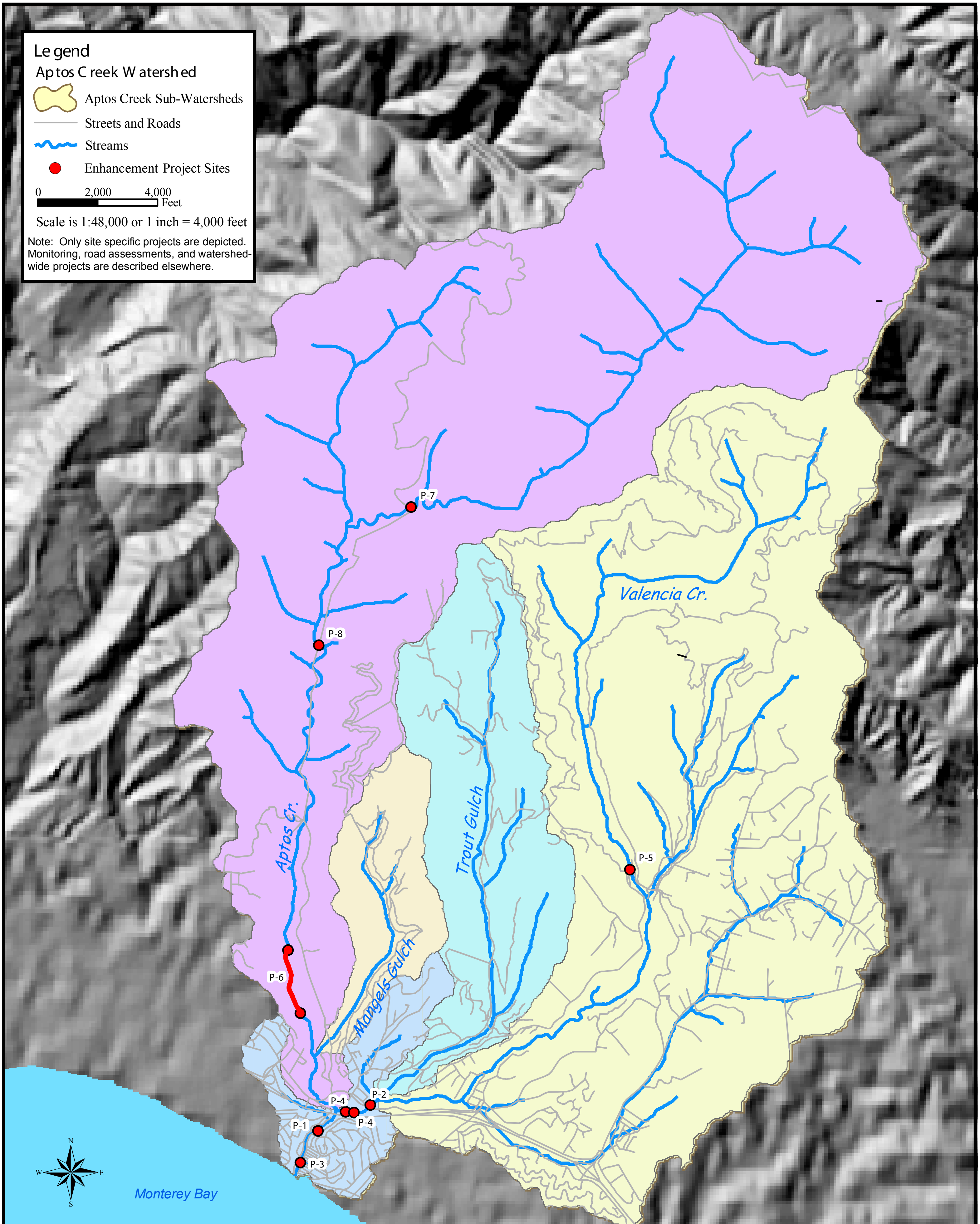
Table 10 lists the projects, descriptions and ranking. Several high priority projects (ranked 1 or 2) are detailed as conceptual plans in this section to facilitate future implementation and are described more fully than the other projects. Descriptions for conceptual plans include estimated costs and other important information to facilitate implementation.

Table 10: Prioritized Restoration Project List

Location	Project Title	Project Description	Priority (1-5)
Lower Aptos Creek	Spreckels Road grade control modification	Modify the grade control just upstream of Spreckels Bridge that acts as a fish passage impediment under low flow conditions. Modification options may include an appropriately sized notch or complete removal, depending upon identified opportunities and constraints.	1
Lower Valencia Creek	Soquel Avenue culvert fish ladder	Engineering plans have already been developed to install a fish ladder at this location. This project would just need to be funded and permitted to proceed to the implementation phase.	1
Upper Aptos Creek	Stormproof Aptos Creek Road	A road assessment & erosion reduction plan was recently funded for Santa Cruz State Parks, which will include Aptos Creek Road. Once this work is completed, implementation of the erosion reduction plan should be a high priority.	1
Lower Aptos Creek	Lagoon Assessment & Enhancement Plan	Past filling and channelization of the lagoon has resulted in a smaller lagoon that is confined by concrete walls & lacks habitat diversity. Develop a lagoon plan to assess the feasibility of lagoon enhancement through land acquisition and restoration.	2
Lower Valencia Creek	Highway 1 culvert modifications	Two culverts downstream of the Soquel Avenue crossing, limit salmonid access. Modify these culverts to improve fish passage and provide a self-cleaning mechanism that will reduce the need for future maintenance.	2
Watershed-wide	Aptos watershed roof runoff detention/surface water capture program	Rapid runoff from impervious surfaces reduces percolation to groundwater, potentially resulting in lower summer baseflows. Develop an incentive program for a roof runoff collection system by detaining runoff in a cistern system that could be used for summer landscape irrigation.	2

Upper Valencia Creek	Valencia Road culvert modification / bridge	Though the County recently installed a new culvert at this site, fish passage is limited under low to moderate flow conditions due to the steepness of the culvert and culvert access conditions. Conduct an alternatives assessment be conducted to study options including; a span bridge, arch culvert, or modifications to existing conditions.	2
Watershed-wide	Aptos watershed road runoff pretreatment and detention/surface water infiltration program	Roads are the largest impervious element of a rural / suburban landscape. We recommend providing BMP materials for installation of sediment traps for pretreatment, and a modified culvert system that can act as efficient detention systems.	2
Valencia watershed	Valencia roads assessment (County/private)	Develop a roads assessment and sediment reduction plan for both private and County-maintained roads within the Valencia Creek watershed to reduce road-associated sediment.	2
Aptos Creek (Forest of Nisene Marks State Park)	Public outreach regarding salmonid habitat conditions (FNMSP & Lagoon)	Educational materials and signage at appropriate locations (stream crossings, interpretive centers) should be developed to educate the public about salmonid life-cycles and how to minimize negative impacts from recreational activities.	3
Lower Nisene Marks State Park	Trail management plan/maintenance guidelines for Forest of Nisene Marks State Park	Develop a program to reduce erosion, decommission duplicate & unplanned trails, and provide better signage to keep hikers and mountain bikers on designated trails. Establish maintenance guidelines for Aptos Creek Road including times of grading, public access through the winter gate, and general BMPs to reduce erosion.	3
Mangels Gulch	Water quality monitoring	Install a continuous water quality sampler be installed at three locations: 1) On Aptos upstream of Mangel's, 2) On Aptos downstream of Mangel's, and 3) On Mangel's at the Aptos Creek Road Bridge. The continuous sampler should monitor pH, Conductivity, and other indicators of chemical contamination.	4
Aptos Creek near Kiosk	Aptos Creek trails and crossings upgrades to pedestrian bridges	Designate clearly defined stream crossings and install permanent pedestrian and bike access crossings.	4

Aptos Creek Road (reaches A4 & A5)	Remediate and upgrade existing stream crossings (2)	Upgrade crossings near the Bridge Creek and Aptos Creek trailheads to support all necessary vehicle including fire trucks. The fords should be remediated to improve bank stability and reduce erosion.	5
Aptos Creek at Old Mill Site	Exotic vegetation management	Invasive exotic vegetation, especially periwinkle, is a problem throughout the watershed. Particularly problematic sites, such as at the Old Mill, should be remediated and revegetated with appropriate native plants.	5
Watershed-wide	Erosion source treatment	Prioritize and treat erosion sources identified in Table 11 of the Aptos Creek Watershed Assessment Geomorphic and Erosion Source Technical Report.	Not ranked
Valencia hydrology/geomorphology assessment	Valencia Creek watershed	Conduct a multi-year, comprehensive study for the Valencia Creek watershed to more closely examine baseflow and sediment transport dynamics.	Not ranked



Swanson Hydrology and Geomorphology
115 Limekiln St. Santa Cruz, CA 95060
tel. 831-427-0288 fax. 427-0472

Aptos Creek Watershed
Enhancement Projects

Figure 10

CONCEPTUAL PLANS FOR HIGH PRIORITY PROJECTS

Though a number of potential habitat improvement projects were identified and prioritized during the enhancement planning process, the level of detail necessary to fund and implement these projects requires further analysis. There is limited funding available through local, state, and federal grants and agencies, and typically, the funding entities have a limited amount of time to review all prospective projects and make decisions about the feasibility, cost and overall benefit to salmon and steelhead population enhancement.

Therefore, it is important, to take the first steps in defining the important elements of the higher priority projects. These steps include a description of the project need, initial site assessment, conceptual level solutions, preliminary cost estimates, and expected benefit of the project. Additionally, some projects may not necessarily be engineering solutions but could be part of a programmatic effort that will benefit salmon and steelhead populations in the long-term. In these cases, it is important to define the initial steps that would be needed to move such a program forward.

The following high priority projects have been developed to a conceptual level as part of this plan (Figure 10):

- Spreckels Road Grade Control Modification (Site P-1)
- Soquel Avenue Culvert Fish Ladder (Site P-2)
- Aptos Lagoon Enhancement Feasibility Study Scope of Work (Site P-3)
- Highway 1 Culvert Modifications (Site P-4))
- Roof Runoff Detention Technical Assessment and Cost Analysis

Appendix F contains design specifications for the Soquel Avenue culvert fish ladder and the Highway 1 culvert modifications on Valencia Creek.

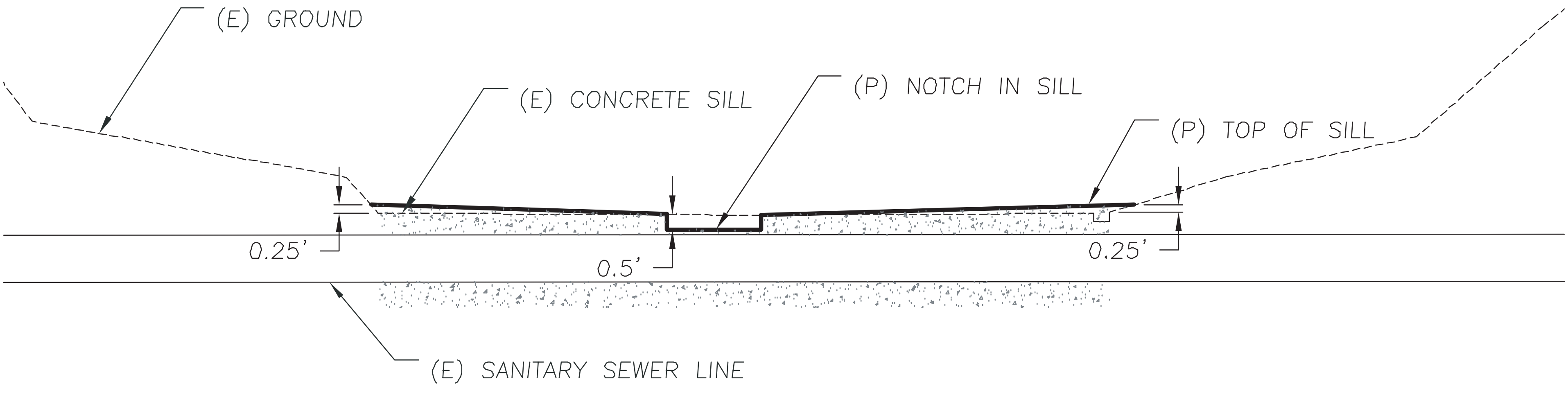
Spreckels Road Grade Control Modification

This fish passage impediment, just upstream of Spreckels Road on lower Aptos Creek (Figure 11), consists of a concrete sill that is 3 feet long, spans the entire width of the channel, and is of an unknown depth. It appears to act as protection and grade control for a sewer pipe that crosses the Aptos Creek at this location, though the County of Santa Cruz Public Works Department was unable to verify this. This high priority site will ensure that salmonids can access the majority of habitat in both Aptos and Valencia Creeks.

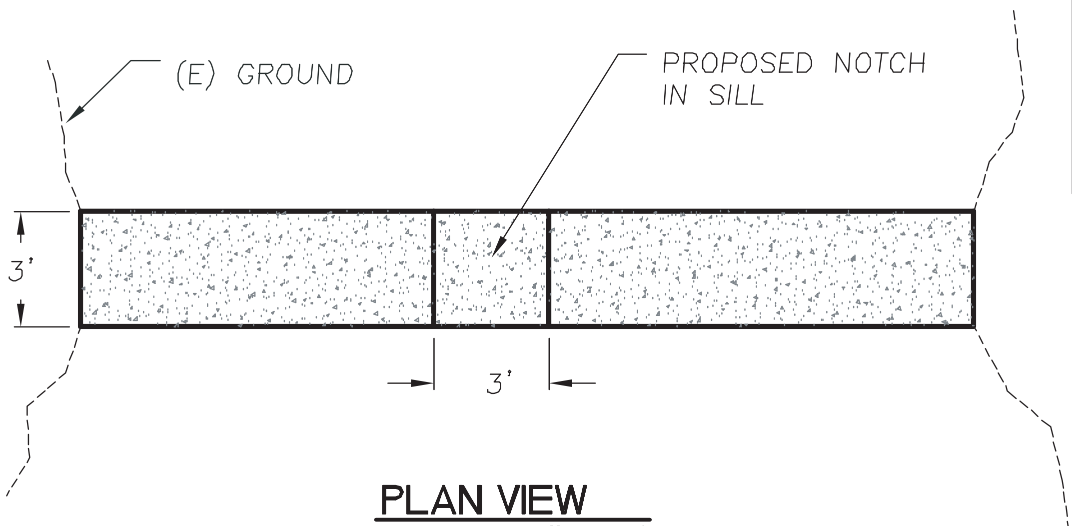
During winter, spring, and early summer, when a sand bar is absent at the mouth of the Aptos Creek there is a drop of approximately 2 feet between the top of the sill and the channel bed downstream. Sandy conditions throughout this reach result in very little pool formation, except under higher flow conditions where a temporary scour pool is formed that may allow adult salmonids to navigate the grade control structure. Under low to moderate flow conditions, water sheets across the level concrete sill, resulting in little to no jump pool downstream and shallow flow conditions over the sill. During the late summer and fall months, when the sand bar is present at the mouth of Aptos Creek and the lagoon is full, the grade control is backwatered and does not impede salmonid movement.

To improve passage at the concrete grade control, we recommend creating a low flow notch with dimensions of approximately 6 inches deep by 3 feet wide, by modifying the existing sill (Figure 11). The benefits of such a modification include the following:

- The total jump height would be reduced by six inches, resulting in greater passage,
- Flow would be focused over the sill, resulting in concentrated flows over the grade control and adequate water depths over the center of the sill,
- The focused flow over the sill would result in a more permanent jump pool at the base of the grade control, increasing the success of passage under low to moderate flow conditions, and
- The low-flow notch in the concrete sill would result in formation of a more well-defined low flow channel upstream of the site that would increase water depths and improve migratory conditions through the reach.



SECTION VIEW
SCALE: 1"=10'



ALTERNATIVE 1: CUT A 3' WIDE BY 6" DEEP NOTCH IN EXISTING SILL TO LOWER JUMP HEIGHT AND INCREASE WATER DEPTH OVER SILL. RAISE HEIGHT OF SILL BY 3" (MAX.) TO CREATE A SLANTED SURFACE TO FOCUS FLOW OVER NOTCH.

PLAN VIEW
SCALE: 1"=10'

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Figure 11: Spreckels bridge grade modification.

The most significant design constraint at this site involves the presence of the sewer line embedded within the concrete sill. An alternative design at this site would be to completely remove the concrete sill, reroute the pipeline by attaching it to the underside of the bridge, and constructing a grade control structure that would be more fish friendly. Though this alternative is feasible from an engineering standpoint, our opinion is that it would be cost prohibitive since the existing pipeline was constructed at grade with the connections on either side of the channel, suggesting gravity flow rather than use of siphons or pumps. To attach the pipeline to the road would require siphons and pumps. Additionally, grade control would need to be maintained at the site to limit bank instability upstream of the site along a corridor that includes single family residences on both sides of the creek. The selected alternative is a cost effective approach to fish passage while also taking into consideration other constraints at the site.

Potential Lead Agency or Group: County of Santa Cruz

Preliminary Cost Estimate (not including permitting): Engineering Design and Structural Review - $5,000; Implementation: $6,000.

Soquel Avenue Culvert Fish Ladder

The Soquel Avenue Culvert is a well-known site in the Valencia Creek watershed and acts as a passage impediment to salmonids under most flow conditions. The site consists of a concrete box culvert that flows under Soquel Avenue. The drop from the outlet to the bed of the channel varies, depending upon the level of sedimentation that has occurred at the base of the culvert, but ranges between 3 and 5 feet. During the winter months, flows are often adequate to scour a jump pool at the base of the culvert. Under low flow conditions the jump pool fills with fine sediment resulting in water depths at the base of the culvert outlet that are too shallow for fish to jump from. It is likely that this site is only passable under high flow conditions when the nearby, downstream culvert is backwatered, resulting in a lower jump height at the Soquel culvert.

Besides the jump height, the Soquel culvert also presents difficulties for migrating salmonids due to the length of the culvert. The existing culvert has been equipped with baffles and a low flow sill that was constructed in conjunction with a fish ladder that failed shortly after construction. The failure was likely due to the lack of a foundation that caused the structure to collapse when the loose sand underneath was scoured during a high flow event. Consequently, the existing structure still sits in the middle of the channel, further limiting the ability for migrating salmonids to jump into the low flow channel.

Two alternatives were considered for the site including culvert backwatering through the use of downstream weirs and a more structurally sound fish ladder. The fish ladder was chosen over the weirs due to concerns about liability of making such channel modification and the feasibility of bringing in the necessary material to construct weirs. The site occurs within a very narrow gorge with evidence of past bank failure. A single family home sits at the top of one particularly precarious bank. Modifications to the channel, such as weir installation which would aggrade the existing bed, could result in assumed liability in the event the adjacent bank failed. After consultation with several permitting agencies and County staff we decided that this alternative was not preferred, despite the fact that it may have been the preferred alternative from a fish passage perspective.

The chosen design consists of a fish ladder that would be founded in bedrock both in the bed and the bank. Since the new fish ladder would be placed on the opposite side of the culvert as the failed ladder, the existing baffles would need to be removed and rebuilt on the opposite side of the culvert. The complete engineering plans have already been prepared for this project and are included in this document, along with an engineers cost estimate (**Appendix F**). Hydraulic calculations conducted for this design suggest that fish passage would occur under 70% of flow conditions, which would be a considerable improvement over existing conditions (**Appendix F**). The project still needs to be permitted prior to implementation.

Potential Lead Agency or Group: County of Santa Cruz

Preliminary Cost Estimate (not including permitting): Final Geotechnical Analysis (to be completed at time of construction) - $4,000; Implementation: $89,000.

Aptos Lagoon Assessment and Enhancement Plan

Based on the findings of the Aptos Creek Enhancement Plan, a detailed assessment and identification of restoration opportunities of the Aptos Creek Lagoon should be conducted to improve the overall effectiveness of the watershed enhancement efforts. A healthy and functioning lagoon ecosystem will improve the overall habitat quality of the watershed with a direct benefit to federally listed salmonid populations, endemic to the Aptos Creek Watershed.

The Aptos Creek Lagoon Assessment and Enhancement Plan should be an integrated ecological system analysis that tightly merges the data collection efforts and expertise of hydrologists, water chemists, vegetation specialists, and fisheries biologists to evaluate the existing conditions in the Aptos Lagoon system and compare these conditions to the healthy natural system. The data should be collected with the intent to understand the primary physical, chemical and/or biological processes that are currently limiting the health of the lagoon. The end goal will be to provide site-specific future management recommendations and restoration actions to improve the overall ecological function. The site-specific seasonal data collected from Aptos Lagoon should be put into a regional context to improve our understanding of lagoon function as a result of the interaction between physical, chemical and biological characteristics.

The proposed duration of the project is two years to ensure that the data collection efforts capture some variability in climatic, physical, chemical and biological conditions. The following tasks would be conducted:

<u>Task 1. Historical and existing data analysis</u>

Efforts should be made to compile and review previous physical, chemical, and biological data collected from the Aptos Lagoon. Historical maps and aerial photographs should be used to reconstruct the natural conditions of the lagoon system prior to human alterations. A chronology of the development history of the contributing watersheds will be developed to determine the timing of such events as increased nutrient delivery from local land uses, significant physical and hydraulic changes, and alterations of the riparian corridor of the lagoon system. Previous water quality data should be obtained and interpreted to determine any past seasonal or long term trends. The water quality data should also be critically evaluated for indications of source locations, biogeochemical cycling and indications of past aquatic health. Available data on previous population studies and fisheries analyses in the Aptos Lagoon should be obtained and reviewed, and key findings summarized. In addition to scientific data, the existing management regulations and specific needs of the Aptos Lagoon will be investigated and documented. The regulations and needs may include local flood control, water quality, recreational activities, aesthetic values, etc, and will continue to underlie the possible site specific management alternatives as the project continues. These efforts should also include current parcel information that defines land ownership, utility locations, easements and estimated land values to assess the feasibility of land acquisition for restoration alternatives.

<u>Task 2. Existing Conditions Analysis</u>

The existing conditions of the Aptos Lagoon should be evaluated to understand the dynamic interaction of the physical, chemical and biological factors influencing and controlling the existing ecosystem conditions. Efforts should be made to compare the existing conditions to the anticipated natural conditions prior to human impacts.

Physical Analysis
A detailed survey should be conducted and a topographic map developed for Aptos Lagoon. Factors such as water depth as a function of storage, area of inundation and depth distributions relative to water volume, filling rate calculations following closure and magnitude of closure will provide insight on the detailed physical functioning of the Lagoon. The detailed surfaces will also be used to model the habitat benefit and complexity that is present during different water surface elevations during a closed lagoon. Indices of peak habitat performance should be determined based on vegetative cover, water depth, channel complexity and areas of inundation.

Biogeochemical Analysis
The chemical (water quality) conditions and seasonal biogeochemical dynamics of the lagoon system should be investigated. The data collection efforts should focus on identifying the primary chemical factors influencing the compromised water quality conditions observed within Aptos Lagoon. Continuous water quality data should be collected to capture both the daily and seasonal chemical response to the physical changes that occur throughout the spring, summer and fall months of the year. In addition, the biogeochemical variations in the vertical water column throughout seasonal closure should be investigated. All water quality and chemical data should be put into the context of the physical and/or biological processes driving the chemical variations observed in the system. Efforts should be made to capture the chemical conditions during breaching events and assess the potential impacts of sustained closure vs. occasional breaching vs. frequent breaching on water quality, vegetation, fauna and the physical system.

Vegetation Analysis
The distribution of the lagoon vegetation communities, including riparian and wetland vegetation, should be documented. Qualitative data collection may include: GIS mapping of vegetation distribution, vegetation species diversity studies and the seasonal studies within the lagoon waters and along the riparian corridor. This data collection and species identification should then be linked to physical and chemical conditions that have allowed the existing species to succeed. The environmental variables that may play a role in vegetation distribution should be investigated and documented. These environmental variables may include wind stress, shading by riparian vegetation, tidal energy, bathymetric features (e.g. lagoon depth, slope and width), turbidity and/or water quality conditions. Efforts should be made to compare the environmental variables and vegetation distribution to the vegetation observed in other local lagoons systems.

Fisheries analysis
The fisheries analysis should be focused on determining the relative habitat quality of the lagoon system. Factors that most limit the quality of the fish habitat in the lagoon system should be identified. This task should identify the key water quality and habitat parameters that regulate the lagoons' value to fish, including rearing steelhead, and provide useful information to guide lagoon and watershed management activities to enhance the ecological function as well as the fish populations within Aptos Lagoon. The biologist should also make observations of the lagoon condition following breaching to assess the physical and chemical impacts of the breach on the fish populations, taking into account the timing of breach, magnitude of water loss and location of the openings and other variables that may have an impact on the health of the resident fish populations. The fisheries biologist should collaborate with the vegetation specialist and biogeochemist to strategize data collection to ensure the efforts are useful to all parties.

Task 3. Technical advisory, stakeholder coordination and public outreach

Technical advisory meetings and stakeholder coordination should include coordination of resource and regulatory agency staff and other key stakeholders to ensure collective agreement of data interpretation and progress toward project goals. Meetings will be held at regular intervals or at appropriate milestones. Public outreach will include information dissemination in the form of meetings, brochures, signage, and/or press releases to gage the public interest in the lagoon enhancement and provide information regarding the feasibility of proposed enhancement actions.

Task 4. Opportunities and constraints analysis of potential restoration

Based on the historical and current conditions identified by the consultants, a wide range of restoration alternatives that will have a direct benefit to the ecological health of the Aptos Lagoon should be explored. Stresses (i.e. factors that cause degraded conditions), opportunities and constraints, related to physical, social, economic and/or regulatory conditions and the project goals, should be developed. The biogeochemist, vegetation specialist, hydrologist and fisheries biologists should identify general problems that appear to have the greatest impact on the local fauna, such as exotic vegetation, limiting physical conditions, water quality conditions, aquatic cover limitations, etc. Opportunities for enhancement to improve the seasonal lagoon function could include potential lagoon expansion or other physical alterations, water level management, water quality improvements, vegetation management, or any other potential enhancement features that will directly improve the health of the system.

The consultant team must analyze the opportunities and constraints related to land use, zoning infrastructure, public access, economics and flood control. These will be related to and considered with habitat enhancement, resource management, and other factors. The opportunities and constraints analysis should include a cost benefit analysis to assess the feasibility of each of the proposed restoration actions. The potential restoration actions should be presented and reviewed with the TAC and

PAG to reach a collective agreement on the priority actions. The final outcome of this task should be a recommended list of both short term and long term feasible restoration actions that will have the greatest anticipated benefit to the health of the Lagoon system while meeting the needs of the local community.

Task 5. Aptos Lagoon Enhancement Plan

At the conclusion of the project, all data, findings and interpretations should be compiled into the Aptos Lagoon Enhancement Plan. The Plan will contain the historical investigation information, outline the exiting management needs and regulations, and present the results and interpretations from the historical and existing conditions analyses for Tasks 1 and 2. The Plan will provide a discussion of the opportunities and constraints and a detailed summary of a number of future recommended management actions for the Aptos Lagoon. The potentially feasible alternatives that satisfy the underlying management needs and regulations of the lagoon will be conceptualized and the cost estimates for all aspects of the restoration actions, including post-project success monitoring and assessment, should be included.

Potential Lead Agency or Group: Coastal Watershed Council

Estimated Cost: $75,000

Highway 1 Culvert Modifications

Downstream of the Soquel Avenue culvert there are two culverts associated with Highway 1. The upstream culvert (referred to as Culvert 1 in this document) consists of a 186-foot long box culvert with a concrete low flow sill and concrete baffles on one side. The grade of the culvert is 0.54%. A total of 6 baffles were determined to be damaged along with the sill at the upstream side which is intended to divert low flows into the baffled side of the culvert (**Appendix F**).

The significant issues for fish passage at Culvert 1 occur at the downstream end of the culvert. The concrete apron at the downstream side extends beyond the outlet of the culvert for 15 feet and supports a wing wall. Flow over this concrete apron is shallow since it spreads out across the entire width of the apron. This can be easily remedied by extending the concrete low flow sill and adding additional baffles.

Downstream of the concrete sill, the bank and bed of the channel is lined with sacked concrete that causes flow to be spread out and shallow under low to moderate flow conditions. Additionally, there is a 1-foot drop at the end of the sacked concrete treated bed, meaning migrating salmonids would be required to jump onto shallow sheet flow conditions before reaching the culvert. To remedy this condition, we recommend installing a series of three redwood groins that can be fastened to the concrete bed to focus flows and allow for development of a low flow channel and increase the roughness of the bed.

The downstream culvert (referred to as Culvert 2 in this document) consists of a 241-foot long concrete arch culvert with a combination concrete and redwood low flow sill and redwood baffles on one side. The grade on the culvert is 0.85%. Overall, the culvert and baffles are in adequate shape to provide adult salmonid passage except for the most downstream baffle (Appendix F). This baffle was either damaged or inadequately designed, resulting in low flows discharging onto a concrete sidewall.

We are recommending this last baffle be removed and replaced with a concrete weir that will result in low flows being discharged into a deeper pool at the culvert outlet.

While in the process of conducting the passage surveys on each of the three lower culverts that occur on Valencia Creek, we observed a need for periodic maintenance of the Washington baffle systems previously installed to improve fish passage through these long culverts. The Washington baffle system has been a standard velocity reduction treatment for culverts for the last several decades. Unfortunately, what has become apparent following widespread use is their tendency to collect debris, which limits their effectiveness.

In Valencia Creek, small logs or branches have a tendency to block the baffles, resulting in a back-up of sand-sized sediment that is moving through the system and a reduction in flow depth through the baffles. Improving the blocked condition only requires simple, periodic maintenance to remove the blockage but funding for maintenance is often hard to obtain on a yearly basis. Given the low gradient, there may be an opportunity to modify the Washington baffle configuration to allow for improved debris and sediment passage, while at the same time, maintaining adequate roughness and backwater areas that are required to allow fish to pass.

The best way to approach baffle modifications in these three culverts would be to test a particular baffle configuration and monitor the success in terms of reducing velocities and passing debris. To meet this aim, we recommend selecting a culvert and modifying the baffle configuration on a 20-30 foot section, followed by several years of monitoring to assess the effectiveness. The most appropriate initial test for the 20-30 foot section would be to remove every other diagonal piece and retain all of the orthogonal pieces. The orthogonal pieces would provide a low velocity area, whereas the retained diagonal pieces would break up any high velocity flows. We feel this configuration would reduce debris capture by providing more overall space between the baffles.

Potential Lead Agency or Group: County of Santa Cruz

Preliminary Cost Estimate for Recommended Culvert 1 and Culvert 2 Modifications (not including permitting): Engineering Design - $6,000; Implementation - $14,000

Preliminary Cost Estimate for Test Modifications to Baffle Configuration (not including permitting): Engineering Design - $0; Implementation - $2,000; Monitoring (2 years w/ report) - $7,500

Roof Runoff Detention Technical Assessment and Cost Analysis

Water demand is increasing in Santa Cruz County. At the same time, runoff from roofs is causing erosion, sedimentation and downstream flooding. Collection and storage of rainwater from roofs provides an excellent alternative water source for domestic use. Stormwater detention may also be provided through the collection and metered release of peak flows. Benefits to landowners will include long-term cost-savings through a reduction in water bills; land conservation by reducing creek side erosion; and a conservation-based practice that homeowners can implement.

Components

Rainwater harvesting, storage, and distribution systems consist of the following four components:

1) **Roof** - An impermeable galvanized iron, ceramic tile or slate roof will yield high runoff of good quality water. Drinking water should not be collected from roofs coated with bitumen-based paints, or from asbestos cement roofs. Normal guttering is sufficient provided that it is kept clear of leaves and debris.

2) **First flush device** – This device prevents the initial portion of the rainfall runoff from entering into the rainwater tank. The first flush flows typically contain the highest levels of contaminants, such as dust and debris that have collected on the roofing surface. Their diversion results in cleaner water at the tank and minimized maintenance of the storage and distribution system. This device is typically designed to filter out leaves as well.

3) **Storage tank** – Cylindrical or cubic tanks are manufactured from concrete, steel, and polypropylene. The tank is usually the most expensive component of the system. Tank location is an important consideration. Locating the tank underground produces space savings and may satisfy aesthetic concerns. Underground tanks have the following disadvantages:

    a. repairs are more difficult;
    b. installation costs are high
    c. tanks may be "floated" out of the ground by groundwater, and
    d. tree roots may penetrate tanks.

    Locating the tank above ground requires space and subjects the tank to weathering. Aboveground tanks are more easily installed, more easily inspected and often result in greater potential for the use of gravity distribution systems, instead of pumped.

Figure 12. Examples of water storage tanks for irrigation

4) **Delivery** – The delivery system may consist of a simple hose bib at the tank, from which water is used upon demand. More elaborate setups may include a pump, water distribution system, pressure tank, timers, etc. If stored water is to be used for human consumption, a filtration system will also be required. An environmental engineer should always be consulted on designs intended for this use. Each system will need to be carefully designed according to the site

topography, available water supply, demand, and intended use. Costs will vary accordingly.

Typical System

The following simplified calculations show approximate storage requirements and installed costs for a small domestic garden drip system in Santa Cruz[4].

Sizing

Consumption per week:		150 gal.
Average dry period:	+/-20 weeks	
Storage required (= 150 x 20)		**3000 gal.**
(7' diameter x 12' high)		

Cost (installed)

3000 gal. Tank (polyethylene)	$1200
Gutter modifications	$ 600
Labor	$2000
Total Gravity System	**$3800**
Pump, pressure tank and electrical parts	$1500
Labor	$1000
Total Pressure System	$2500
Total System Cost	**$7300**

Constraints

The following factors can reduce the applicability of this technology:
Site access, slope, space availability
Shingled roofs
Large irrigation demand

Potential Lead Agency or Group: County of Santa Cruz and Coastal Watershed Council

Erosion Control Sites for Aptos Creek Watershed

In addition to the conceptual plans developed for high priority projects, several erosion control sites have been identified by SH&G for restoration (Table 11).

[4] References

1. Rainwater Tanks Revisited: New Opportunities for Urban Water Cycle Management. Peter John Coombes. A thesis submitted to the University of Newcastle, N.S.W., Australia for the Degree of Doctor of Philosophy, January 2002. http://rambler.newcastle.edu.au/~cegak/Coombes/
2. Domestic Roofwater Harvesting. Development Technology Unit, School of Engineering, University of Warwick. A website for very low cost development. http://www.eng.warwick.ac.uk/dtu/rwh/components1.html
3. Polyprocessing tank manufacturing company http://www.polyprocessing.com/

Table 11.Erosion control sites for Aptos Creek watershed

Location[1]	Project Title	Project Description	Erosion Reduction Priority (Ranking)[2]	Preliminary Construction Cost Estimate[3]
Lower Aptos Creek	EC-5	**Existing Conditions:** Slope failure at edge of road 30 ft. long by 10 ft tall. **Repair Options:** Rebuild slope with geosynthetics, rock or retaining wall. Replace existing culvert and extend to toe of slope. Repair pavement in vicinity and Revegetate toe area.	medium (6)	$50,000-$120,000
Mangels Gulch	EC-8	**Existing Conditions:** Plastic tarp repair at downslope edge of road, where existing 14" corrugated metal pipe culvert has eroded away the toe of bank and appears to have been the cause of a slide on a 40 ft. high by 15 ft. wide section of slope. Poor street drainage design on opposite side of road has caused concentrated runoff to pass directly over slope. **Repair Options:** Requires a slope drain extension and a slope reconstruction or retaining wall. In addition, improvements must be made to ensure street drainage reaches culvert.	medium (7)	$40,000-$90,000
Mangels Gulch	EC-10	**Existing Conditions:** Consists of 300 ft. long by 8 ft. tall eroding cut-bank with mature trees at the top of slope. Existing roadside ditch has downcut and destabilized the toe of slope. **Repair Options:** It appears infeasible to lay the slope back, as there are mature oaks at the top of the slope, providing root strength, raindrop impact protection, and mulch. Recommend construction of rock check-dams within incised portions of roadside ditch. Dams would arrest further incision and trap sediment to rebuild toe and buttress the mid-slope region. Feasibility of this option is dependent upon hydraulic capacity requirements of the existing swale, to be determined by a drainage study.	medium (5)	$3,500
Trout Gulch	EC-12	**Existing Conditions:** Consists of 65 ft. long by 15 ft. tall road-cut. Toe appears stable, with some vegetation established. Top of slope is undercut, with tree roots exposed. **Repair Options:** Remove trees in undercut portion of slope. Recontour slope to provide rounding of upper portion, protect with 5-year geosynthetic fabric and revegetate. Provide toe protection, consisting of rock lining, in eroding portions of roadside swale.	low (9)	$10,000-$20,000
Trout Gulch	EC-13	**Existing Conditions:** Road cut in clay soil with established trees at the top. Slope is approximately 15 ft. tall and runs along entire road, with multiple failures. Located on a private road. In addition, a small culvert passes under the private road at a location just upslope from a slide failure that is encroaching into roadside ditch. **Repair Options:** As this site is located on a private road, I believe it's outside the scope of this report. However, a small improvement to the culvert inlet at this location could prevent the potential mobilization of a large amount of sediment associated with the adjacent slide deposits. The cut-slope would require extensive regrading, stabilization with fabric and/or mulch, and revegetation to be stabilized, as the soils are not stable at the present angle.	low (8)	$15,000-$45,000

Trout Gulch	EC-14	**Existing Conditions:** Convergence of large incised tributary with roadside ditch has caused incision and Headcutting. Gully is approximately 12 ft. wide by 8 ft. deep. Where gully intersects road drainage, headcut is moving upslope along road shoulder. **Repair Options:** Gully at road should be arrested with headcut armoring. Check dams should be placed at multiple locations within the incised portion of the drainage. A drainage study should be conducted to determine cause of erosion and to recommend additional corrective measures.	high (1)	$8,000-$20,000
Valencia Creek	EC-15	**Existing Conditions:** Consists of a road fill that has not been effectively vegetated. Rills are forming on slope. Dimensions are approximately 60 ft. by 60 ft. and slope is approximately 1h: 1v. **Repair Options:** Fabric, coir rolls and revegetation should be placed on slope. Adjacent roadside ditch should be improved to ensure that concentrated drainage is not allowed to reach fill materials.	high (2)	$3,000-$10,000
Valencia Creek	EC-17	**Existing Conditions:** Consists of a 350 ft. long by 15-20 ft. high cut slope in sandy soils, constructed to widen road after a slide forced construction of a geoweb-reinforced slope on opposite side of road. Existing jute netting has failed and acacia trees are primary vegetation. Portions of slope are slumping into the roadside ditch and sediment is washing to creek. An existing driveway is located parallel to the top of the slope. **Repair Options:** Requires geotechnical analysis of slope to determine stable angle. Pending results of analysis, repair could consist of a combination of regrading top and retaining toe. To regrade entire slope to stable angle, it appears that the private driveway at the top would need to be realigned. Gentle grades at the top of slope would make realignment feasible.	high (3)	$150,000-$400,000
Valencia Creek	EC-19	**Existing Conditions:** A steep slide failure on the outside edge of the road, above creek. Cracks in road adjacent to site indicate that additional failures may be likely. Dimensions of failure are approximately 40 ft. wide by 50 ft. high. Slide debris has landed in the creek bed below. **Repair Options:** A geotechnical analysis of the failure would be required to determine feasible repair options. However, it appears that any repair would involve extensive slope reconstruction and repaving or the installation of a large retaining wall. Primary motivation for repair would be road stability, as the potential for additional sediment loss at the site appears low.	medium (4)	$40,000-150,000
Trout Gulch	EC-21	**Existing Conditions:** Appears to be a slow rate of erosion from the toe of a 100 ft. long by 15 ft. high cut-bank in clay material. Mature oaks are located at the top of slope. Toe appears relatively stable and well vegetated. Oak roots are undercut and exposed. Mid-slope region is steep and devoid of vegetation. **Repair Options:** A repair would need to regrade the slope to a stable angle, as determined by a geotechnical engineer, face the slope with armor or fabric, construct a retaining wall, or use some combination of the above.	low (10)	$90,000-220,000

1 - Sites on this list were identified during a preliminary reconnaissance survey of erosion sources in the watershed from publicly accessible roads. To develop detailed prescriptions, an engineer returned to the site for additional evaluation. If the site was not determined to contribute a significant amount of sediment or the potential repair of the site was not determined to be feasible, it was dropped from the preliminary list. Additionally, sites located within the Forest of Nisene Marks were not included in this list since the California Department of Fish and Game have funded a study to assess erosion sources from roads in State Parks on the Central Coast of California. Sites were generally located using a USGS 1:24,000 Quadrangle map and are shown in Figure ?.

2 - Summary Ranking of priority for repair, based upon the potential amount of sediment trapped per cost of the project (1 is the most favored project).

3 - The costs shown reflect construction costs. Design, permitting, mapping, project administration and other incidental costs are not included since those costs would depend heavily on the chosen design.

MONITORING PROGRAM

The primary objective of a monitoring program is to assess physical and biological changes in watershed conditions over time following implementation of enhancement actions. It is meant to monitor the success or failure of enhancement actions and provide the necessary data to adjust, or adaptively manage, the implemented enhancement program. In the case of the Aptos Creek watershed, the focus of this plan is to improve habitat conditions and ecosystem performance for salmon and steelhead populations while providing a net benefit to the human system that is increasingly dominant in the watershed..

When developing a monitoring program, we must also consider the cost of implementing the program. It is relatively easy to request a comprehensive monitoring program that assesses and analyzes all potential variables, but it is often not feasible to pay for the cost of such monitoring. One example of a highly successful monitoring program that is finding difficulties persisting due to the lack of interest in long-term, expensive programs is the network of stream gages established by the U.S. Geologic Survey. Many streamflow monitoring sites have been discontinued since the peak following World War II (Lanfear and Hirsch, 1999). Though this data is extremely valuable, the cost and maintenance of the program has become prohibitive. With this in mind, we attempt to establish a monitoring program that is straightforward, simple, and cost effective, while still providing the basic information required to assess habitat conditions.

In the Aptos Creek watershed an excess of fine sediment has resulted in pool filling, impairment of riffle and spawning habitat, loss of cover, and a general degradation of habitat quality. These conditions are particularly acute in the Valencia Creek watershed where little habitat remains for both spawning adults and rearing juveniles. Much of the excess sediment appears to be derived from a general unraveling of adjacent streambanks and channel incision associated with urbanization impacts and exacerbated by large flooding events and legacy impacts such as logging. Valencia Creek also has the added impact of several significant adult salmon passage impediments that limit the free movement of fish to higher quality habitat located in the upper watershed.

To monitor these impacts and assess potential long-term improvements in the watershed, we are proposing a set of surveys that repeats critical data collected during this assessment. Table 12 discusses the elements of our proposed monitoring plan:

Table 12. Aptos Creek watershed monitoring parameters

Monitoring Parameter	Description	Frequency	Potential Lead Agency or Group	Estimated Cost
Pool Habitat	Pool habitat was determined to be lacking in most of Valencia and several reaches of lower Aptos. Monitoring should characterize pool density and habitat by inventorying the number of pools and the habitat conditions via a walk-through survey at the reach scale. Data collected for each surveyed year should be compared to previous and baseline (2001) conditions.	Every 3rd Year and following significant high flow years.	California Department of Fish & Game	$5,000 / year
Substrate Embeddedness	High fine sediment load was determined to impact spawning and rearing habitat and may impact macroinvertebrate production in riffles. These impacts were observed throughout the watershed though the impacts are more acute in Valencia and lower Aptos. Monitoring would conduct a walk-through survey to visually assess embeddedness in pool tails, spawning gravels, and riffles. The results should be compared to previous and baseline (2001) conditions.	Every 3rd Year and following significant high flow events.	County of Santa Cruz or Coastal Watershed council	$7,500 / year
Streamflow	Little is still known about hydrologic conditions in Valencia. Long term monitoring should include a permanent streamflow gage on Valencia, reestablishing a gage on Aptos & low flow monitoring. Any potential gage site on Valencia should be carefully selected due to unstable bed conditions.	Continuous	Coastal Watershed Council	Approximately $15,000 per year per gage site
Temporary Passage Issues	Temporary rock dams constructed on Aptos Creek within lower Nisene Marks State Park may be detrimental to free movement of adult and juvenile salmonids. This monitoring effort would include walking the creek during mid to late fall to remove temporary rock dams.	Annually	Coastal Watershed Council or other local watershed group	Volunteer
Channel Stability and Substrate Conditions	Cross-sections established throughout the watershed during 2001 should be monitored in the future to assess changes in cross-section geometry & to assess sediment movement. Pebble counts should also be repeated at these sites.	Every 3rd Year and following significant high flow years.	County of Santa Cruz or Coastal Watershed Council,	$8,000 / year
Fish Passage	Existing passage barriers at culverts on Valencia require periodic monitoring and maintenance. We recommend annual monitoring at these sites that would include site visits at the beginning of the winter, following the first flush which can carry large amounts of debris, and following significant flow events. During these site visits, debris and sediment should be removed from the facilities.	Continuously	County of Santa Cruz	Annual contract of $4,000 to CCC's or similar work program
Fish Populations	Following installation of the proposed fish ladder on Valencia Creek at Soquel Avenue, fish populations should be visually assessed using a similar method as the work completed in 2001. The results should be compared to previous and baseline (2001) conditions.	Annually for 3 years, then every 3 years.	California Department of Fish & Game	$4,000 / year
Lagoon water quality	The CWC, Surfrider, and the County should continue to assess lagoon water quality and attempt to determine the reason for high fecal coliform and nutrient conditions in the lagoon.	Annually		Unavailable

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IV. TECHNICAL APPENDICES

A. SALMONID HABITAT AND LIMITING FACTORS ASSESSMENT

B. GEOMORPHOLOGY AND SEDIMENT SOURCE ASSESSMENT

C. HYDROLOGIC AND WATER QUALITY ANALYSIS

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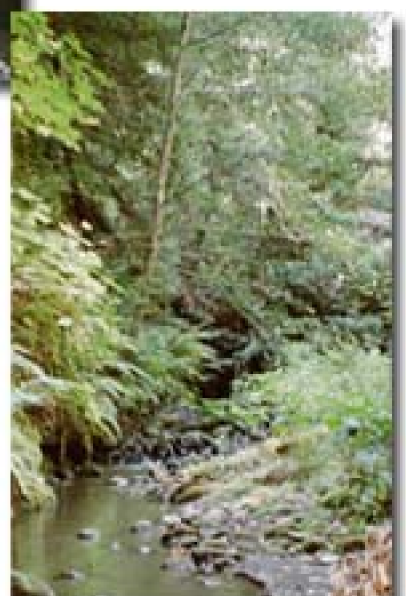
E. LARGE WOODY MATERIAL RECRUITMENT POTENTIAL IN APTOS CREEK WATERSHED

F. DESIGN SPECIFICATIONS FOR VALENCIA CREEK CULVERTS 1 AND 2



APTOS CREEK FISHERIES HABITAT ASSESSMENT

Technical Memorandum

Prepared for: **Coastal Watershed Council**

Prepared by **Hagar Environmental Science**

March 3, 2003

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APTOS CREEK WATERSHED ASSESSMENT AND ENHANCEMENT PLAN: SALMONID HABITAT AND LIMITING FACTORS ASSESSMENT

This Technical Memorandum was prepared to document one of several tasks supporting the Coastal Watershed Council in development of the Aptos Creek Watershed Assessment and Enhancement Plan. In conjunction with the results of other tasks, including a hydrologic and water quality assessment, geomorphic and erosion/deposition assessment, and riparian overstory description and mapping, this document provides a basis for developing site-specific habitat protection and restoration projects to benefit native steelhead and coho salmon populations.

1.0 Summary of Existing Information

Aptos Creek has long been recognized as an important steelhead spawning and nursery stream (California Department of Fish and Game (CDFG) stream surveys 1934, 1960, 1965, 1975). A 1960 stream survey estimated abundance of steelhead/rainbow trout at up to 65 per 100 feet and abundance at 40-50 per 100 feet for much of the lower section to the mouth. A 1965 survey estimated that there were 8 miles of nursery area with the average number of rearing steelhead/rainbow trout estimated at 100 per 100 feet of stream except for a half mile section with density of 140 trout per 100 feet of stream.

Aptos Creek is near the southern extent of the known range of coho salmon in North America. Coho salmon have been documented historically as far south as the Pajaro River although there are undocumented reports that they occurred as far south as the Santa Ynez River (Anderson1995). Coho runs disappeared from most streams south of San Francisco Bay during the late 1960's, 1970's, and early 1980's and were last reported from Aptos Creek in 1973. Non-native coho were stocked in Aptos Creek, along with other coastal streams, by the Department of Fish and Game during the 1960's including a large plant in 1963 of 10,000 Alsea stock fish reared at Darrah Springs hatchery in Shasta County (Evans 1963).

Fish sampling and habitat assessments were conducted in both Aptos and Valencia Creeks in 1981 as part of a regional assessment for Santa Cruz County (Harvey & Stanley Associates, Inc. 1982). Compared to other streams surveyed that year, abundance of smolt sized trout was relatively high in Aptos Creek upstream of the second bridge (reach 5 in the present survey) and in Valencia Creek near the Valencia Road crossing (Table 1). Downstream reaches of Aptos Creek had lower densities of smolt sized trout, particularly downstream of Valencia Creek. The study rated the rearing capacity of Aptos Creek as fair to below average at sites downstream of the second bridge and good at the upstream sites. Rearing capacity in Valencia Creek was rated as good at the site downstream from Valencia Road and fair at the site upstream. Primary limiting factors identified in the study included substrate, cover, and spawning in Aptos Creek and pool depth, substrate, and flow in Valencia Creek.

Average pool depths in 1981 ranged from 0.75 to 1.3 feet in Aptos Creek and from 0.45 to 0.6 feet in Valencia Creek. In Aptos Creek bedrock and sand comprised 53% to 90% of the substrate in pools and from 25% to 68% in riffles and runs. In Valencia Creek bedrock and sand made up 70% to 85% of substrate in pools but only 30% to 48 % in riffles and runs. Gravel and cobble substrate in riffles and runs was 30% to 65% in Aptos Creek and 50% to 70% in Valencia Creek. The present study found significantly changed conditions in Valencia Creek with respect to pool depth and substrate conditions. Large amounts of sand substrate were deposited in Valencia Creek during the wet winter of 1982 (J. Smith, San Jose State University, personal communication). Additional sedimentation may have occurred during wet winters in the

Table 1. Rearing Densities of Smolt-sized Steelhead in Santa Cruz Streams

Stream	Average Number of Smolt-
San Vicente	40.9
San Lorenzo River	29.8
Aptos (Nisene Marks, upstream from 2nd Bridge)	24.0
Zayante	22.0
Carmel	21.8
Valencia (downstream of Valencia Road)	17.0
Browns	16.5
Corralitos	16.1
Valencia average	15.0
Baldwin	13.8
Valencia (up flume road 0.75 miles	13.0
Newell	13.0
Shingle Mill Gulch	12.7
Bear	12.0
Fall	12.0
Soquel West Fork	11.3
Aptos (County Park above railroad crossing)	11.0
Boulder	10.5
Mill (San Lorenzo)	10.5
Aptos Average	9.6
Bean	9.5
Majors	9.4
Jamison	8.0
Hester	7.0
Laguna	7.0
Aptos (just above Valencia)	6.0
Aptos (Nisene Marks, upstream from Steel Bridge)	6.0
Bates	6.0
Liddell	6.0
Pescadero	6.0
Ramsey	6.0
Soquel East Fork	6.0
Kings	5.0
Liddell West Fork	5.0
Moore's Gulch	5.0
Gamecock	4.0
Hinkley	3.0
Liddell East Fork	3.0
Lockhart Gulch	3.0
Soquel	3.0
Carbonera	1.7
Aptos (below Valencia)	1.0

Source: Harvey and Stanley Associates (1984)
Notes: Numbers shown in red are within the Aptos/Valencia Creek watershed

mid- to late 1990s. Changes in sediment composition since 1981 may have resulted in changes in trout density. Abundance of rearing trout downstream of Valencia Road was about 70% of that at the best site in Aptos Creek in 1981. This contrasts to the present survey where abundance of rearing trout in that reach of Valencia Creek was only 10%, at best, of that in upper Aptos Creek (based on visual observations).

Aptos and Bridge Creeks also apparently suffered during the winter of 1982. United States Geological Survey (USGS) gage data shows flows reached a peak of 3,980 cubic feet per second (cfs) on January 4, 1982. Stream surveys in Bridge Creek by CDFG in June 1982 concluded that there was virtually no habitat to support an anadromous fishery and that no fish were observed in the creek. It was noted that high water marks on trees indicated a stage increase of 20 feet. High levels of sedimentation were also noted with many landslides and debris jams. Previous surveys in 1960 found that the stream was a good spawning and nursery stream below the natural falls and steelhead/rainbow trout of 2 to 6 inches were seen throughout the lower and mid sections in fair numbers.

A stream survey in the summer of 1982 in Aptos Creek found that there were no spawning areas, most pools were filled in with silt and averaged less than 6 inches in depth, and no fish were seen except an unidentified cyprinid. It is interesting to note that a 1975 survey of Aptos Creek estimated substrate characteristics as 10% fine gravel, 25% coarse gravel, 35% fine rubble, and 25% coarse rubble while the 1982 survey noted 80% sand and silt, 15% boulders and rubble, 4% bedrock, and 1% gravel. A 1985 survey of Aptos Creek indicates that conditions may have improved significantly from 1982. The survey indicated that abundant yearling steelhead were present although few young-of-year were seen. Pools were estimated to be about 50% of the length surveyed with depths up to 5 feet. Substrate was reported as a mosaic of silty sand and rubble upstream of Highway 1. Habitat conditions in Bridge Creek also appear to have improved since 1981 based on abundance of rearing juveniles in the present survey.

CDFG conducted qualitative sampling in Aptos Creek in 1996 and found densities of 1+ and older trout between 1.8 and 25.8 per 100 feet in pool type habitat. This is roughly comparable to the results for 1981. Both the 1981 and 1996 estimates appear to be well below estimates from the 1960's, however the earlier estimates are not well documented.

A stream inventory was conducted by CDFG in Aptos Creek watershed during 1997. Significant findings included:

- Limited water temperature sampling indicated temperature conditions near the upper optimal limit for juvenile salmonids in Valencia, Aptos, and Bridge Creeks.
- Numerous rock dams were constructed within the creek, preventing upstream movement of juvenile fish in Aptos Creek.
- Trash was being dumped and accumulating in the lower part of Aptos Creek.
- Several trees had been cut up and left in Aptos Creek below The Forest of Nisene Marks State Park.
- Most of the existing cover in Valencia Creek was provided by small woody debris and the habitat could benefit from more large woody debris.
- Most existing cover in Trout Creek is from boulders, woody cover in pools, and flatwater should be increased.
- A need to inventory, map, and treat sediment sources was identified in Valencia, Trout, and Aptos Creeks.

2.0 Habitat Requirements for Steelhead and Coho Salmon in Aptos Creek Watershed

Steelhead/rainbow trout and coho salmon habitat requirements are associated with distinct life history stages including migration from the ocean to inland reproductive and rearing habitats, spawning and egg incubation, rearing, and seaward migration of smolts and spawned adults. Steelhead/rainbow trout have a highly flexible life history and may follow a variety of life-history patterns including residents (non-migratory) at one extreme and individuals that migrate to the open ocean (anadromous) at another extreme. Intermediate life-history patterns include fish that migrate within the stream (potamodromous), fish that migrate only as far as estuarine habitat, and fish that migrate to near-shore ocean areas. These life-history patterns do not appear to be genetically distinct, and have been observed interbreeding (Shapovalov and Taft 1954). Habitat requirements and life-history timing for steelhead can vary widely over the steelhead's natural range (Barnhart 1986; Pearcy 1992; Busby *et al.* 1996).

Coho salmon have a more rigid life history with less variable life history patterns and timing. All coho salmon in California Coastal streams migrate to the ocean to mature and all adult coho die after spawning. Essentially all California wild female coho salmon spawn at 3 years of age. This results in three distinct brood year lineages in each stream. Extreme events in any given year (floods, droughts, toxic spills, etc.) that dramatically reduce or eliminate a single year class will result in the loss or reduction of the entire lineage and will be expressed as a low or missing run every third year (Anderson 1995). Under natural conditions, depression of any lineage will continue until it is rebuilt by straying or exceptionally good reproduction from a small residual spawning population.

The following paragraphs describe general life history traits and habitat relationships for steelhead and coho salmon. Some of the best information on steelhead and coho life histories comes from a multi-year study in Waddell Creek in the Santa Cruz mountains (Shapovalov and Taft 1954) and that study provides a basis for much of the following discussion.

2.1 In-migration of Adults

Steelhead and coho along the Central California coast enter freshwater to spawn when winter rains have been sufficient to raise streamflows and breach the sandbars that form at the mouths of many streams during the summer. Increased streamflow during runoff events also appears to provide cues that stimulate migration and allows better conditions for fish to pass obstructions and shallow areas on their way upstream. The season for upstream migration of steelhead adults lasts from late October through the end of May but typically the bulk of migration (over 95% in Waddell Creek) occurs between mid-December and mid-April. Coho salmon have a more abbreviated spawning season that occurs earlier in the winter. In California, coho spawning migrations occur between late October and early March with more southern populations typically spawning slightly later. Between 1933 and 1942, the coho migration in Waddell Creek occurred between early December and early March with 90% of the run completed by early February (Shapovalov and Taft 1954). This relatively early spawning period for coho salmon increases the probability that their embryos will be exposed to severe conditions during high flow episodes and has resulted in very weak year classes in some of the remaining runs south of San Francisco Bay (Anderson 1995).

Steelhead have strong swimming and leaping abilities that allow them to ascend streams into small tributary and headwater reaches. Steelhead can swim at rates of up to 4.5 feet per second (fps) for extended periods of time and can achieve burst speeds of 14 to 26 fps during passage through difficult areas (Bell 1986). Leaping ability is dependent on the size and condition of fish and hydraulic conditions at the jump. Given satisfactory conditions, a conservative estimate of steelhead leaping ability is a height of 6 to 9 feet (Bjornn and Reiser 1991), though other estimates range from 11 feet (Bell 1986) to as high as 15 feet (McEwan 1999). Coho have slightly lower swimming and leaping ability than steelhead, with cruising speeds up to 3.5 fps and burst speed of 10-21 fps (Bell 1986). Maximum jumping height for coho is reported by Bell (1986) at just over 7 feet. These differences in swimming ability may limit coho to relatively lower gradient reaches of coastal streams. In Waddell Creek, Shapovalov and Taft (1954) found that coho consistently spawned lower in the creek. Coho are known to spawn in very small tributary streams though fry often move out of these smaller tributaries after hatching.

2.2 Spawning and Egg Incubation

Shapovalov and Taft (1954) found no differences in characteristics of spawning sites chosen by steelhead and coho in Waddell Creek. Both species select spawning sites with gravel substrate and with sufficient flow velocity to maintain circulation through the gravel and provide a clean, well-oxygenated environment for incubating eggs. Preferred flow velocity is in the range of 1-3 feet per second for steelhead (Raleigh 1984) and 0.7-2.3 feet per second for coho (McMahon 1983). Preferred gravel substrate is in the range of 0.25 to 4 inches in diameter for steelhead and 0.5 to 4 inches for coho (Bjornn and Reiser 1991). Non-anadromous rainbow trout prefer spawning gravel in the range of 0.25 to 2.5 inches in diameter.

Typically, sites with preferred features for spawning occur most frequently in the pool tail/riffle head areas where flow accelerates out of the pool into the higher gradient section below. In such an area, the female will create a pit, or redd, by undulating her tail and body against the substrate. This process also disturbs fine sediment in the substrate and lifts it into the current to be carried downstream, cleaning the nest area. Incubation and emergence success are influenced by accumulation of fine sediments (generally less than 3.3 mm) in the substrate. Embryo survival for steelhead decreases when the percentage of substrate particles less than 6.4mm reaches 25-30% and is extremely low when fines are 60% or more. Emergence of steelhead and coho fry is generally high when fine sediments are less than 5% of substrate volume but drops sharply with fine sediment volume of 15% or more.

Coho fecundity ranges from about 1,600 eggs for a 22-inch female to over 4,000 for a 30-inch fish. Steelhead have significantly higher fecundity with a 22-inch female producing around 4,800 eggs and a 30-inch fish producing an average of 9,000-10,000 eggs (Shapovalov and Taft 1954). Even a 12-inch non-anadromous rainbow trout may produce 1,000 eggs or more. Survival of fertilized eggs through hatching and emergence from the gravel are most often limited by severe changes in flow that can dislodge eggs from the substrate, result in sedimentation, or de-water incubation sites. Since the majority of coho usually complete spawning by January or early February their eggs are more susceptible to damage from winter storms than steelhead, many of which may spawn as late as March or April. In addition, where the two species occur together, the earlier coho redds may be disrupted by later spawning steelhead.

Steelhead eggs range from 3 to 6 mm in diameter and are mostly spherical. At hatching steelhead larvae (alevins) are approximately 14 to 15.5 mm total length (TL) (Wang 1986; Emmett et al 1991). At completion of yolk sac absorption (~emergence) steelhead larvae are approximately 22-25mm TL. Coho salmon eggs are reported to be from 6.6 mm to almost 8 mm in diameter in the U.S. (they are smaller in Canada). The coho alevins are somewhat larger than steelhead, ranging from 17 to 19 mm at hatching and 27 to 30 mm at emergence (Emmett et al. 1991).

2.3 Rearing

After emergence from the gravel, fry inhabit low velocity areas along the stream margins. As they feed and grow they gradually move to deeper and faster water. In Central California streams coho typically rear for one year in freshwater and steelhead typically rear one or two years. Steelhead juveniles of 4-6 inches (generally in their second year of life) may be commonly found in riffle habitat, particularly in warmer streams. Parr larger than 6 inches are more often found in deeper waters where low velocity areas are in close proximity to higher velocity areas and cover is provided by boulders, undercut banks, logs, or other objects. Heads of pools generally provide classic conditions for older trout. Trout and juvenile coho can inhabit quite small streams, particularly in coastal streams. Often habitat may be far more limiting for older juveniles than habitat for younger fish. The critical period is during base flow conditions that generally occur between May and October in Central California. Streamflow can drop to very low levels with loss of depth and velocity in riffle and run habitats, or in the extreme, only isolated pools with intervening dry sections of stream. Any diversion or other depletion of streamflow during this critical period can be potentially damaging to rearing juvenile steelhead.

Although standard definitions of good trout rearing habitat often include conditions such as baseflows of at least 25% to 50% of the average annual daily flow, 1:1 riffle-to-pool ratios, and depths of a foot or more, these conditions may not always be achieved in Central California streams that still support relatively good steelhead/rainbow trout populations. Steelhead/rainbow trout populations in Central California can occur in streams with relatively low baseflow and in streams varying widely in terms of standard evaluation parameters such as pool:riffle ratio and mean depth. Often, local populations thrive under conditions that may depart widely from species norms (Behnke 1992). Steelhead juveniles respond to stream conditions that limit habitat for older trout by leaving the small streams to complete the maturation process in the more accommodating ocean environment.

Coho parr are most abundant in large, deep pools (greater than 1 foot) with abundant cover in the form of logs, roots, woody debris, undercut banks, and overhanging vegetation (McMahon 1983). Some studies have shown positive correlations between coho standing crop and pool volume (McMahon 1983). Food and cover are key factors for rearing steelhead and coho (Mason and Chapman 1965; Shapovalov and Taft 1954). Food availability, in terms of production of aquatic and terrestrial insects, is influenced by substrate composition, extent of riffles, and riparian vegetation. The highest production of aquatic invertebrates is in gravel and cobble substrate with low amounts of fine sediments, often occurring in riffle type habitats. Production of coho has been shown to be higher in pools with larger riffles upstream (Pearson *et al.* 1970). Coho production decreases with high levels of fine sediments and high embeddedness of cobble substrate (Crouse *et al.* 1981). Bjornn *et al.* (1977) found that the density of rearing steelhead and chinook salmon in artificial channels was reduced in nearly direct proportion to increased cobble embeddedness. Response to increased embeddedness was even greater during the winter. During the high flows, reduced food abundance, and lower temperatures occurring in winter, both coho and steelhead may move into the substrate or other cover. Backwater habitat, small tributaries, or other low velocity areas may also be important winter habitat.

Temperature is an important factor for steelhead/rainbow trout and coho, particularly during the over-summer rearing period. In many Central California streams growth slows or ceases in conjunction with warm, low flow conditions in late summer. The influence of water temperature on steelhead and other salmonids has been well studied and the influence on individual trout populations is complicated by a number of factors such as local adaptations, behavioral responses, other habitat conditions, daily and annual thermal cycles, and food availability. The most definitive temperature tolerance studies have been conducted in laboratory settings where experimental conditions have been highly controlled and fish were exposed to constant temperatures (Brett 1952; Brett *et al.* 1982). Upper lethal temperature for Pacific salmonids is in the range of 75°F to 77°F (24ºC-25ºC) for continuous long-term exposure. Upper incipient lethal temperature ranges from 23ºC to 26ºC for coho fry and is 24ºC to 25ºC for rainbow trout.

Elevated temperature below the lethal threshold can have indirect influence on survival due to depression of growth rate, increased susceptibility to disease, and lowered ability to evade predators. The swimming ability of coho is reduced at temperatures exceeding 20ºC or below 9ºC. Growth of coho is high at 9ºC -13ºC but decreases at 18ºC and ceases at 20.3ºC (McMahon 1983). Preferred temperatures for steelhead parr range from 12ºC to 18ºC, although optimum growth rates may occur at slightly higher temperatures if food is abundant. Temperature also influences the smoltification process. In some studies, steelhead have exhibited decreased migratory behavior and decreased seawater survival at temperature in excess of 55°F (13ºC) (Zaugg and Wagner 1973; Adams *et al.* 1975).

In most streams water temperature varies over the course of a day and from day to day, generally tracking changes in air temperature. Although the peak temperature on a given day may exceed the lethal level, steelhead/rainbow trout can survive short periods at temperatures above the lethal threshold. In Brett's study, juvenile chinook salmon experienced no mortality at temperatures up to 75°F (24ºC) for 7 days. At 79°F (26ºC) half the juvenile salmon survived a 5-hour exposure period and at 81°F (27ºC) half survived a 1.5-hour exposure. The temperature that the fish are acclimated to is also an important variable. Juvenile salmon acclimated to 75°F (24ºC) experienced 50% mortality after 8.5 days at 77°F (25ºC) while those acclimated to 59°F (15ºC) experienced 50% mortality after only 42 hours of exposure at 77°F (25ºC) (Brett 1952). Some trout populations are able to thrive under temperature conditions unsuitable for other populations. Behnke (1992) has found native redband trout in intermittent desert streams thriving in water of 83°F (28ºC) and actively feeding at that temperature. These populations have apparently become adapted to conditions in the region.

Smith (1999) describes two different habitat types used by Central Coast steelhead and resident trout. The primary habitat consists of shaded pools of small, cool, low-flow upstream reaches typical of the original steelhead habitat in the region. In addition, they can use warmwater habitats below some dams or pipeline outfalls, where summer releases provide high summer flows and fast-water feeding habitat. Trout metabolic rate and thus food demand increases with temperature. Trout rely heavily on insect drift for food and drift increases with flow velocity. Under conditions of low flow and high temperatures trout have increasing difficulty obtaining sufficient food to meet metabolic costs. Smith and Li (1983) found that in Uvas Creek (Santa Clara County), a relatively warm stream with summer maximum water temperature of 23ºC to 25°C, steelhead/rainbow trout move into higher velocity microhabitats in riffles and runs where sufficient food can be obtained. These habitats are created by summer releases from an upstream reservoir. Under augmented flow conditions trout can occupy warmer habitats than may otherwise be possible.

2.4 Smolt Out-Migration

Behavior of steelhead/rainbow trout in Waddell Creek is probably typical for most Central California populations. Trout of various ages migrated out of Waddell Creek in all months of the year but the majority migrated in April, May and June. Downstream migration of young-of-year fish (less than a year old) extended from late-April through the following spring; however this movement may have been just dispersal to downstream rearing areas and not a true seaward migration. Downstream migration of 1-year old steelhead was from April through late June and 2-year old fish from March through late May. Coho in Waddell Creek migrated almost exclusively as one-year old fish and 96% of all migration occurred between April 1 and June 15.

In addition to temperature and flow conditions, smolts are subject to predation, primarily by birds including cormorants, mergansers, and herons. Although predation by fish can be high in certain situations, large predatory fish are not present in most smaller coastal streams. Predation by birds can increase under conditions where smolts have to traverse shallow sections of streams without cover. With clear water, birds can be particularly effective predators. Conditions favoring predation by birds occur in channel reaches modified for flood control where the channel is maintained in a wide, shallow configuration and is largely devoid of in-stream large woody debris and riparian vegetation.

2.5 Out-Migration of Adults

All coho die following spawning. Steelhead that survive spawning return downstream to re-enter the ocean. As many as 20% of adult spawners may be repeat spawners and some fish may return to spawn up to 3 or 4 times (Shapovalov and Taft 1954). In some streams fish return downstream immediately after spawning while in others they may remain for a period up to several months. After spawning, these fish do not typically resume feeding while in freshwater. In Waddell Creek the bulk of adults returned downstream from April through June. Fish that remain in the stream for any period of time generally reside in deeper pools. Adequate cover and cool temperature are critical habitat variables for adults that hold over for the entire summer.

3.0 Salmonid Habitat Assessment

3.1 Habitat Assessment Methods

Stream habitat was assessed between late August and early October, 2001 using the California Salmonid Stream Habitat assessment methodology. Surveys were completed in 8.5 miles of Aptos Creek from the mouth upstream to a point southeast of Whites Lagoon. Bridge Creek was surveyed from the Aptos Creek confluence upstream for 1.2 miles. A total distance of 5.2 miles in Valencia Creek was surveyed from the Aptos Creek confluence to approximately 1.7 miles upstream of Valencia Road. Trout Creek Gulch was surveyed from the Valencia Creek confluence to the road crossing 1.3 miles upstream. A short section of Mangels Gulch was surveyed but was mostly dry.

Prior to initiating field surveys, the watershed was segmented into discrete reaches based on gradient, tributary inflow, stream channel type, natural barriers, and other available channel morphology data. Reach designations were confirmed or adjusted during the field surveys based on actual channel conditions.

Stream habitat types were inventoried in accordance with the California Salmonid Stream Habitat Restoration Manual (Flosi *et al.* 1998) with the following modifications:

- Habitat typing was conducted at a Level IV classification using a ten percent sampling protocol (Flosi *et al.* 1998).
- In each sample reach all habitat units were identified by type and length measured. First encounters for each habitat type, and a randomly selected 10% sample was characterized in full detail.
- Maximum depth, pool tail crest depth and pool tail embeddedness were recorded for every pool encountered.
- Canopy density was recorded for every third habitat unit.

- Bank composition and vegetation components were not included since detailed information on these features was collected in the geomorphic and erosion/deposition assessment (Task 2) and riparian and overstory description and mapping task (Task 4).

Habitat assessment data were evaluated by summarizing habitat type frequency of occurrence and parameter values within discrete, homogenous stream reaches. Tabular and graphical summaries were developed to aid in limiting factor analysis.

Potential barriers to migration were identified, located by GPS when possible, photo documented and described with reference to species specific criteria in the scientific literature for passage at both natural and constructed obstacles (Bjornn and Reiser 1991; NMFS 2000; WDFW 1999).

As an additional layer of information and to aid in interpreting the habitat assessment data, visual observations of fish were also recorded during the habitat assessment. Counts by size class and species were recorded on a fish observation datasheet for each habitat unit where fish were observed.

In conjunction with the habitat assessment, large woody debris occurring within the channel was tabulated by size using the protocol outlined in the CDFG Salmonid Stream Habitat Restoration Manual (Flosi *et. al.* 1998). Information describing the impact that large woody debris (LWD) has on channel structure, pool formation and habitat complexity within each reach was also collected.

3.2 Habitat Assessment Results

Six reaches of Aptos Creek and one reach of Bridge Creek were surveyed (Figure 1). The lowest reach of Aptos Creek consisted of the lagoon and a low gradient reach between the lagoon and the confluence with Valencia Creek. The second Aptos reach extended upstream from Valencia Creek for about 1.4 miles and was characterized by relatively low gradient and low confinement. The third Aptos reach (about 1.6 miles) was also relatively low gradient but was more confined, often running between steep bedrock walls, and extended to just upstream of the steel bridge. The fourth Aptos reach was low gradient but less confined than the downstream reach and extended almost 2 miles to near the historic location of the old sawmill. The fifth Aptos reach included the Bridge Creek confluence and extended upstream to a point where the gradient increased and extensive log jams began, near the Loma Prieta epicenter. The sixth Aptos reach extended upstream for about 1.5 miles and was characterized by relatively steep gradient, numerous landslides, and frequent log debris jams. The lower 1.2 miles of Bridge Creek had characteristics similar to the sixth reach of Aptos Creek. Much of Bridge Creek and Aptos reach 6 may be inaccessible to anadromous fish at most times.

Valencia Creek was segmented into three reaches, a higher gradient reach where the stream trends in a more north-south orientation upstream of Valencia Road, and two lower reaches separated at the point where drainage from a large basin to the southeast enters the Creek (Figure 1). Trout Creek was surveyed from Valencia Creek upstream to for approximately 1.3 miles to the vicinity of the Trout Creek Gulch road crossing. Most of Mangels Gulch was dry at the time of the survey. A 13-foot cascade with associated debris jam located approximately 680 feet upstream from the Aptos Creek confluence is a migration barrier. The substrate downstream of the barrier is dominated by sand and the channel bed is uniform (without pool development). Based on these conditions, Mangels Gulch is not expected to support steelhead or coho.

The results of habitat surveys and fish observations were evaluated to identify key factors that potentially limit fish populations in the watershed (Section 4). Several key habitat features were

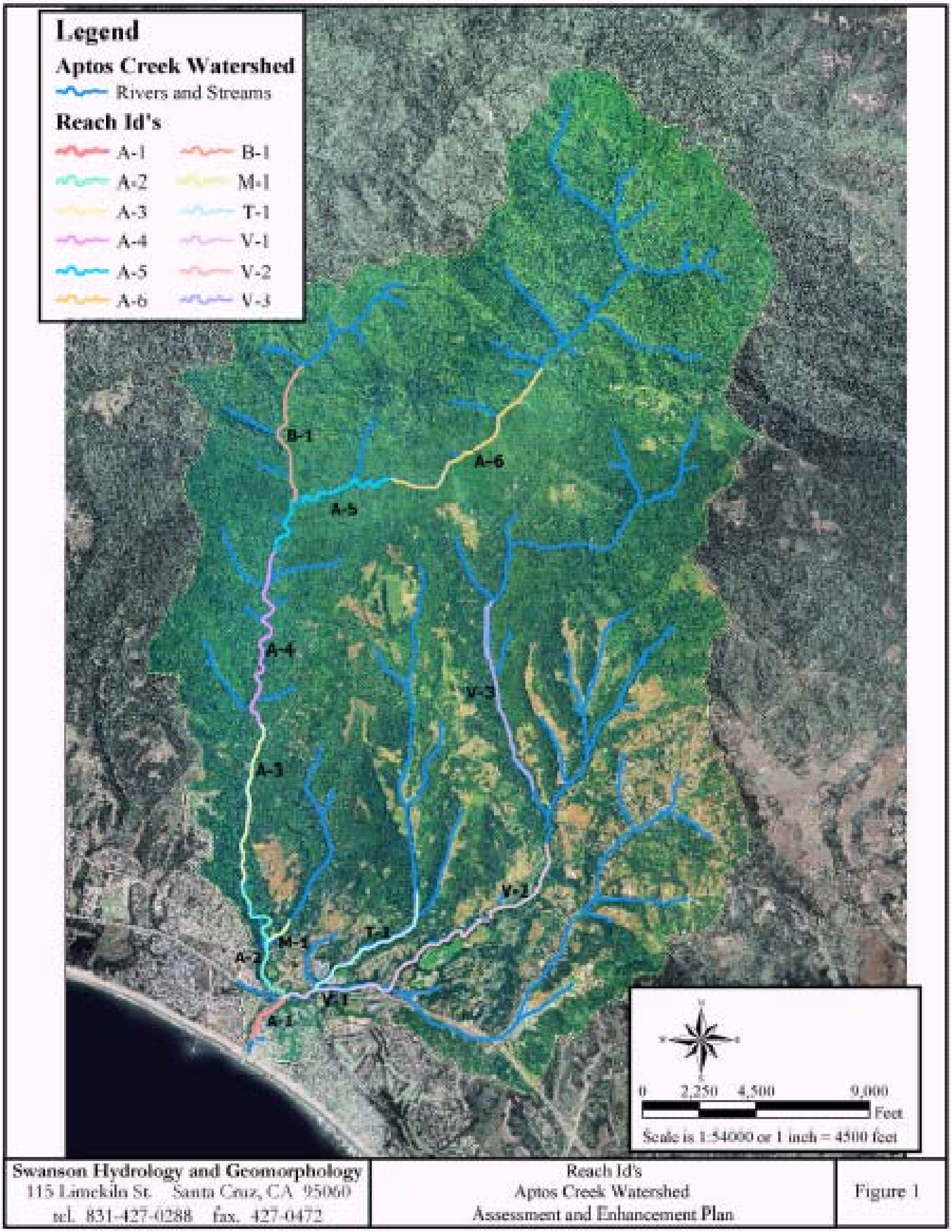


Figure 1. Survey Location Map – Aptos Creek Watershed

considered in determining potentially limiting factors and potential for improvement including habitat type and stream dimensions, shelter characteristics, substrate conditions, bank and canopy conditions, stream temperature, and barriers to fish movement. The discussion of results that follows is organized around these key features.

3.2.1 Habitat Type and Stream Dimensions

The habitat inventory assesses the amount and quality of different habitat types within each reach. Habitat dimensions (depth, area) and type (pool, riffle, flatwater) influence the ability of a stream to support trout and salmon populations. Riffle habitats are important for production of aquatic insects and other organisms used as food sources. Riffles can also provide good habitat for younger age classes of salmonids and can be good foraging areas if they are sufficiently deep. Flatwater runs and glides can also be used for foraging and can support greater numbers of rearing juveniles depending on depth and cover characteristics. Flatwater habitats also tend to have areas where velocity and substrate characteristics are suitable for spawning. Pool habitat is important because pools provide habitat during the summer low flow period and during periodic droughts. Deeper pools with good cover characteristics provide very important habitat for adult resident trout, coho parr, and second year steelhead parr. Although these fish may inhabit pools with mean depths in the range of 0.5 to 1.5 feet in small streams, they generally occur at greater densities in streams with more pools in the 1.5 to 2.5 foot mean depth range or deeper. Excessive fine sediments in a stream may result in loss of pool depth and cover components.

Habitat conditions varied considerably between sub-watershed areas and between reaches within sub-watersheds (Figure 2). Most of Valencia Creek and Trout Creek consisted of narrow, shallow channels with predominantly sand substrate and no pools. Valencia Creek had lower flow and a narrower wetted channel (mean width) than Aptos and Bridge Creeks (Table 2). Depth was less for all habitat types in Valencia and Trout Creeks than in Aptos and Bridge Creeks, even in the smaller, upper reaches of Aptos Creek (Table 3).

As would be expected, estimated discharge and average wetted width in Aptos Creek decreased higher in the watershed as did the amount of pool habitat (% by length) and pool depth (Table 2). Aptos reach 1 was atypical in that approximately half its length included the lagoon. The other half was highly influenced by Valencia Creek and consisted primarily of wide shallow glide type habitat dominated by sand substrate. Habitat conditions improved upstream of Valencia Creek with lower amounts of sand substrate and better habitat development. Pools were most extensive in reach 3 of Aptos Creek where they were typically long and deep with steep bedrock sides (Figure 3). The pools were generally sufficiently deep to support older age classes of resident trout and juvenile steelhead and coho. The great majority of pool habitat (75% to 85% by length) in reaches 2, 3, and 4 of Aptos Creek had mean depths over 1 foot and maximum depths of at least 2 feet (Figures 4 and 5). A significant number of pools in these reaches had maximum depths of 3 feet or more (29% of pools in reach 2, 44% in reach 3, and 40% in reach 4). In the upper two reaches of Aptos Creek and in Bridge Creek, pools were less extensive and more shallow (Tables 2 and 3). Pools in Aptos reach 6 and Bridge Creek were only 18% and 9% of the habitat by length and the majority had mean depth of less than 1 foot and maximum depth of 2 feet or less. This type of habitat would presumably support fewer fish past their first year than the lower reaches. Only three pools were identified in Valencia Creek, all in the uppermost reach (reach 3). A single pool was found in the 7,018 feet of Trout Creek that were surveyed. It was a small deep backwater pool formed by scour around the butt of a redwood log.

Scour against bedrock was the primary pool formation factor in Aptos Creek (Table 4). Wood, in the form of logs or roots was a relatively important pool formation factor in reaches 2 and 3 (41% and 30% of pools, respectively) but was relatively unimportant in the upper reaches, particularly reach 5. Since bedrock pools were longer on average than wood-formed pools, they made up

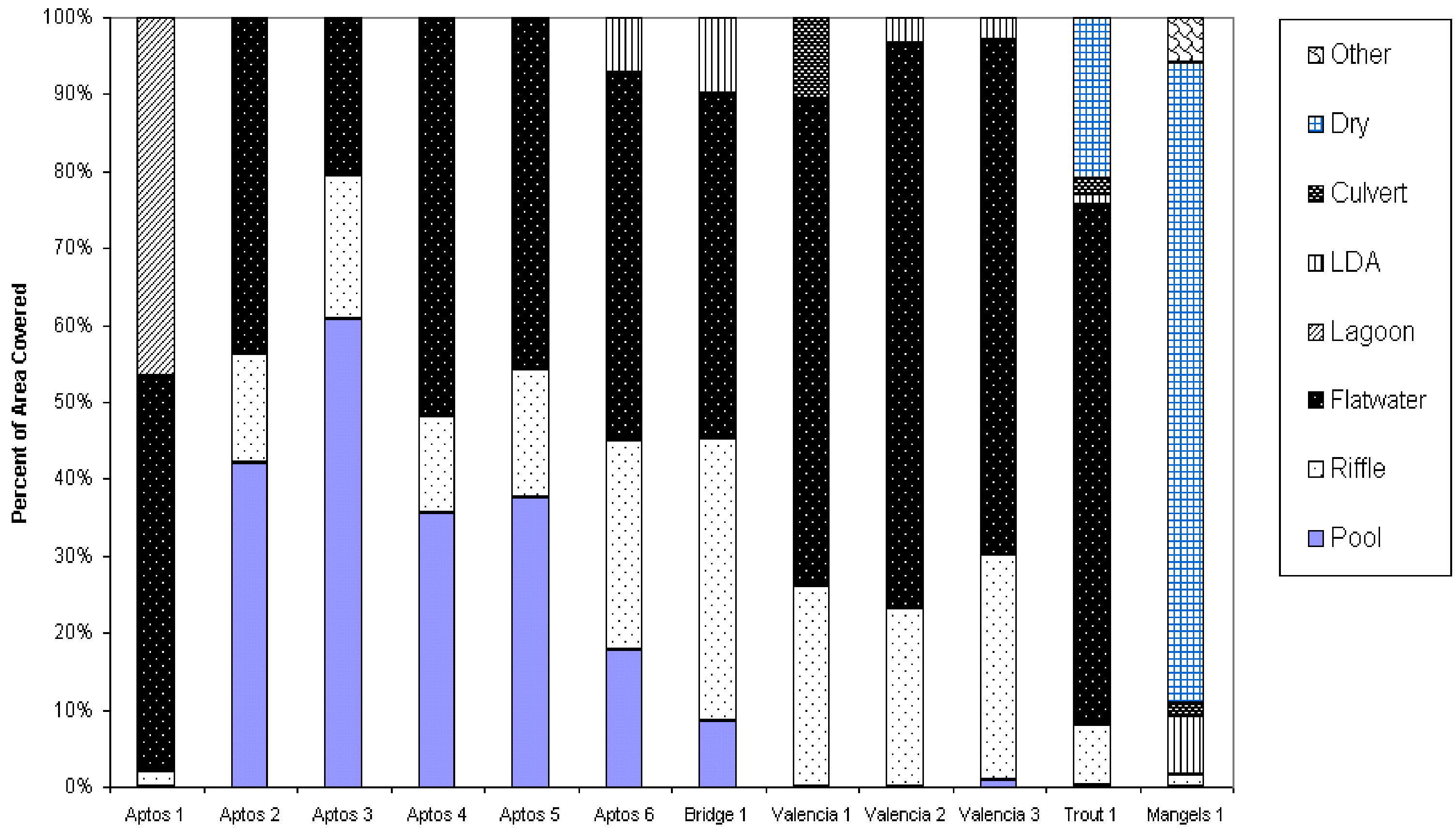


Figure 2. Habitat Type Composition

Table 2. Aptos Creek Watershed Pool Characteristics

	reek						Bridge Creek	Valencia Creek			Trout Creek
		A-2	A-3		A-5			V-1	V-2		
Reach Length (ft)	1,649	7,134	8,340	10,366	9,251	7,952	6,461	5,599	12,581	9,232	7,018
Estimated Flow (cfs)	n.m.	2.5	n.m.	2.5	1.3	1.0	1.0	0.5	0.5	0.5	0.1
Mean Width (ft)	28.8	12.6	14.7	12.8	10.5	8.3	7.8	6.8	6.3	6.9	3.6
Average Pool spacing (ft)	n.a.	183	203	247	189	209	294	n.a.	n.a.	3,077	7,018
Mean Length of Pools (ft)	n.a.	77	124	88	71	37	25	n.a.	n.a.	25	10
Number of Pools	0	39	41	42	49	38	22	0	0	3	1
% pools by length	0%	42%	61%	36%	38%	18%	9%	0%	0%	1%	0
% pools with mean depth >=1.5 ft	*	26%	29%	29%	2%	8%	0%	*	*	0%	+
% pools with mean depth >= 2 ft	*	5%	2%	10%	0%	3%	0%	*	*	0%	+
% pools with maximum depth >= 3ft	*	29%	44%	40%	14%	11%	0%	*	*	0%	+

Notes: ft: feet
cfs: cubic feet per second
n.m.: not measured
n.a.: not applicable, habitat type did not occur in stream reach
*no pools present
+only single pool identified in Trout Creek

Table 3. Depth Characteristics by Habitat Type and Reach

	Aptos Creek						Bridge Creek	Valencia Creek			Trout Creek	Mangels Creek
	A-1	A-2	A-3	A-4	A-5	A-6	B-1	V-1	V-2	V-3	T-1	M-1
	Average of Mean Depth											
Flatwater	0.25	0.55	0.58	0.60	0.43	0.46	0.36	0.15	0.24	0.23	0.06	n.a.
Pool	n.a.	1.34	1.28	1.37	0.99	1.02	0.81	n.a.	n.a.	0.60	1.30*	n.a.
Riffle	0.30	0.35	0.30	0.28	0.33	0.25	0.20	0.15	0.25	0.26	0.06	n.a.
	Average of Maximum Depth											
Flatwater	1.10	1.11	1.05	1.05	0.86	1.26	0.93	0.30	0.70	0.53	0.26	n.a.
Pool	n.a.	2.92	3.04	2.81	2.27	2.13	1.80	n.a.	n.a.	1.30	2.30*	n.a.
Riffle	0.60	0.55	0.64	0.68	0.85	1.05	1.75	0.33	0.68	0.50	0.20	n.a.

Notes: * single pool measured in Trout Creek
n.a. habitat type did not occur in stream reach

Figure 3. Typical bedrock pool in Aptos Creek, reach 3

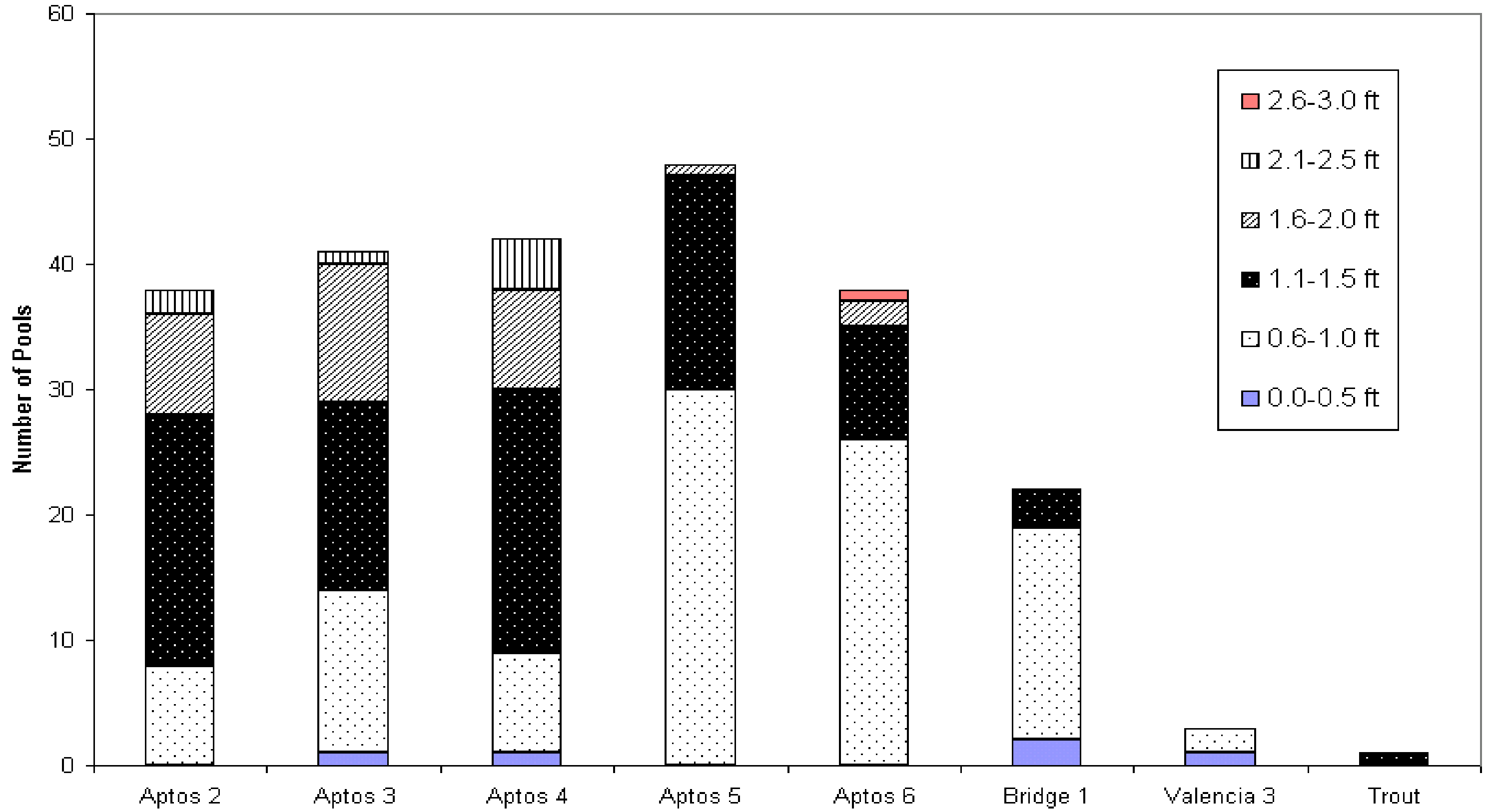


Figure 4. Pool Mean Depth by Reach

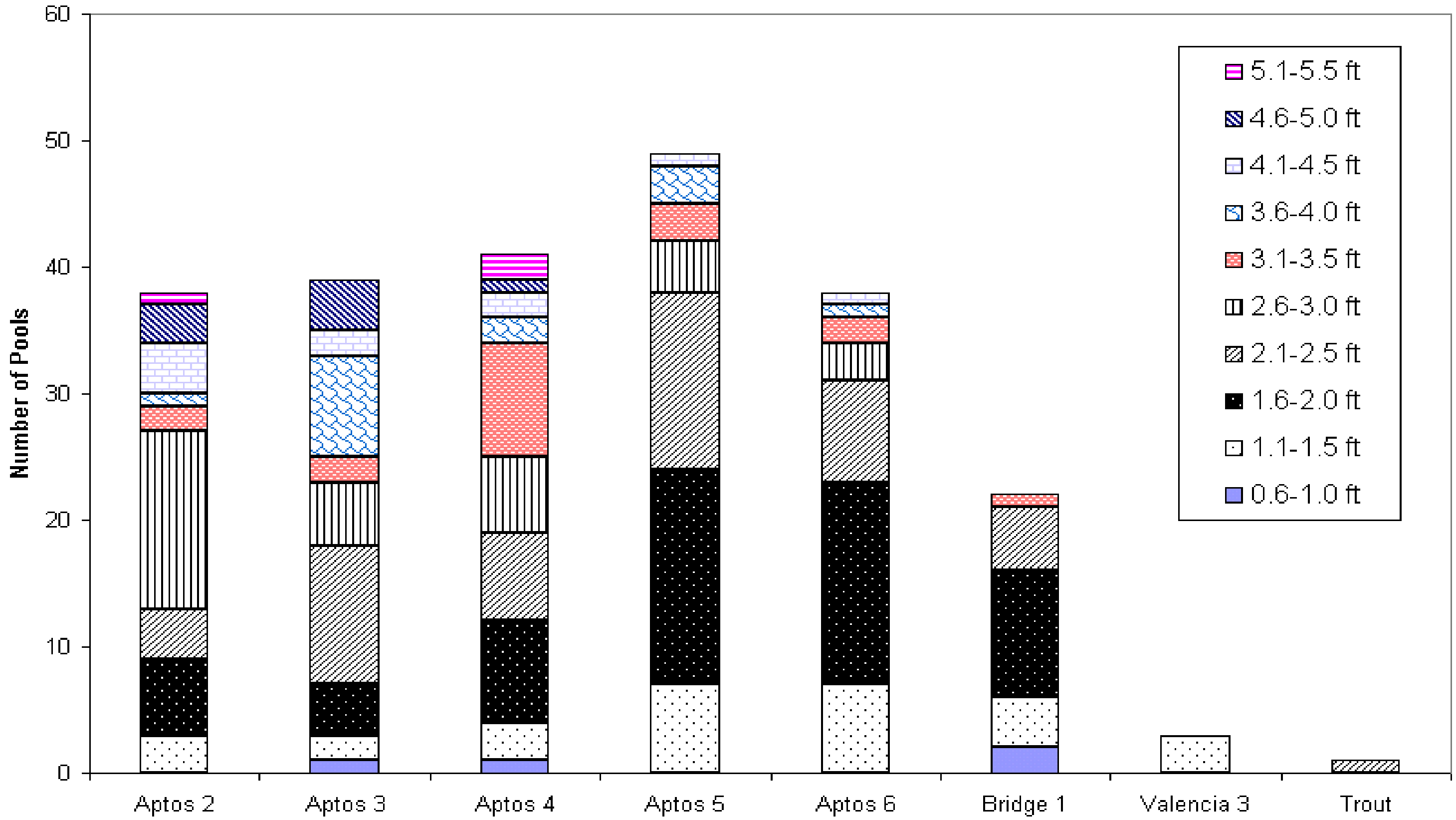


Figure 5. Pool Maximum Depth by Reach

Table 4. Pool Primary Formation Factors by Reach

Habitat Unit Type	Number of Pools					
	Aptos Creek A-2	Aptos Creek A-3	Aptos Creek A-4	Aptos Creek A-5	Aptos Creek A-6	Bridge Creek B-1
Backwater Pool-Log Formed		1				
Dammed Pool		2				
Lateral Scour Bedrock Formed	14	23	30	27	15	7
Lateral Scour Boulder Formed				4	6	2
Lateral Scour Log-enhanced	6	6	4	8	5	4
Lateral Scour Pool	1		1			
Lateral Scour Root-wad enhanced	8	5	2	1	3	
Mid-Channel Pool	5	2	2	6	3	1
Plunge Pool					5	7
Secondary Channel Pool				1		
Step Pool		1			1	1
Grand Total	34	40	39	47	38	22
% pools formed by woody debris	41%	30%	15%	19%	21%	18%
mean length woody debris pools (feet)	72	63	76	48	49	
mean length bedrock pools (feet)	89	160	97	88	35	
woody debris pools, % by length	34%	18%	12%	11%	27%	23%
bedrock pools, % by length	41%	73%	79%	69%	38%	38%

a much greater proportion of the stream length than wood formed pools (Table 4). The contribution of wood-formed pools to habitat should not be discounted. However, since much of the useful habitat in a pool is at the head of the pool , much of the longer bedrock pools may not be used for rearing. In other words, a relatively short wood formed pool may have nearly as much useable habitat as a long bedrock pool. It is surprising that even in reach 6, where a substantial amount of large woody debris was available, it was less important than other factors in pool formation. This is primarily because the available wood was suspended above the channel or was concentrated in debris jams.

Flatwater habitat was relatively extensive in all reaches of Aptos Creek (Table 5). Riffle habitat was relatively scarce in the lower five reaches of Aptos Creek. Flatwater habitat dominated both Valencia and Trout Creeks with lesser amounts of riffle habitat. Flatwater in Valencia and Trout Creeks was shallower and more dominated by sand than in Aptos Creek.

3.2.2 Shelter Characteristics

There are numerous potential predators on juvenile salmonids inhabiting streams and the presence of adequate cover, or shelter, can greatly influence survival rates. Important predators in streams of California's Central Coast include birds such as the belted kingfisher, common merganser, little green heron, great blue heron, and various species of egret; the western aquatic garter snake; and mammals including river otter and raccoon. Instream and overhead cover in the form of undercut banks, tree trunks and branches (whether alive or dead), grasses, herbs, and shrubs, floating or rooted aquatic vegetation, cobbles and boulders, bedrock ledges, and surface turbulence can inhibit the ability of predators to see and capture juvenile salmonids.

The proportion of each habitat unit that was influenced by some type of shelter was estimated as a percentage of the total surface area of the unit. A shelter complexity rating of low, medium, or high was also estimated for each habitat unit based on the areal coverage, structural complexity, and utility of cover present. Percent coverage was generally moderate to low in all reaches of Aptos and Bridge Creeks (Table 6). Percent shelter coverage ranged from 19% to 32% when all habitat types are considered and from 22% to 37% for pool habitats. A relatively high percentage of habitat units were rated as "low" in shelter complexity in the lower 3 reaches of Aptos Creek and in Bridge Creek and the proportion of pools rated as "low" was relatively high in reaches 2, 3, and 4. Even many of the pools that were rated "moderate" in terms of shelter complexity did not have extensive areas of shelter. A high proportion of pools in reaches 2 through 5 and in Bridge Creek had shelter coverage of only 20% or less. Woody debris was present as a cover component in at least a quarter to a third of the pools but was present in nearly two thirds of the pools in Aptos reach 3 and in Bridge Creek.

The most frequently encountered cover types in Aptos Creek were substrate roughness (substrate particles of 5-inch median diameter or greater), a component in 87% of surveyed units, small woody debris (58% of units), and surface turbulence (50% of units) (Table 7, Figure 6). In terms of the areal extent of influence the most extensive cover types included terrestrial vegetation (primarily in reaches 1 and 2) and substrate roughness (more important in the higher gradient, upper watershed reaches). Small woody debris, bedrock ledge, large woody debris, undercut banks, and surface turbulence were present in similar amounts but were distributed differently in different reaches. Bedrock ledges were particularly prevalent in reach 3 and 5. Large woody debris was more extensive in reach 3 than other reaches (Figure 6). In Valencia Creek small woody debris and overhanging terrestrial vegetation were the most prevalent cover types lower in the creek while substrate roughness and surface turbulence became more important in the upper reaches. In pool habitats, small woody debris and overhanging terrestrial vegetation were

Table 5. Habitat Type Summary by Reach

	Aptos Creek						Bridge Creek	Valencia Creek			Trout Creek	Mangels Creek
	A-1	**A-2**	**A-3**	**A-4**	**A-5**	**A-6**	**B-1**	**V-1**	**V-2**	**V-3**	**T-1**	**M-1**
	Number of Habitat Units											
Culvert								3			1	1
Flatwater	2	38	22	47	38	46	36	13	36	60	19	
Pool		39	41	42	49	38	22			3	1	
Riffle	1	27	31	28	28	50	45	12	31	54	15	2
LDA					1	14	6	0	13	3	5	3
Lagoon	1											
Dry											2	7
Other								1				1
	Percentage by Length											
Culvert	0%	0%	0%	0%	0%	0%	0%	11%	0%	0%	2%	2%
Flatwater	51%	44%	21%	52%	45%	48%	45%	62%	73%	67%	68%	0%
Pool	0%	42%	61%	36%	38%	18%	9%	0%	0%	1%	0%	0%
Riffle	2%	14%	19%	13%	17%	27%	37%	26%	23%	29%	8%	2%
LDA	0%	0%	0%	0%	0.2%	7%	10%	0%	3%	3%	1%	8%
Lagoon	47%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Dry	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	21%	83%
Other	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	6%

Notes: cfs – cubic feet per second
ND – not determined
LDA – large debris accumulation

Table 6. Shelter Characteristics by Reach

	Aptos Creek						Bridge C	Valencia Creek			Trout Creek
	A-1		A-3	A-4	A-5	A-6	B-1	V-	V-2	V-3	T-1
Number of units surveyed	4	25	21	21	24	41	21	6	12	16	11
Number of pools surveyed	0	12	12	9	13	17	10	0	0	3	1
Number of units with "high" shelter complexity	0	4	2	0	4	7	2	0	1	0	0
Number of units with "medium" shelter complexity	1	10	12	17	17	28	13	0	4	12	1
Number of units with "low" shelter complexity	3	11	7	4	3	6	6	6	7	4	10
% of all units with "low" shelter complexity	75%	44%	33%	19%	13%	15%	29%	100%	58%	25%	91%
% of pools with "low" shelter complexity		25%	33%	33%	15%	12%	20%	na	na	33%	0%
% pools with 20% or lower shelter coverage		33%	50%	78%	46%	18%	40%	na	na	100%	0%
% pools with large woody debris as cover component		25%	58%	33%	31%	35%	60%	na	na	33%	100%
Average of % Unit with Shelter											
All Habitat Types	19%	29%	30%	23%	30%	32%	25%	6%	16%	21%	4%
Pools	0%	37%	25%	22%	29%	33%	30%	n.a.	n.a.	20%	35%*
Flatwater	5%	24%	32%	22%	35%	34%	22%	5%	16%	17%	2%

Notes: * single pool measured in Trout Creek
n.a. habitat type did not occur in stream reach

Table 7. Aptos Creek Watershed Shelter Components

							Bridge Creek	Valencia Creek			Trout Creek
			A-3	A-4	A-5	A-6	B-1		V	V-3	T-1
Frequency of Occurrence	**Number of Habitat Units**										
Undercut bank	1	11	5	7	2	8	4	4	3	4	2
Small woody debris	2	20	16	10	9	22	10	5	11	12	3
Large woody debris	0	3	10	5	6	13	8	1	5	5	3
Root mass	0	2	2	1	0	3	0	2	0	0	0
Terrestrial vegetation	3	19	7	5	8	9	4	4	7	7	0
Rooted aquatic vegetation	1	2	1	0	0	0	0	2	0	1	0
Floating aquatic vegetation	0	0	0	0	0	0	2	0	0	0	0
Surface turbulence	2	9	8	13	14	22	7	0	4	8	0
Substrate (diameter>5")	2	19	18	21	23	35	17	0	5	10	0
Bedrock ledge	0	6	5	4	11	8	4	1	2	1	1
Other	0	0	0	0	0	0	0	0	0	0	0
Total Surveyed Units	4	25	21	21	24	41	21	6	12	16	11
Areal Extent	**Percent of Total Cover Area**										
Undercut bank	0%	20%	9%	11%	1%	6%	12%	17%	9%	11%	4%
Small woody debris	7%	18%	13%	5%	9%	9%	8%	44%	36%	18%	26%
Large woody debris	0%	7%	21%	8%	8%	12%	15%	3%	20%	10%	64%
Root mass	0%	3%	4%	2%	0%	2%	0%	4%	0%	0%	0%
Terrestrial vegetation	86%	23%	3%	5%	5%	2%	4%	26%	16%	7%	0%
Rooted aquatic vegetation	5%	1%	0%	0%	0%	0%	0%	4%	0%	1%	0%
Floating aquatic vegetation	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Surface turbulence	1%	2%	7%	14%	9%	10%	4%	0%	2%	12%	0%
Substrate (diameter>5")	1%	16%	21%	45%	49%	54%	47%	0%	16%	36%	0%
Bedrock ledge	0%	10%	22%	10%	18%	5%	9%	2%	1%	5%	6%
Other	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

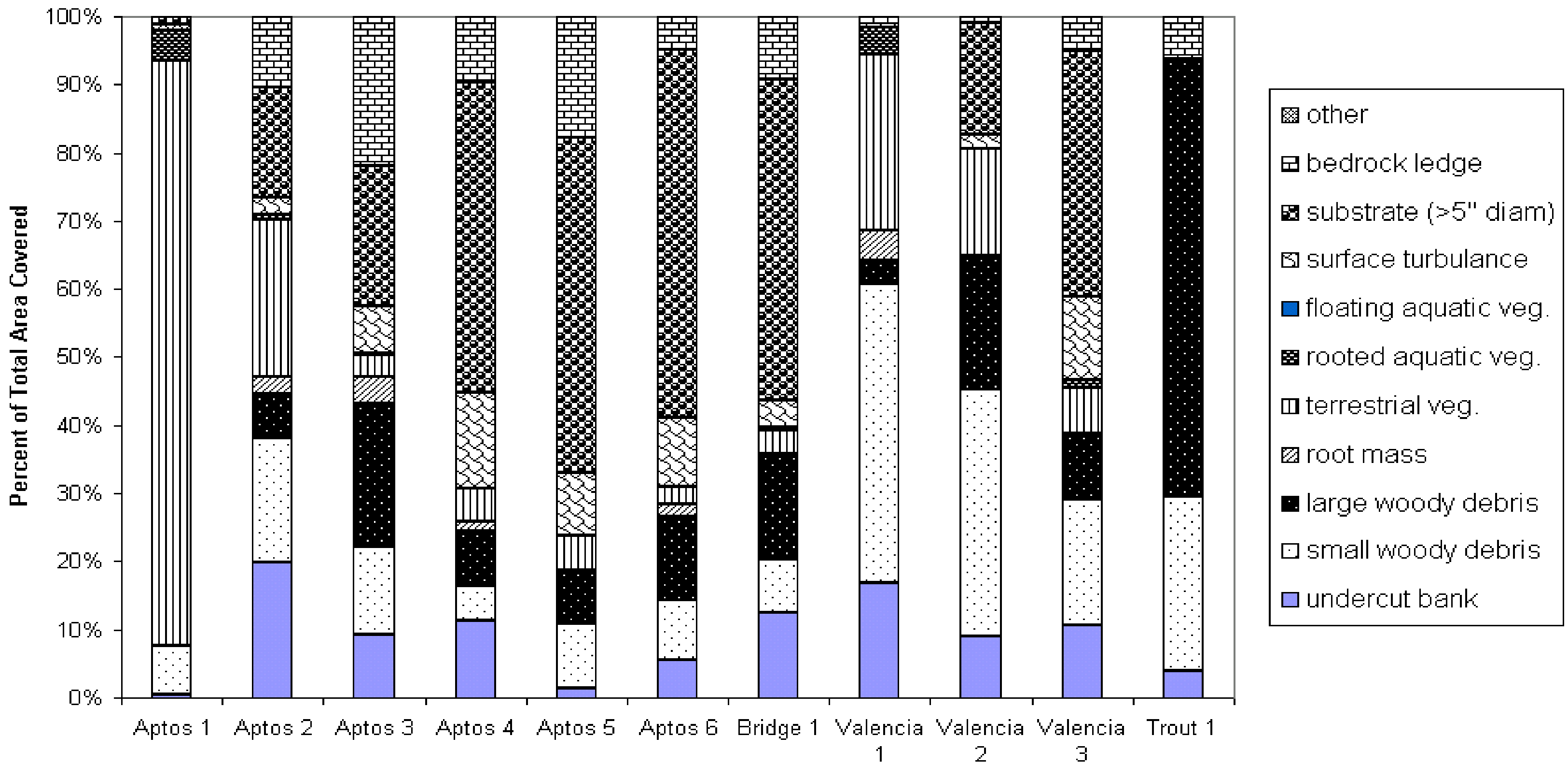


Figure 6. Shelter Components for all Habitat Types

common in the lower part of Aptos Creek while bedrock ledge, substrate roughness, and large woody debris were dominant in the upper reaches (Figure 7).

3.2.3 Substrate Condition

Substrate conditions influence spawning and egg incubation, cover for juveniles, and production of aquatic invertebrates important in the aquatic food chain. Steelhead and coho salmon rely on relatively loose, clean gravel substrate with low amounts of fine sediments for reproduction. Larger substrate such as cobbles and boulders can provide hiding areas for juveniles of many species including trout. Fine sediments (silt and sand) present in excessive amounts fill spaces between the larger substrate elements and reduce its ability to support invertebrate production, spawning, and escape cover. A number of criteria are used to describe substrate mixtures occurring in streams and assess suitability for different life stages of anadromous salmonids (Kondolf 2000). The most detailed methods involve bulk sampling of the streambed and characterization of the complete range of sediment size classes. A simpler method, and one that is more appropriate for basin-wide assessment level surveys, involves estimating cobble embeddedness. This is accomplished in habitat surveys by observing the average proportion of individual cobble size substrate that is embedded in finer material. Embeddedness is estimated both in pool tails and in other areas with suitable conditions for spawning. Fish density, particularly for juvenile trout and salmon, is generally reduced as embeddedness increases. Steelhead appear to be less sensitive than some other salmonid species. Young-of-year fish are particularly sensitive during winter and can be impacted at embeddedness levels greater than 5%-10%. Older juveniles during summer may tolerate embeddedness levels of 30%-50% without significant impacts on population density. Excessive amounts of fine sediment may also fill in pools and other deep areas and reduce their utility as habitat for adult fish.

Habitat conditions in Aptos and Bridge Creeks were influenced by high levels of sand in the substrate (Figure 8). Sand was the dominant substrate in 59% to 70% of habitat units in reaches 2 through 6 and was dominant in all units in reach 1 (downstream of the Valencia Creek confluence). Sand was the subdominant substrate in an additional 10% to 17% of habitat units in reaches 4, 5, and 6 (Figure 9). In Bridge Creek, sand was the dominant substrate in 95% of habitat units and subdominant in the other 5%.

Riffles provide important habitat for production of aquatic invertebrates and salmonid spawning areas are typically located near the head of riffles. High amounts of sand impairs both these functions. In Aptos Creek riffle habitats, sand was still the dominant substrate in reach 1, half the units in reach 2, and two-thirds of the units in Bridge Creek (Figure 10). Sand was the subdominant component in 17% to 30% of riffle habitat units in reaches 4, 5, and 6 of Aptos Creek (Figure 11). In Bridge Creek, sand was the dominant substrate in 2 of 3 riffles surveyed and was subdominant in the third.

Valencia Creek was even more heavily influenced by sand than Aptos Creek (Figure 12). Sand was the dominant substrate in 100% of habitat units in the two lower reaches (Aptos Creek to Valencia Road). Sand was also dominant in 94% of the habitat units in reach 3 (upstream of Valencia Road). As a result, there were no pools in reaches 1 and 2 and pools made up slightly less than 1% of the length of reach 3. Gravel and cobble substrate were present as dominant substrates only in reach 3, where these classes were dominant in 6% of all units and 20% of riffle units. Even in reach 3 of Valencia Creek, sand was either dominant or subdominant in 80% of the habitat units.

Trout Creek was less dominated by sand substrate than Valencia Creek but sand was still the dominant substrate in over 70% of all surveyed units and was dominant in 60% of surveyed riffle habitats. Small cobble was the dominant size class most in units where sand was not dominant.

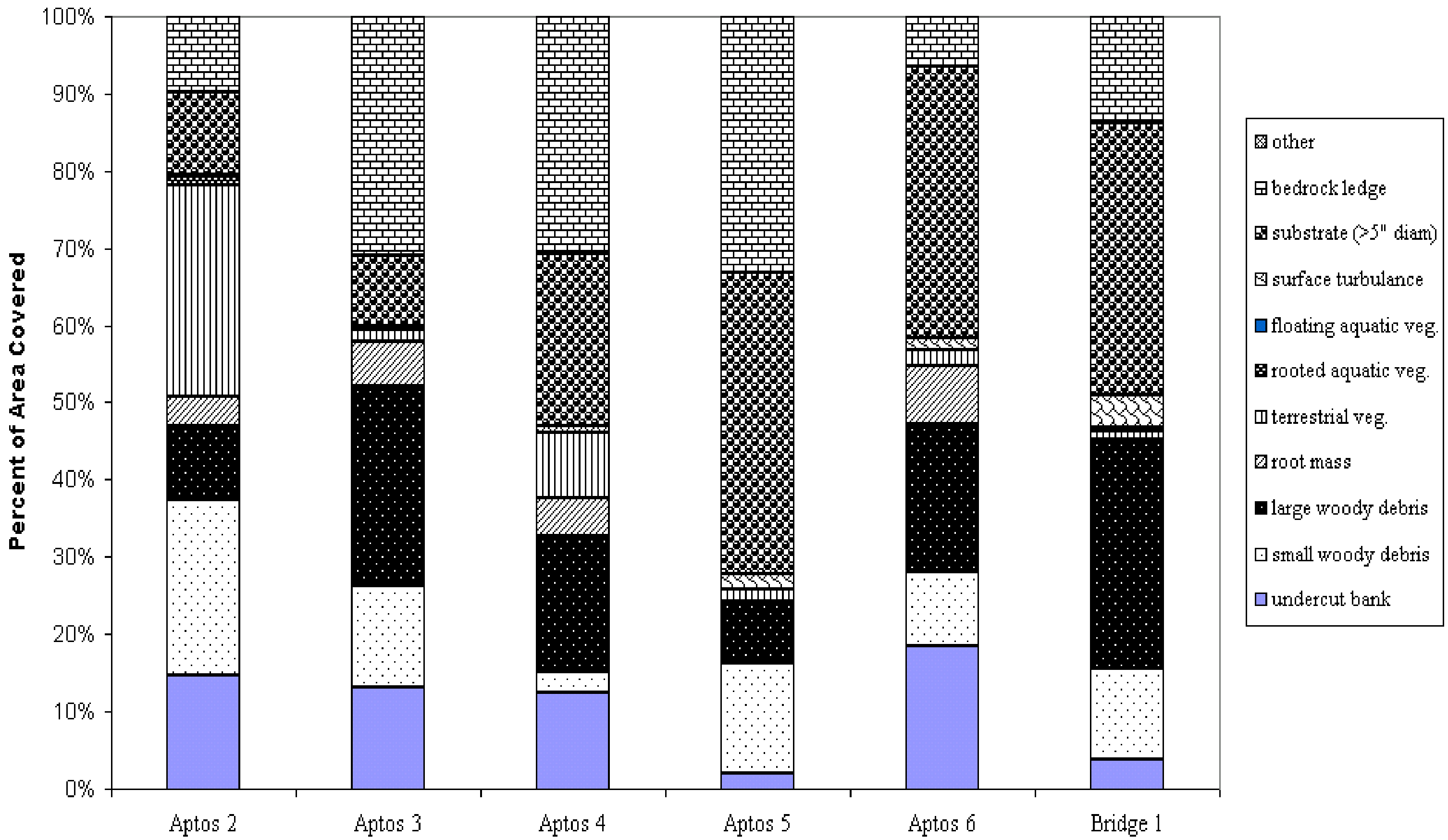


Figure 7. Shelter Components for Pool Habitat Types

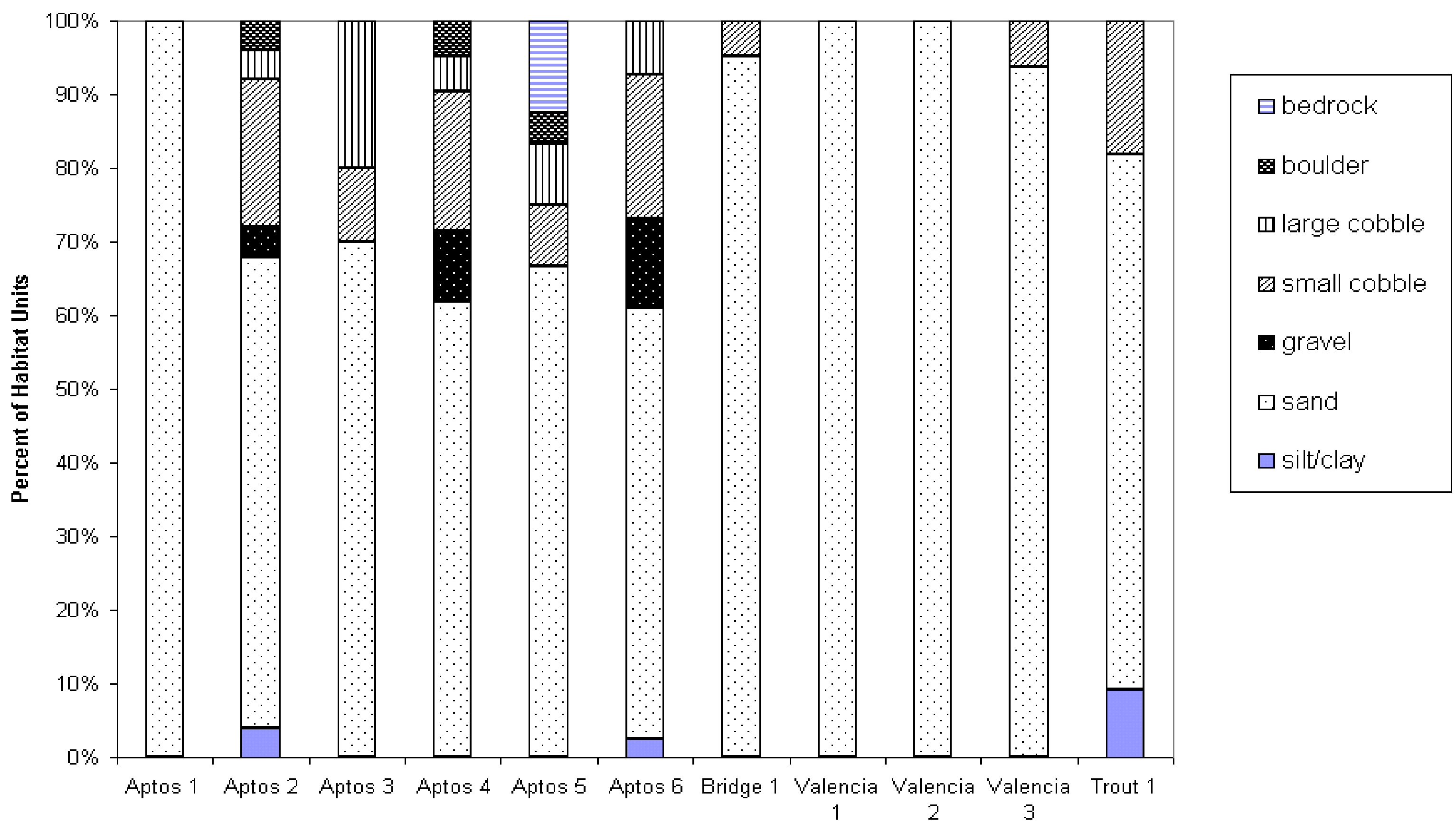


Figure 8. Dominant Substrate Composition

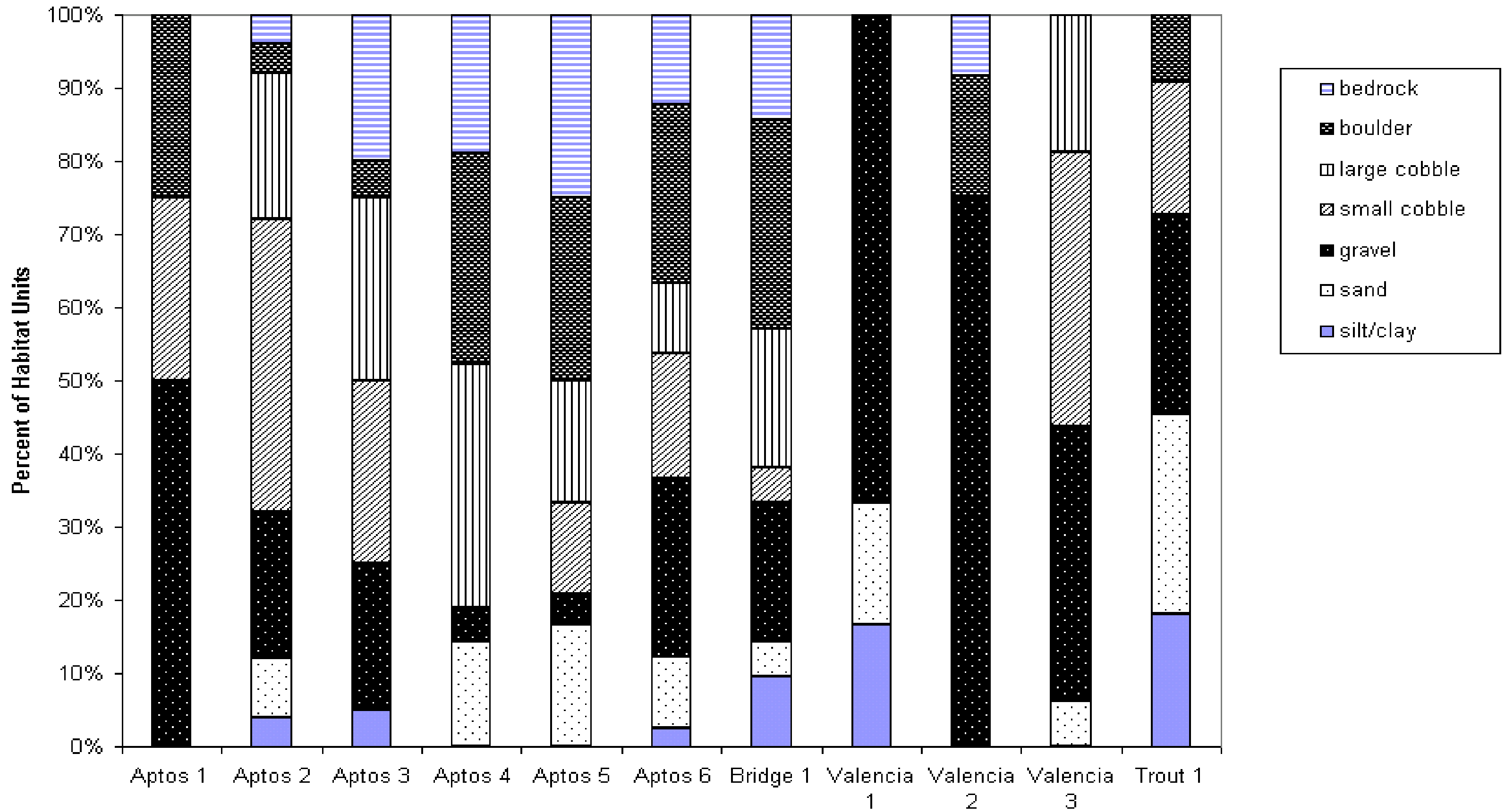


Figure 9. Subdominant Substrate Composition

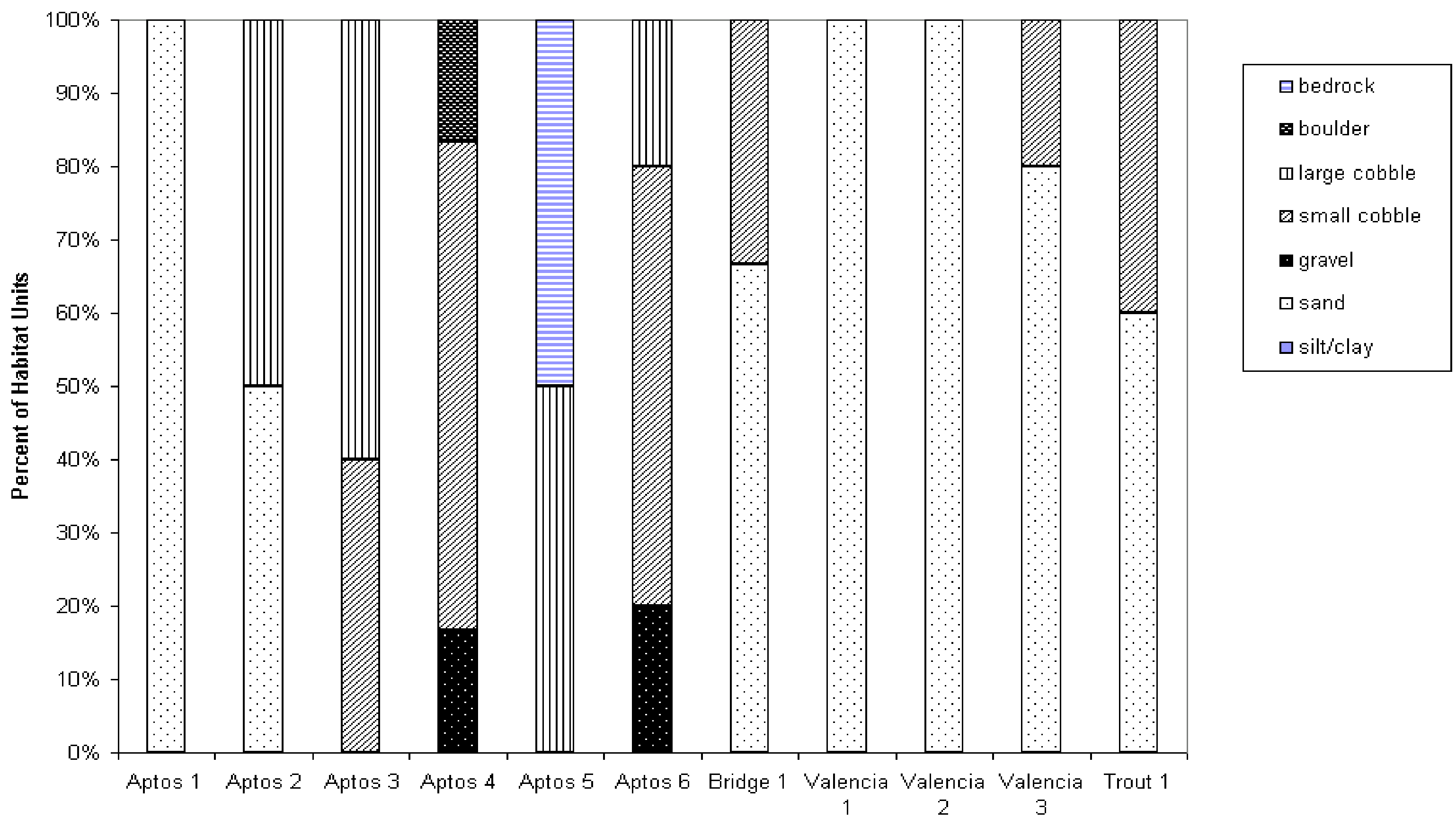


Figure 10. Dominant Substrate in Riffle Habitats

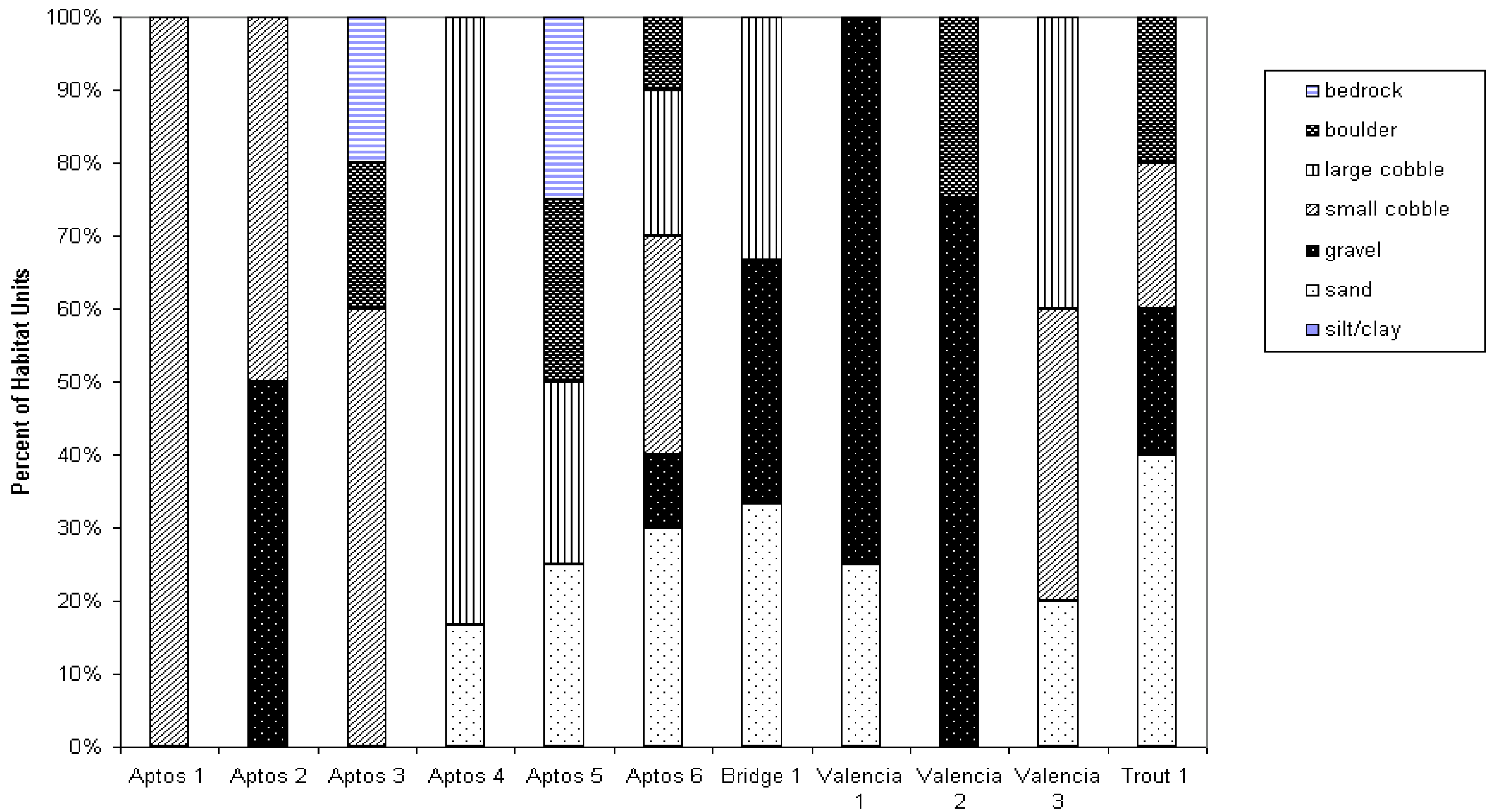


Figure 11. Subdominant Substrate in Riffle Areas

Figure 12. Riffle/Glide Habitat in Valencia Creek

Gravel was present only as a subdominant size class and was never estimated at more than 5% in any habitat unit.

Areas with suitable substrate and hydraulic conditions for spawning were relatively scarce throughout the watershed (Table 8). In Aptos Creek, reach 4 had the greatest concentration of spawning areas although reaches 2, 3, and 5 also had some areas with good spawning conditions. The low frequency of suitable spawning areas resulted primarily from high levels of sand in the substrate.

The presence of large quantities of sand was evident in the embeddedness data. In Aptos Creek, over 50% of all pool tails had embeddedness of more than 30% in reaches 2, 3, and 4 (Figure 13). Embeddedness was lower in reaches 5 and 6 with, respectively, only 36% and 33% of sampled units having embeddedness greater than 30% (Table 8). Reaches 5 and 6 also had the highest percentage of units with relatively low embeddedness ratings of 15% or lower (28% and 41% of units, respectively). In Bridge Creek, 60% of units had embeddedness of more than 30% while only 10% had embeddedness of 15% or lower. For those areas judged to provide the best conditions for spawning, embeddedness ratings were generally better than in pool tails as a group (Figure 14). The least embedded spawning areas were in reach 5 where 75% of all potential spawning areas had embeddedness of 15% or less. Only about a third of the spawning areas identified in reaches 4 and 6 had embeddedness of 15% or less. Reaches 2 and 3 also had some spawning areas with relatively low embeddedness. Although the amount of potential spawning area identified in Bridge Creek was very small (2 areas totaling only 23 square feet), embeddedness was low.

In Valencia Creek, pools were present only in reach 3, where 2 of the 3 pool tails assessed had embeddedness ratings of 30% or greater. Also, due to extensive sand substrate, areas with suitable conditions for spawning were not identified in reach 1 of Valencia Creek and were extremely limited in reaches 2 and 3. Where present, potential spawning substrate had relatively low embeddedness with the majority of areas having 15% or lower embeddedness and no areas having embeddedness greater than 50%.

No embeddedness estimates were made in Trout Creek. Embeddedness was not measured in the single pool since it was a backwater pool without a tail typical of main channel pools. There were no sites identified in the entire reach that had potential as spawning sites.

3.2.4 Bank and Canopy

Vegetation on the stream bank is intricately linked to the aquatic environment and influences it in many ways. Vegetation provides shade and moderates temperature conditions. This vegetation also serves as an important source of nutrients to the stream, both through direct input of organic matter and as a source of terrestrial insects. Aquatic productivity can be inhibited under conditions of continuous closed canopy, and the ideal condition is a moderately dense canopy (55%-85%) with occasional small openings. Terrestrial environments near the stream provide important habitat for amphibians such as frogs, salamanders, newts and reptiles such as turtles and snakes. The roots of riparian species such as alder, willow, sycamore, and redwood form networks that strengthen and retain the bank and lead to formation of scour pools and undercut banks that provide excellent instream cover for fish. As these trees age they may eventually fall into the stream and their trunks and branches alter flow patterns and provide hard structures resulting in scouring of pools. Terrestrial vegetation hanging over the stream bank also can provide useful overhead cover for fish. Basic information for canopy and riparian vegetation is provided here. More detailed information can be found in the companion Technical Memorandum describing the Riparian Overstory Description and Mapping Task.

Table 8. Substrate Characteristics by Reach

	Aptos Creek						Bridge Creek	Valencia Creek			Trout Creek
	Aptos Creek A-1	**Aptos Creek A-2**	**Aptos Creek A-3**	**Aptos Creek A-4**	**Aptos Creek A-5**	**Aptos Creek A-6**	**Bridge Creek B-1**	**Valencia Creek V-1**	**Valencia Creek V-2**	**Valencia Creek V-3**	**Trout Creek T-1**
Areas with Spawning Gravel Surveyed	0	13	9	21	16	13	2	0	4	2	0
Spawning Gravel Area (square feet)	0	260	252	455	213	138	23	0	14	7	0
Spawning Area (square feet) per 100 feet	0.0	3.6	3.0	4.4	2.3	1.7	0.4	0	0.1	0.1	0
Average spawning site size (square feet)	0	20	28	22	13	11	12	0	3.5	3.5	0
Pool Tail Embeddedness (%)	**Number of Habitat Units**										
0-15%	n.a.	8%	0%	14%	28%	41%	10%	n.a.	n.a.		n.a.
16-30%	n.a.	41%	46%	30%	36%	27%	30%	n.a.	n.a.	100%	n.a.
31-50%	n.a.	30%	49%	47%	32%	19%	40%	n.a.	n.a.		n.a.
>50%	n.a.	22%	5%	9%	4%	14%	20%	n.a.	n.a.		n.a.
Number of Pools Surveyed	0	37	39	43	47	37	20	0	0	3	0
Spawning gravel embeddedness (%)	**Number of Habitat Units**										
0-15%	n.a.	23%	11%	33%	75%	31%	100%	n.a.	75%	50%	n.a.
16-30%	n.a.	69%	89%	52%	25%	46%	0%	n.a.	25%	50%	n.a.
31-50%	n.a.	8%	0%	14%	0%	15%	0%	n.a.	0%	0%	n.a.
>50%	n.a.	0%	0%	0%	0%	8%	0%	n.a.	0%	0%	n.a.

Notes: n.a.: no pools or no spawning areas occurring in stream reach

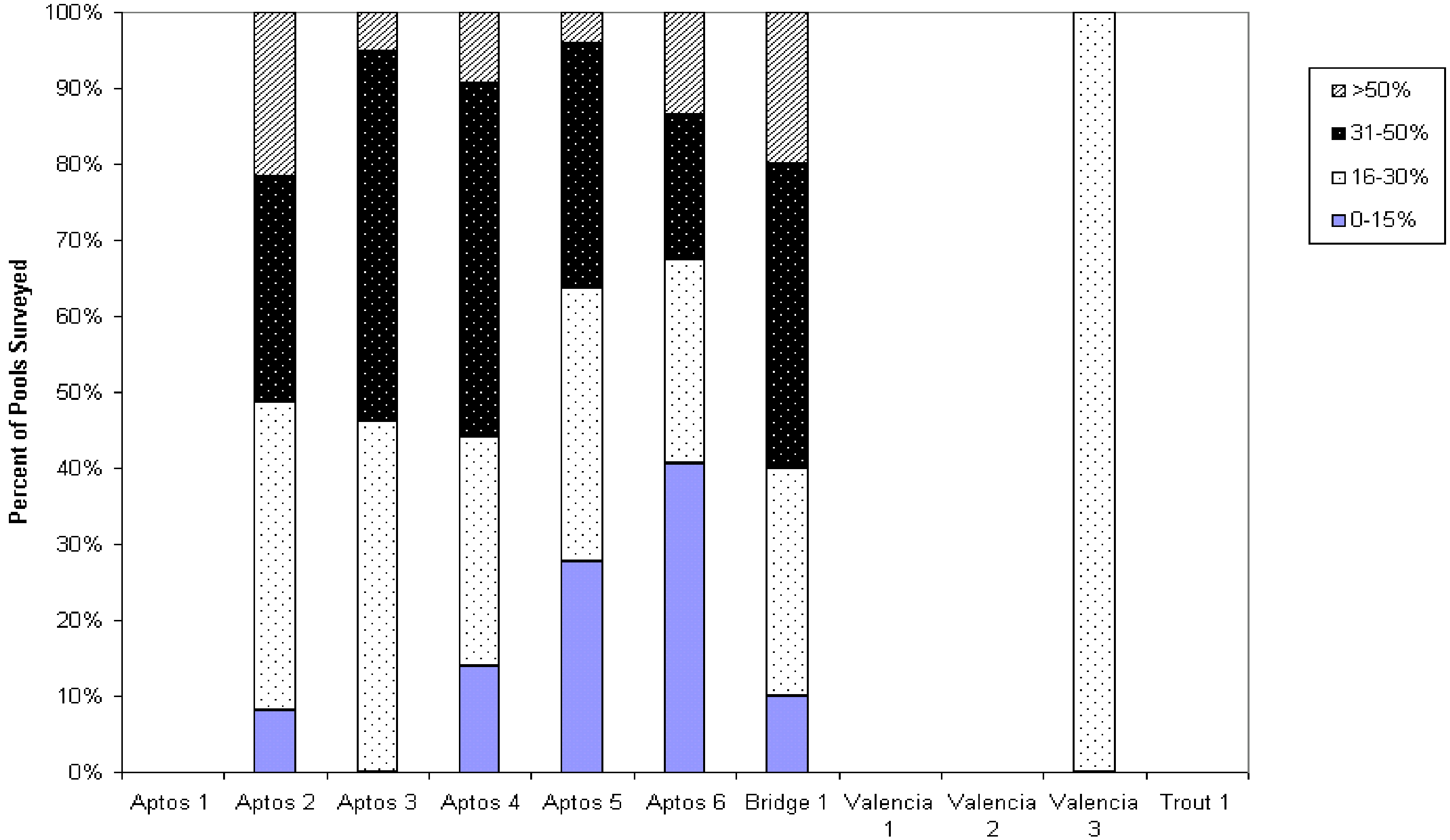


Figure 13. Pool Tail Embeddedness Ratings

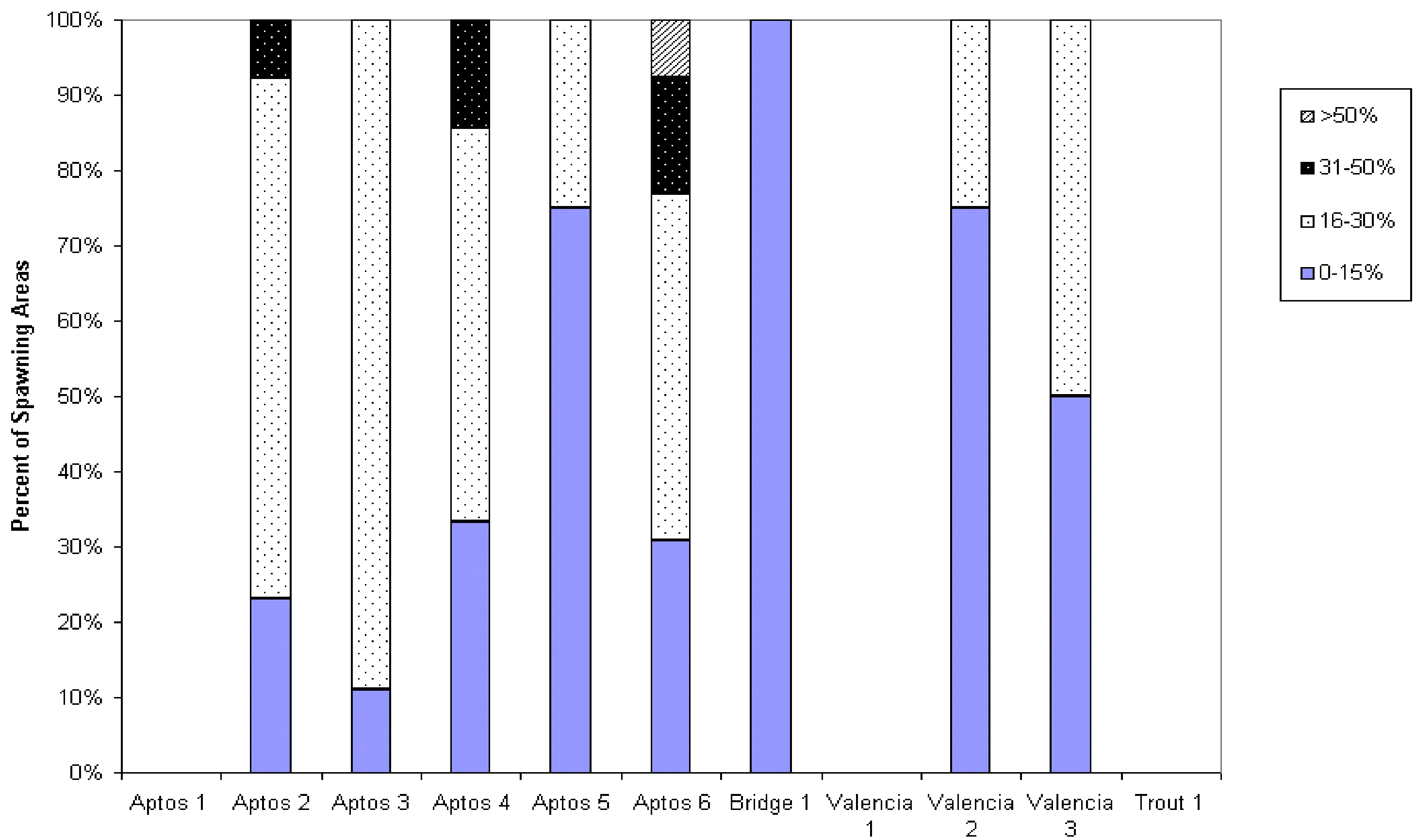


Figure 14. Spawning Area Embeddedness Ratings

Canopy was highly variable in Aptos and Bridge Creeks, ranging from 10% or less to 95% or more in each reach. No clear differences between reaches were distinguishable (Table 9). Valencia Creek had higher levels of canopy closure than Aptos and Bridge Creeks. Average canopy coverage was generally at least 60%. Habitat units with relatively open canopies were fairly well dispersed through the watershed. A more open canopy can enhance aquatic productivity and trout growth rates as long as associated temperature increase is not extreme. Most stream reaches have a generally north-south orientation, which together with topographic shading from the steep terrain, minimizes direct solar radiation.

Alder was the dominant canopy species in 50% of the habitat units in Aptos Creek and was the subdominant species in an additional 26% of habitat units (Table 9). Alder was less dominant with distance upstream in Aptos Creek and was rarely dominant in Bridge Creek. Maple, redwood, tan oak, and willow became more often dominant in upper reaches of Aptos Creek. Large woody debris was a dominant canopy component in a few units in reach 6. Redwood was the dominant species in 76% of habitat units in Bridge Creek, with maple, tan oak, and alder dominant in most of the remaining units. Alder was also the most common dominant species in Valencia Creek. Box Elder was also a common dominant species in lower Valencia Creek. Trout Creek had redwood and maple as the most common dominant species and two species, blackberry and oak, appeared as dominant species in Trout Creek but nowhere else.

3.2.5 Temperature

Temperature determines the distribution of many native fish species and of salmonids in particular. Stream temperature generally fluctuates on a daily basis in parallel with air temperature and reaches maximum levels in streams of Central California in July and August. Temperature becomes lethal for both steelhead and coho as it approaches and exceeds about 25°C (77°F). Though there is much variation, temperatures below 18°C (64°F) are generally regarded as optimum for rearing steelhead although temperatures up to 21°C (70°F) may be suitable if food is sufficiently abundant. For coho salmon, optimum temperature is commonly cited in the range of 11°C to 15°C (52°F-59°F) and extended periods with temperatures exceeding 18°C (64°F) may significantly limit coho populations.

Temperature monitoring was not conducted as part of this study. Temperature grab samples ranged from 13°C to 15°C (55°F-59°F) in Aptos Creek during surveys in late August, and 12°C to 15°C (54°F-59°F) in Valencia Creek in early October (air temperature ranged up to 20.5°C (69°F) in August and 23°C (73°F) in October). Temperature data have been collected by Coastal Watershed Council and CDFG during 1999 and 2000. These data indicate that peak temperature in Aptos Creek almost never exceeds 18°C (65°F). Temperature monitoring by CDFG in 1999 (Nelson, 2000) indicated temperatures in Aptos Creek near George's Picnic Area exceeded 15°C (55°F) 36% of the time between July 22 and November but never exceeded 17.8°C (64.1°F). At a more upstream monitoring location temperature exceeded 15°C (59°F) 55% of the time with a maximum of 18.9°C (66.1°F). Data collected by CDFG indicate that temperature conditions in Aptos Creek in 1999 were comparable to other Central Coast streams supporting coho salmon including Waddell Creek and Scott Creek.

3.2.6 Barriers to Fish Movement

Full levels of production for anadromous salmonids in Central California coastal streams relies on the ability of adult steelhead to enter the streams and easily access spawning and rearing habitat in the upper reaches and for smolts to return to the ocean. Even obstacles that are not complete barriers can impair populations by delaying migration rates and exposing fish to potential predation or poaching. Instream movement of rearing juveniles may also be important.

Table 9. Canopy Characteristics by Reach

	Aptos Creek						Bridge Creek	Valencia Creek			Trout Creek
	A-1	A-2			A-5		B-1	V-1	V-2		T-1
Average canopy (percent)	68%	60%	61%	67%	56%	64%	48%	70%	70%	72%	66%
Maximum canopy (percent)	90%	95%	95%	95%	95%	95%	98%	85%	95%	95%	95%
Minimum canopy (percent)	50%	5%	0%	10%	10%	5%	5%	45%	25%	10%	0%
% of units with 55-85% canopy	50%	40%	41%	42%	47%	46%	36%	82%	64%	48%	47%
Dominant Canopy Species	**Number of Habitat Units**										
Alder	3	33	20	29	17	30	2	8	9	19	3
Blackberry	0	0	0	0	0	0	0	0	0	0	1
Box elder	0	0	0	0	0	0	0	2	1	0	0
Dogwood	0	1	0	0	0	0	0	0	0	0	0
Large woody debris	0	1	2	0	3	8	2	0	2	1	0
Maple	0	3	5	6	8	17	3	0	8	6	4
Oak	0	0	0	0	0	0	0	0	0	0	2
Redwood	0	2	4	5	12	9	38	0	7	10	7
Sycamore	0	1	0	0	0	0	0	0	0	0	0
Tan oak	0	1	8	8	11	4	3	1	6	9	1
Willow	1	6	1	0	0	4	1	0	1	1	0
Witch hazel	0	0	0	0	0	0	1	0	0	0	0
Total Surveyed Units	4	48	40	48	51	72	50	11	34	46	18

Rearing juveniles need to disperse from spawning areas to rearing habitat. Young trout prefer shallower glide and riffle areas in or near relatively swift current but as they mature they move to deeper habitats. In some streams, seasonal movement may be important to avoid sections that go dry during summer months. Extreme events may eliminate fish from sections of stream. During droughts some sections may go dry. Individuals may move into small tributaries or to lower gradient reaches during extreme high flows. Episodes of poor water quality conditions may eliminate fish from a section of stream. In these cases dispersal from refuge areas is required to re-populate the stream. If the only refuge areas are downstream, barriers may result in failure of re-colonization and loss of fish populations from otherwise suitable habitat upstream. The following sections detail migration obstacles in each of the surveyed stream reaches.

3.2.6.1 Aptos Creek Mainstem

There are no significant obstacles to migration of adult steelhead and coho salmon in the lower five reaches of Aptos Creek, although there are three locations where adult upstream migration may be impaired at lower levels of flow (Table 10, Figure 15). The first of these is immediately upstream of Spreckels Road and consists of a concrete weir spanning the creek (Figure 16). At the time of the survey the weir rose about 1.5 feet above the downstream water surface with a relatively shallow depth of flow up to about 1 foot deep immediately downstream of the weir. It is expected that the loose sand substrate would be scoured out from below the weir at higher flows, forming a deeper pool from which fish could leap over the weir. This condition was observed on December 12, 2001 when a pool up to 4 feet deep had been scoured below the weir. In addition, observations on October 1, 2001 indicated that at higher lagoon stages (0.85 on SH&G lagoon staff gage), the water surface backs up over the weir and eliminates any barrier effect (photos available). Upstream of the weir the sandy channel is wide and uniformly shallow for a long distance upstream (a few hundred feet).

The other two locations in Aptos Creek, reaches 1-5, where adult passage may be impaired are caused by accumulations of large woody debris (LDAs) and these did not appear to present significant obstacles to passage of healthy adult steelhead or coho. The first had an elevation change of only about 2.5 feet and at higher flows this would be reduced. An unobstructed side channel was also available that would likely provide passage at higher flows. The second LDA had a more substantial elevation change of about 5.5 feet but there was relatively good flow under the debris and adults would likely be able to pass through the jam at moderate flows.

Upstream of Reach 5, LDAs increase in frequency (Figure 15). Some of these accumulations likely shift under varying flow conditions and may become more or less of an obstacle at different times. They are also transient in that new accumulations form and old ones break up over time although the lifespan of any given LDA is not known. It is very difficult to be sure whether these debris accumulations form a barrier to migration or under what flow conditions a given LDA may become passable (Figure 17). Due to the increasing frequency of LDAs, we believe that the upper limit of anadromy in Aptos Creek is somewhere within Reach 6 and possibly is quite low in the reach. The first LDA encountered, at the break from reach 5 to reach 6 appeared to be a relatively significant obstacle at the time of the survey. It had an overall drop of about 6 feet without apparent passage through any side channel. Although a migrating adult may be able to pass some of these obstacles, or pass many of them under ideal flow conditions, their cumulative effect is likely to severely limit the frequency of access to upper parts of the reach and reduce the number of individuals that can successfully pass. It is perhaps significant that the density of young-of-year steelhead dropped off fairly sharply after the first significant LDA, at the break between reach 5 and 6 (Figure 18).

Table 10. Potential Migration Barriers

Stream Reach	Location	Survey Date	Habitat Unit Number	Survey Distance (feet)	Photo #	Type	Barrier Degree Adult	Degree Upstream Juvenile
A-1	N 36° 58.414" W 121° 54.226'	28-Aug-01	2	1012	7	Weir	Low Flow	Most Flows
A-3	N 36° 59.378" W 121° 54.462'	27-Aug-01	107	9420	18	LDA	Low Flow	Most Flows
A-5	N 37° 01.908' W 121° 53.453'	30-Aug-01	396	34324	24,1	LDA	Low Flow	No Obstruction
A-5	N 37° 01.876' W 121° 53.315'	30-Aug-01	410	35486	2	LDA	Most Flows	Near Complete
A-6		30-Aug-01	414	35699		LDA	Low Flow	Low Flow
A-6	N 37° 01.848' W 121° 53.175'	30-Aug-01	426	36260	3	LDA	Undetermined	Undetermined
A-6	N 37° 01.851' W 121° 53.000'	30-Aug-01	438	37235	4	LDA	Low Flow	No Obstruction
A-6	N 37° 01.841' W 121° 53.023'	3-Oct-01	439	37257		LDA	No Obstruction	No Obstruction
A-6		3-Oct-01	470	39350	21	LDA	Low Flow	No Obstruction
A-6	N 37° 02.070' W 121° 52.691'	3-Oct-01	478	39724	23,24	LDA	Near Complete	Near Complete
A-6		7-Oct-01	484	40220		LDA	Low Flow	Low Flow
A-6		7-Oct-01	518	41699	3	LDA	Low Flow	Low Flow
A-6	N 37° 02.411' W 121° 52.291'	7-Oct-01	520	41767	4	LDA	Low Flow	Low Flow
A-6		7-Oct-01	522	41891	5	LDA	Low Flow	Most Flows
A-6		7-Oct-01	544	42936	6	Cascade	Most Flows	Most Flows
A-6	N 37° 02.622' W 121° 52.156'	7-Oct-01	554	43356		LDA	Most Flows	Near Complete

Table 10. Potential Migration Barriers (continued)

Stream Reach	Location	Survey Date	Habitat Unit Number	Survey Distance (feet)	Photo #	Type	Barrier Degree Adult	Degree Upstream Juvenile
B-1	N 37° 01.860' W 121° 54.095'	5-Oct-01	11	711	12,13	LDA	Low Flow	Most Flows
B-1		5-Oct-01	24	1,544	15,16	LDA	Most Flows	Most Flows
B-1		5-Oct-01	33	1,895	17	Cascade	Low Flow	Most Flows
B-1		5-Oct-01	40	2,203	18	Cascade	Low Flow	Most Flows
B-1		5-Oct-01	74	3,778	22	LDA	Complete	Complete
V-1		1-Oct-01	2	70	3,4,5	Culvert	Low Flow	Low Flow
V-1		1-Oct-01	6	1108	7,8	Culvert	Low Flow	Low Flow
V-1		1-Oct-01	8	1512	9,10,11	Culvert	Most Flows	Most Flows
V-2		1-Oct-01	2	5724	18	Cascade	Low Flow	Most Flows
V-2	N 36° 58.733' W 122° 53.116'	1-Oct-01	7	6818	21	LDA	Low Flow	Most Flows
V-2	N 36° 58.900' W 121° 52.693'	1-Oct-01	28	10405	3	LDA	Low Flow	Most Flows
V-3	N 36° 59.881' W 121° 52.142'	2-Oct-01	1	20577	8,9	Culvert	Low Flow	Low Flow
V-3	N 37° 00.739' W 121° 52.457'	2-Oct-01	84	26883	14	LDA	most Flows/complete	Most Flows/complete
M-1		4-Oct-01	4/5	679	6		Complete	Complete
M-1	N 36° 58.971' W 121° 54.093'	4-Oct-01	11	1190	9		Complete	Complete

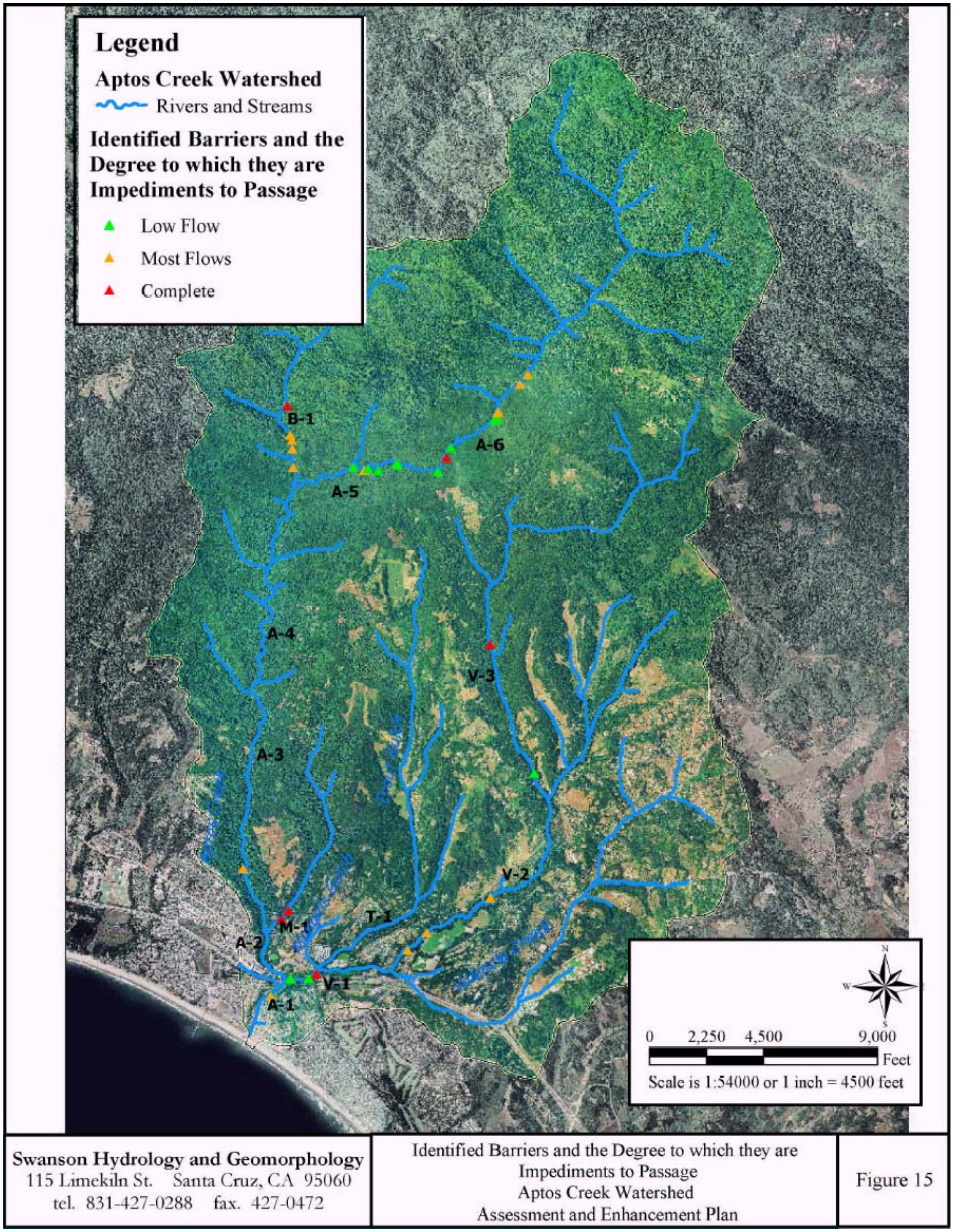


Figure 15. Identified Passage Barriers

Figure 16. Weir at Spreckels Road

Figure 17. Large Debris Accumulation (LDA), Upper Aptos Creek

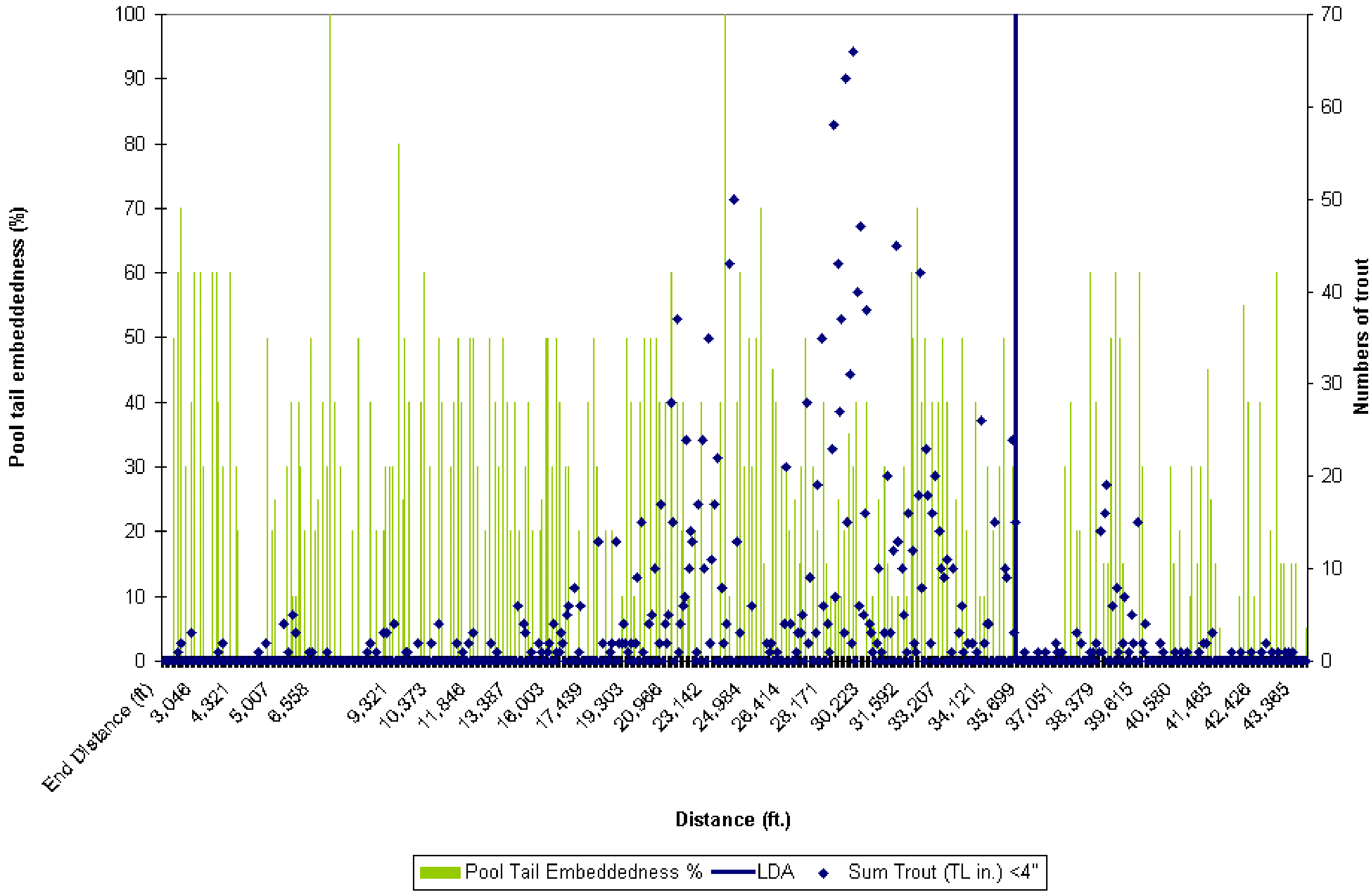


Figure 18. Aptos Creek Pool Tail Embeddedness and Distance

3.2.6.2 *Bridge Creek*

There were a total of 5 passage obstacles in the lower 3/4 mile of Bridge Creek. The first four, two LDAs and two cascades, were likely only obstacles to passage of adult steelhead or coho during low flow conditions. The last, an LDA, was judged to be a complete barrier for upstream migration of both adults and juveniles. This final LDA had a drop of about 6 feet with sediment filling the upstream channel and no jump pool below. There was no flow through the LDA at the time of the survey as the entire flow of the creek (estimated at 0.5 cfs to 1.5 cfs) seeped into the sediment accumulated upstream. This barrier was located about 3,778 feet (0.72 mile) upstream from the Aptos Creek confluence. Juvenile trout were seen up to the barrier but none were seen upstream of it. Also of interest, Pacific giant salamander were not seen below this barrier but became common immediately upstream. On the other hand, foothill yellow-legged frog were seen both above and below this point.

3.2.6.3 *Valencia Creek Mainstem*

A total of eight passage obstacles were identified in Valencia Creek, four of which were culverts (Table 10). The first three obstacles, all culverts, occurred within the lower quarter mile of the Creek. The first two culverts presented low to moderate passage difficulty (Figure 19). They were about 240 feet and 180 feet in length, 10 feet in width, and had gradients between 1% and 2%. Both were fitted with a baffle system on one side, presumably to aid fish passage, but most of the baffle sections had filled with sediment and debris, rendering the systems useless. Both culverts are likely passable at moderate and higher flow levels. The third culvert, at Soquel Drive, is a more significant barrier and probably precludes upstream migration of adult steelhead or coho at most flow levels (Figure 20). Although the interior of the culvert is fitted with a baffle system similar to the lower two culverts, the lower end of the culvert is perched approximately 4 feet above the downstream bed. There was no pool below the culvert at the time of the survey but it is likely that scour forms one during higher flow conditions. This culvert has been considered for remediation. Swanson Hydrology and Geomorphology has developed designs to ladder the lower end of the culvert and remove the baffles.

Three natural obstacles in reach 2, including a 3-foot cascade and two debris jams, present relatively minor obstacles to adults but probably prevent upstream movement of juveniles under a wide range of flows.

The seventh obstacle in Valencia Creek is the culvert at Valencia Road, approximately 3.4 miles upstream from the Aptos Creek confluence (Figure 21). Although fitted with baffles to improve the potential for migration, the culvert is quite steep (gradient of about 4%) and the lower end is perched about 2 feet above the stream bed. Since this culvert is fairly high in the watershed, flows sufficient for passage may be relatively infrequent. The culvert was recently evaluated using FishXing analytical methods and software. Coastal Watershed Council staff observed a 6-8 inch trout enter this culvert and swim part way through it using the baffle system in early November 2002 (Maya Conrad, Coastal Watershed Council, personal communication, January 2003).

The final obstacle recorded in Valencia Creek is a large debris jam about 1.2 miles upstream from the Valencia Road crossing. The debris jam is sufficiently large and complex that it was judged to prevent upstream migration of both adults and juveniles at most, if not all, flow levels. This jam would likely limit anadromous fish in most years.

Figure 19. First Valencia Creek Culvert

Figure 20. Third Valencia Creek Culvert

Figure 21. Fourth Valencia Creek Culvert, at Valencia Road

3.2.6.4 Trout Creek

No significant obstacles to migration were identified in Trout Creek in the lower 1.3 miles that were surveyed.

3.2.6.5 Mangels Gulch

Two complete barriers to upstream migration of adults and juveniles were identified in the lower part of Mangels Gulch. The first was a 13 foot cascade with associated debris jam located approximately 680 feet upstream from the Aptos Creek confluence. The second was the culvert under Aptos Creek Road that was perched about 5.5 feet above the streambed with no plunge pool below.

4.0 Assessment of Limiting Factors

Populations are always limited in abundance or distribution by some factor, even in pristine systems. When one limit is removed or overcome, another will eventually have an effect. More than one factor may act simultaneously. Limiting factors differ by species, life stage, geographic location, and over time. This assessment focuses on the factor or factors that are most likely to limit steelhead and coho salmon production in the Aptos Creek watershed and which are subject to some type of remediation.

Steelhead and coho salmon populations are generally depressed along the California Central Coast. A logical approach to restoring populations would involve determination of factors that limit a given population so that restoration funds can be most efficiently focused on those factors that are likely to make a difference to a given population. Often important limiting factors are readily apparent (e.g., barriers). In other cases they are more obscure. Given natural variability in environmental conditions and the complexity of steelhead life history, collecting sufficient data to conclusively identify limiting factors is an intimidating proposition. Alternatively, potentially limiting factors must be deduced from careful observation of key habitat features and is best combined with population structure and abundance information.

Common factors that limit production of steelhead and salmon in Central California coastal streams typically include migration obstacles that limit or preclude access to suitable habitat; excessive stream temperature that eliminates rearing potential or truncates migration periods; seasonal elimination of rearing or migration habitat through loss or reduction of stream flow during key periods; reduction of rearing capacity due to lack of instream cover; reduction in recruitment and rearing success due to excessive fine sediment accumulations; excessive mortality due to toxic water quality episodes (gasoline spills, waste disposal, swimming pool discharges, etc.); diminished spawning success due to human disturbance; and reduction in spawning populations due to excessive legal or illegal harvest.

Although challenging to implement, the greatest potential for increasing production of steelhead in the watershed would come from improvements in Valencia Creek since it appears to have experienced far greater decline in productivity than Aptos Creek (Section 1.0). The factors believed to be most limiting in the Aptos Creek watershed are presented in Table 11 and discussed in the following sections. Aptos Creek is in relatively good shape due to the protected status of much of its watershed although improvement in habitat conditions could certainly lead to increased production there as well.

Table 11. Limiting Factors

Stream Reach	Primary Limiting Factor	Secondary Limiting Factors
A-1	Sediment	Rearing cover
A-2	Sediment	Rearing cover
A-3	Sediment	Rearing cover
A-4	Sediment	Rearing cover
A-5	Sediment	Rearing cover
A-6	Adult migration access	Sediment
B-1	Sediment	Adult migration access
V-1	Sediment	Adult migration access
V-2	Adult migration access	Sediment
V-3	Adult migration access	Sediment, low stream flow
Mangels Creek	Lack of summer flow	
Trout Creek	Sediment	Adult migration access, low stream flow

4.1 Migration Obstacles

Migration obstacles may limit use of Bridge Creek by steelhead and may limit the ability of steelhead to access upper reaches of Aptos Creek (upstream of reach 5). Migration obstacles in both Bridge Creek and upper reaches of Aptos Creek are caused either by logjams or cascades that, except for possible continuing influence of past timber harvests, are natural in origin. The degree to which any of these obstacles impairs migration is not certain. Although some appear to present more difficult passage than others and a few appear to preclude passage under most conditions, it is likely that they shift over time and therefore present temporary obstacles. The best evidence that these are migration barriers is the low abundance of young-of-year steelhead trout upstream of the log jam defining the break between reach 5 and 6 in Aptos Creek and the absence of any trout upstream of the last recorded log jam in Bridge Creek. A more thorough evaluation, under higher flow conditions, would be needed to more completely assess these obstacles. In any case, they are not likely the primary limiting factors in Aptos or Bridge Creeks.

Migration obstacles are a potentially significant limiting factor in the Valencia Creek watershed. The four mainstem culverts all limit to varying degrees the ability of adult steelhead to access spawning areas and the free movement of juvenile steelhead within rearing areas. Three of the culverts, including one that is probably impassable under most flows, are in the lowest part of the watershed and therefore influence a large proportion of potentially useable habitat. Two of these have been evaluated by Santa Cruz County. Both the culvert under Soquel Drive and the culvert under Valencia Road failed to meet passage criteria for all species of adult salmonids and all age classes of juveniles under all flow conditions (Ross Taylor and Associates 2003). Other obstacles, described in preceding sections, are not likely to form complete barriers to migration of steelhead, rather they act by reducing the periods of time when passage is possible. Although they are a primary limiting factor, removal of barriers in Valencia Creek may have limited benefits for steelhead use of the watershed since significant sediment problems also exist (see below).

4.2 Temperature

Based on CDFG monitoring, temperature does not appear to be a limiting factor for either steelhead or coho in Aptos Creek (see earlier discussion of temperature tolerance). Although maximum observed temperatures approached a level at which growth rates of coho may decline, this likely only occurs during brief periods on the warmest days. Temperature was within the optimum range for coho during part of each day on all but a few days. Based on observed similarities in temperature during the habitat survey, this conclusion can probably be extended to Bridge Creek and Valencia Creek as well.

4.3 Stream Flow

The magnitude of streamflow is important to rearing salmonids since greater levels of streamflow may increase the area of riffles and production of food organisms, increase the transport of these organisms to areas of the stream inhabited by rearing trout, and for sediment transport and channel forming processes. In upper stream reaches, drainage area decreases, and the level of streamflow becomes insufficient to create deeper water habitat for rearing juvenile trout and salmon or for adults to access these areas to spawn. During summer months conditions become particularly critical with some reaches becoming intermittent or dry. The Aptos and Bridge Creek watersheds are almost completely protected from development and have no significant diversions. Hydrographs within these reaches would be considered unimpaired. Other stream reaches in the basin, including Valencia Creek, Trout Creek, and Mangels Gulch have hydrographs that have been altered by development within the watersheds including water diversions and altered runoff patterns.

Habitat surveys indicated that summer flows appear to be non-existent in Mangels Gulch and this condition is the primary factor limiting steelhead. Although some spawning may occur in tributary streams that dry in summer, with juveniles moving to the mainstem to rear, the substrate in Mangels Creek is dominated by sand and is not suitable for spawning.

Trout Creek also had very low flow during the habitat survey and the channel was dry in some areas. Although the extensive deposits of sand substrate in the channel are probably the primary limiting factor in Trout Creek, low stream flow would be considered an important secondary factor. No trout were observed in Trout Creek. Access to Trout Creek is limited by the three lower culverts in Valencia Creek; however even if access was not a problem, sediment conditions would still preclude use by steelhead or coho.

Low streamflows and narrow, shallow channel conditions were also observed in Valencia Creek, particularly upstream of the Valencia Road culvert. Although trout were present in this reach, their abundance is likely limited by the low streamflow levels although this is probably secondary importance to the high amounts of sand sediment and access issues.

4.4 Rearing Capacity

In Aptos Creek there is abundant habitat for steelhead in their first year of growth in both flatwater and pool habitat types. There is also a significant amount of deep pool habitat available for older trout; however, much of this habitat may be of limited value due to the relative scarcity of food producing riffle habitat. The extent to which riffle habitat limits smolt production would depend on the degree to which juvenile steelhead may use other food sources such as terrestrial insects. Since available abundance data indicates relatively good density of 1+ and older steelhead in Aptos Creek, particularly in the upper reaches, there may not be significant food limitations. Better information on abundance and habitat utilization by 1+ and older fish would be needed to fully evaluate this issue.

Habitat surveys indicated that most reaches of Aptos and Bridge Creeks have shelter conditions that are generally within the range consistent with good steelhead production in comparable streams, although the extent and complexity are at the low end of the range. Pool habitats are quite frequent and generally provide good depth conditions. Much of the pool habitat, particularly in Aptos Creek, is in bedrock formed pools. These pools do not develop extensive undercut banks and do not recruit large woody debris to the same extent as habitats with softer banks. Rearing juvenile trout may be less susceptible to predation if cover was more extensive. The best way to determine whether rearing habitat is limiting for older trout would be to quantitatively assess densities and growth rates of young-of-year and older trout and compare them to other streams. Although steelhead population assessment was not conducted as part of this survey, visual observations and results of previous surveys indicate that both young-of-year and 2nd year and older steelhead/rainbow trout are distributed throughout Aptos Creek and are reasonably abundant.

In many coastal streams, lagoons at the stream mouth can provide important rearing habitat. Lagoons can provide conditions that support rearing of large numbers of juvenile salmonids (Smith 1990, Hagar Environmental Science 2002). Growth rates in lagoons can exceed that in tributary streams and steelhead can reach smolt size in a single season rather than the two years or more it would take in stream habitats (Smith 1990). The Aptos Creek lagoon is compromised in its ability to support steelhead and coho salmon in some important ways. First, it has been reduced in size and compressed between vertical concrete walls for much of its length. It is also enriched by undetermined but presumably unnatural nutrient loading (see companion Water Quality Technical Report). Artificial breaching of the lagoon during summer months can lead to conditions that are unsuitable for salmonid juveniles. The degree to which rearing steelhead use the lagoon has not been the subject of any concerted studies and the importance of lagoon rearing for sustaining steelhead runs in Aptos Creek is unknown. Although, water quality monitoring conducted during the course of this study indicated that there may be suitable habitat in the lagoon for rearing juveniles, it could likely be greatly improved by identifying and controlling sources of nutrient enrichment and other pollutants, controlling artificial breaching, and restoring more natural bank conditions.

4.5 *Sediment*

Sediment is likely the major factor limiting salmonid production on both a watershed and individual reach scale. Evidence from past sampling indicates that Valencia Creek has had higher densities of rearing trout and lower levels of fine sediments than currently occur and that conditions changed relatively dramatically after sediment deposition during the high flow winter of 1982. Production of trout in Valencia may be reduced by an order of magnitude relative to Aptos Creek since surveys were last conducted in 1981. The greatest increase in steelhead production on a watershed scale would come from restoring the greatly diminished productive capacity of Valencia Creek. Available evidence indicates that, while both Aptos and Valencia Creeks have high rates of sediment loading, Aptos Creek appears to be better able to flush out fine sediments and recover from extreme events. Valencia Creek, perhaps due to high rates of anthropogenic sediment mobilization and altered hydrology due to increased impermeable surfaces from development in the watershed, appears to accumulate fine sediment and recovers very slowly (see companion Geomorphology Technical Report).

Fine sediments also likely diminish the productive capacity of Aptos and Bridge Creeks though not to the same degree as in Valencia Creek. Abundance of young-of-year steelhead was highest in Aptos Creek in reach 5 where the most extensive areas of low embeddedness also occurred (Figures 18 and 22a-c). Densities of young-of-year steelhead were also relatively high in reach 4 and reach 6 but were lowest in reaches 2 and 3 where embeddedness estimates were generally higher (Table 12). Although substrate conditions were better in reach 6 than in reach 5, most of reach 6 was probably not accessible to steelhead and this may be why visual observations of young-of-year trout were much lower in reach 6.

Both young-of-year and older trout were observed in reaches 2 and 3 of Valencia Creek although abundance was relatively low (Table 12). Density estimates for young-of-year were highest in reach 2, downstream of the Valencia Road culvert, where they were comparable to reach 3 of Aptos Creek. As in Aptos Creek, abundance of young-of-year steelhead in Valencia Creek was greatest in areas where spawning areas were observed and where embeddedness ratings were lowest. No trout were seen in Trout Creek and this corresponded to some of the highest levels of fine sediments observed.

Any increase in sediment loading in Aptos Creek has the potential to reduce steelhead productivity and, in the worst case, could induce a threshold response resulting in dramatic declines in the capacity of the watershed to support steelhead such as has apparently occurred in Valencia Creek.

4.6 *Water Quality*

Water quality issues are a potential concern in the lower, more urbanized parts of the watershed due to contamination from pesticides, herbicides, fertilizers, paint, oil and gas, chlorine from swimming pools and spas, sewage, and other contaminants. More remote parts of the watershed may be subject to contamination related to illegal activities such as methamphetamine production and marijuana cultivation (rat poisons, etc.). Although no obvious water quality problems were identified during the habitat survey, there was a section of Aptos Creek downstream of Mangels Gulch where no fish were observed. Contamination from sources indicated above would tend to be episodic and difficult to detect.

4.7 Disturbance

Nisene Marks State Park is intensively used by recreationists including runners, mountain bikers, and hikers. Most of Aptos Creek within the Park is accessible to Park users. In the lower part of the Park, trails run along and across the creek in several places. Road crossings also occur at two locations. Creek crossings are frequently at pool/riffle transitions in areas suitable for spawning steelhead and coho salmon. Use of crossings by hikers and bikers could disturb spawning activity and damage eggs and pre-emergent fry in the substrate. Hiking off trail, in or along the creek, could also disturb spawning activity.

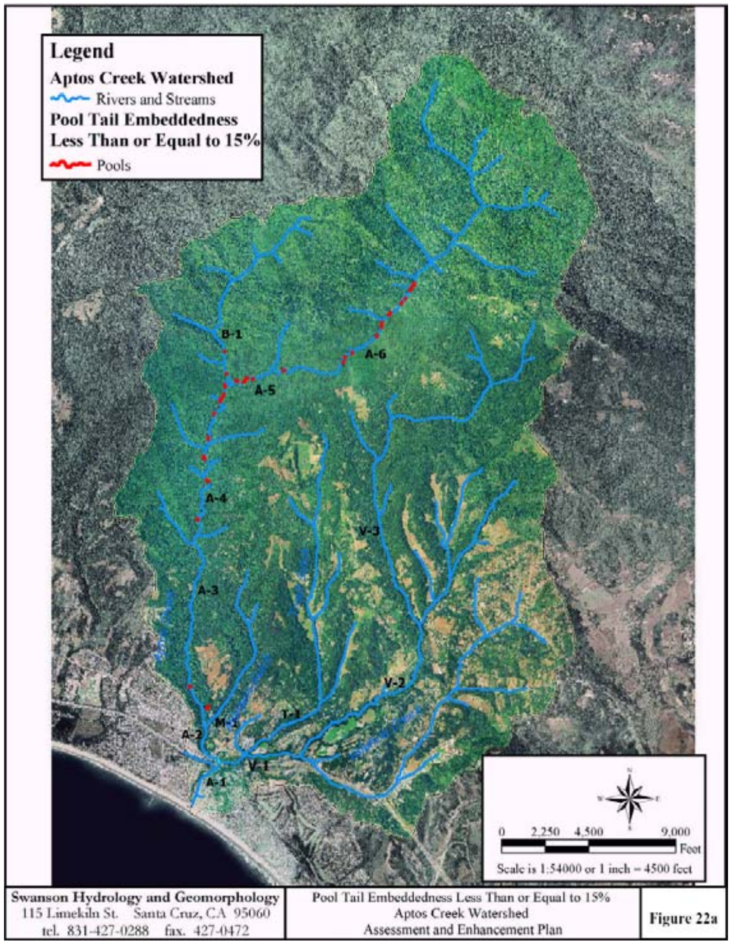
In numerous locations, Park users have piled cobbles across pool tail areas. These cobble dams obstruct free movement of juvenile trout and salmon and may obstruct adults migrating early in the season or at lower flows.

In some parts of Valencia and Trout Creeks, landowners adjacent to the creek have modified stream banks or riparian vegetation to the possible detriment of steelhead and salmon.

It is difficult to judge the potential impact of any of these activities although none of them is likely to act as a major limiting factor. Nevertheless, the disturbance may be susceptible to greater control through educational programs and reduction in the level of disturbance would be beneficial.

4.8 Exploitation

Existing fishing regulations allow fishing for steelhead in Aptos Creek from the mouth to the Steel Bridge between November 16 and February 28. Fishing is restricted to Wednesdays, Saturdays, Sundays, legal holidays, and the season opening and closing days. Only barbless hooks may be used and all caught fish must be released. The rest of the stream, upstream of Highway 1, is closed to fishing all year. The level of angler use, legal or illegal, is not consistently monitored and is unknown. Although the habitat survey did not specifically address this issue, nothing was encountered during the habitat survey that would indicate high levels of legal or illegal fishing.



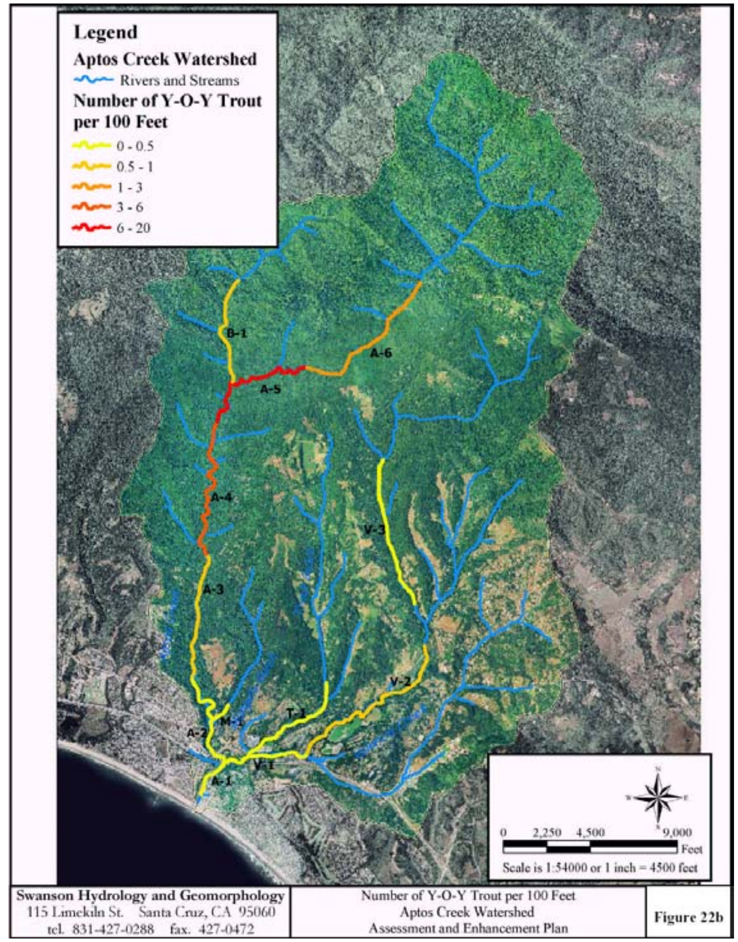


Figure 22a-c. Watershed Embeddedness Estimates and Frequency of Observations of Young-of-Year Steelhead/Rainbow Trout

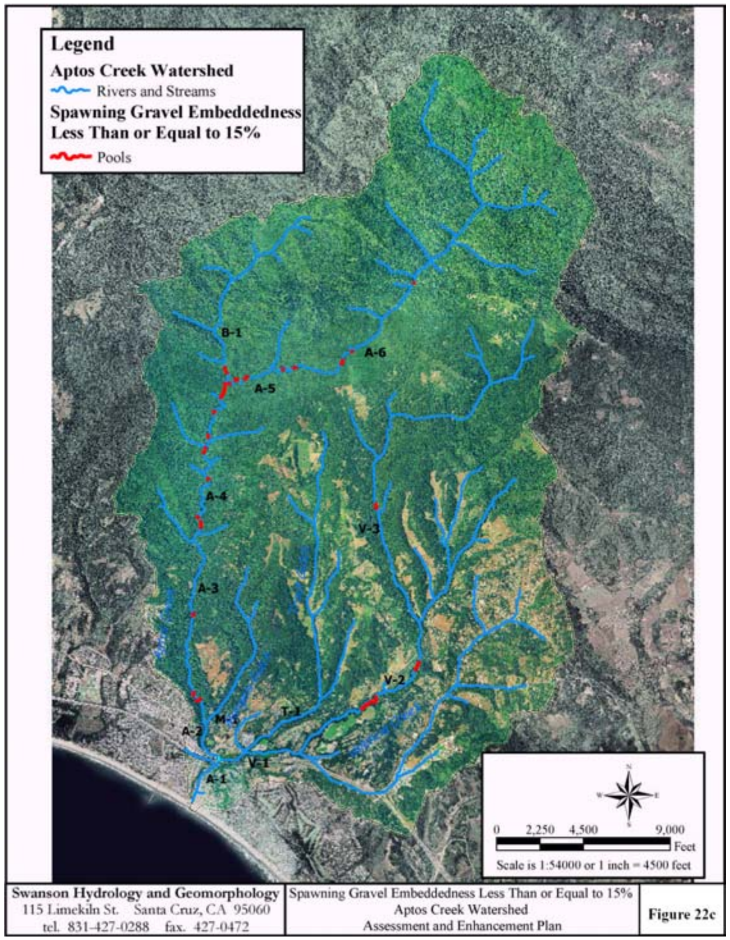


Figure 23a-c. Watershed Embeddedness Estimates and Frequency of Observations of Young-of-Year Steelhead/Rainbow Trout (cont.)

Table 12. Trout Observed during Habitat Inventory by Reach

	Aptos Creek						Bridge Creek	Valencia Creek			Trout Creek	Mangels Creek
	A-1	**A-2**	**A-3**	**A**	**A-5**	**A-6**	**B-1**	**V-1**	**V-2**	**V-3**	**T-1**	**M-1**
Trout 4 in. or less (TL in.)	0	31	58	609	1143	146	59	0	79	34	0	0
Trout over 4 in. (TL in.)	0	16	22	27	20	21	10	0	13	10	0	0
Sum of Habitat Length (feet)	1649	7134	8340	10366	9251	7952	6461	5599	12581	9232	7018	1452
Y-O-Y/100 feet (<4 in.)	0.00	0.43	0.70	5.87	12.36	1.84	0.91	0.00	0.63	0.37	0.00	0.00
Older trout/100 feet (>4 in.)	0.00	0.22	0.26	0.26	0.22	0.26	0.15	0.00	0.10	0.11	0.00	0.00

Notes: in.: inches
TL: total length
Y-O-Y: young-of-year

	Aptos Creek						Bridge Creek	Valencia Creek			Trout Creek
		A-2	**A-3**	**A-**	**A-5**	**A-6**	**B-1**	**V-1**	**V-2**	**V-3**	**T-1**
Y-O-Y/100 feet (<4 in.)	0.00	0.43	0.70	5.87	12.36	1.84	0.91	0.00	0.63	0.37	0.00
Spawning Area (square feet) per 100 feet	0.0	3.6	3.0	4.4	2.3	1.7	0.4	0	0.1	0.1	0
% units with pool tail embeddedness <=15%	n.a.	8%	0%	14%	28%	41%	10%	n.a.	n.a.		n.a.
% spawning areas with embeddedness <=15%	n.a.	23%	11%	33%	75%	31%	100%	n.a.	75%	50%	n.a.

Notes: in.: inches
TL: total length
Y-O-Y: young-of-year

4.9 Coho Salmon

Coho salmon have declined dramatically in streams south of San Francisco Bay. Coho salmon were present in Aptos Creek as recently as 1973 (Anderson 1995). Nearly the entire Aptos Creek watershed is maintained in natural condition as State Park lands and supports a relatively healthy steelhead population. Therefore, the disappearance of coho from Aptos Creek cannot be linked to human activities in the watershed such as residential development, water extraction, timber harvest, or road construction, which may be a factor in other streams. It is more likely that the major factors currently limiting coho in Aptos Creek are external to the watershed or are the result of natural environmental events that have impacted coho to a far greater degree than steelhead.

It is likely that ocean conditions are a significant factor in abundance of coho south of San Francisco Bay. Anderson (1995) points out that the sharp decline or extirpation of coho south of San Francisco Bay in the late 1970's and early 1980's was coincident with a warming trend along the Washington-California coast from 1976 to 1983 and with the severe drought in 1976-1977. Certainly, declining abundance of species at the extremes of range and contraction in range is expected (and widely demonstrated in terrestrial species) in response to long-term climate change. Still, coho maintain populations in nearby Central Coast streams that are, presumably, also impacted by these conditions (e.g., Waddell Creek and Scott Creek).

Due to its rigid 3-year female brood lineages, coho may have been eliminated from Aptos Creek as a result of very poor conditions in a few years. For example, 1972 was a very dry year with flow rarely exceeding 2 to 3 cfs through the winter and declining to about 0.5 cfs during the summer. This would have been a poor year for spawning and reproduction and would have influenced the return of the brood year lineage spawning in 1975, 1978, and 1981. The drought of 1976-1977 could have resulted in poor spawning and recruitment thus impacting the other two female lineages, spawning in 1979 and 1980. The extreme winter of 1982 resulted in near complete loss of rearing habitat and may have seriously reduced the abundance of rearing juveniles from the 1981 brood year that would have spawned in 1984, as well as wiping out eggs or fry and eliminating rearing habitat for the 1982 year class that would have spawned in 1985.

It may be that the primary factor currently limiting coho in Aptos Creek is simply that there is no spawning population. Coho, like other Pacific salmon, will inevitably stray to suitable habitat given sufficient time and the proximity of a viable population. The nearest viable populations occur in Scott and Waddell Creeks. The likelihood that fish will stray from these populations is influenced by their ocean behavior, response to currents and food sources, and abundance. It does not apparently occur with high frequency presently. It may be that reintroduction of coho would be a necessary prerequisite to establishing a population in the near term. The Aptos Watershed Restoration and Management Plan is focused on habitat management and restoration. Reintroduction of coho salmon is an issue that will be addressed by others in other forums, such as the coho salmon recovery team convened by the National Marine Fisheries Service. Until fish are present in the stream it is difficult to predict precisely what may be influencing their abundance there. Beyond limitations imposed by lack of a spawning population and ocean conditions, coho would likely be limited by many of the same factors limiting steelhead as discussed in the preceding section, particularly sediment. Coho at the emergence stage are slightly more sensitive to fine sediments than steelhead (Phillips *et al.* 1975 in Reiser and Bjornn 1979), possibly due to their larger size at hatching.

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