Coastal Watershed Council

Gazos Creek Watershed Assessment and Enhancement Plan

GAZOS CREEK WATERSHED ASSESSMENT AND ENHANCEMENT PLAN

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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. Currently, Central California and Southern California contain the smallest populations of salmonids. By preserving and restoring fish habitat within these areas, we can increase the likelihood that coho and steelhead will remain in this portion of their range thereby maintaining population and species diversity.

Prior to 2001, few watershed studies focused on Gazos Creek (Figure 1). This watershed is of special importance because it is one of the only waterways south of San Francisco Bay that still contains a viable coho salmon population. Gazos Creek is also listed as one of nine watersheds identified in the Draft Strategic Plan for Restoration of Endangered Coho Salmon South of San Francisco Bay, (CDFG, 1998).

Plan Objectives

The Gazos 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) and evaluated the following factors:

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

Based on assessment findings, restoration recommendations and prioritized projects designed to improve salmonid habitat were developed. 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.

The primary objectives of this assessment were (1) to identify physical and chemical habitat constraints in the Gazos Creek Watershed for coho salmon and steelhead and (2) to provide prioritized restoration recommendations for enhancement of these habitats.

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 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:

Name	Title	Entity Represented
Ms. Maya Conrad	Project Manager	Coastal Watershed Council
Mr. Shawn Chartrand,	Project Manager/Hydrologist	Balance Hydrologics
Mr. Jonathan Owens	Hydrologist	Balance Hydrologics
Mr. Donald Alley	Fisheries Biologist	D.W. Alley and Associates
Dr. Jerry Smith	Fisheries Biologist	
Ms. Toni Danzig	Ecologist	
Mr. Barry Hecht	Hydrologist/Geomorphologist	Balance Hydrologics
Ms. Kate Goodnight	Grant Manager	State Coastal Conservancy
Mr. Marty Gingras,	Grant Manager/Fisheries Biologist	Cal. Dept. of Fish & Game

Other groups, including the community at large, a public advisory group, and a technical advisory group, also made essential contributions. Public meetings occurred at the onset and conclusion of the project; 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 process
- Provide input on the proposed work
- Review findings and recommendations
- Brainstorm community-based or outreach-based restoration projects

A technical advisory committee (TAC), comprised of scientists with strong watershed process knowledge, 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 and collaboration.

Major Findings, Restoration Goals and Objectives

Assessment findings were developed through a thorough interdisciplinary evaluation that included:

1) Historical data review
2) Field studies
3) Data analysis

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, providing input and prioritization on recommendations.

The assessment findings were divided into reaches based on salmonid habitat available (Figure 2). A summary of the major findings and recommendations is provided here. A complete list can be reviewed in Section II of the Enhancement Plan.

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

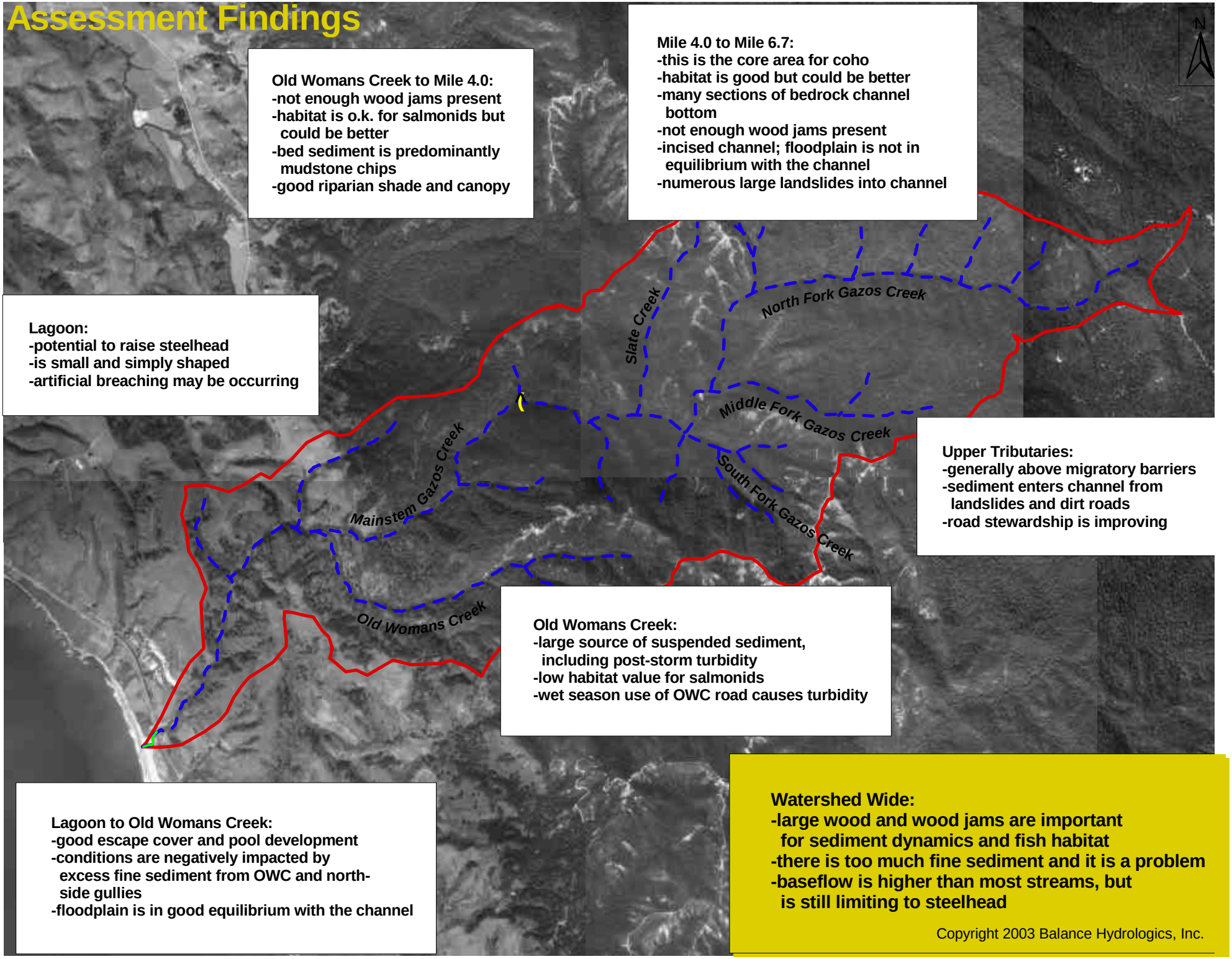
Findings:

- Fine sediment is the primary problem throughout the watershed
- Gazos Creek has higher baseflow (estimated at 1 cfs) during normal water years compared to other Central Coast watersheds but it is a limiting factor
- 2002 was a record year for coho spawning in Gazos Creek, Scott Creek and Waddell Creek

Recommendations:

- Develop/provide rural road and land maintenance best management practices (BMPs) for all private landowners and public landowners (e.g.: nonnative plant removal, erosion control, road winterization) to reduce sedimentation
- Provide natural flows. The need for a water source should be satisfied from well pumping that is sufficiently deep or distant from the Creek so as not to reduce streamflow during dry months (generally between April and October)
- Maximize summer baseflow
- Leave large woody material (LWM) instream & develop a management plan on proper instream large wood management techniques to increase spawning habitat and reduce sediment transport
- Provide information regarding development and cost-sharing programs for private wells

Assessment Findings



Old Womans Creek to Mile 4.0:
- not enough wood jams present
- habitat is o.k. for salmonids but could be better
- bed sediment is predominantly mudstone chips
- good riparian shade and canopy

Mile 4.0 to Mile 6.7:
- this is the core area for coho
- habitat is good but could be better
- many sections of bedrock channel bottom
- not enough wood jams present
- incised channel; floodplain is not in equilibrium with the channel
- numerous large landslides into channel

Lagoon:
- potential to raise steelhead
- is small and simply shaped
- artificial breaching may be occurring

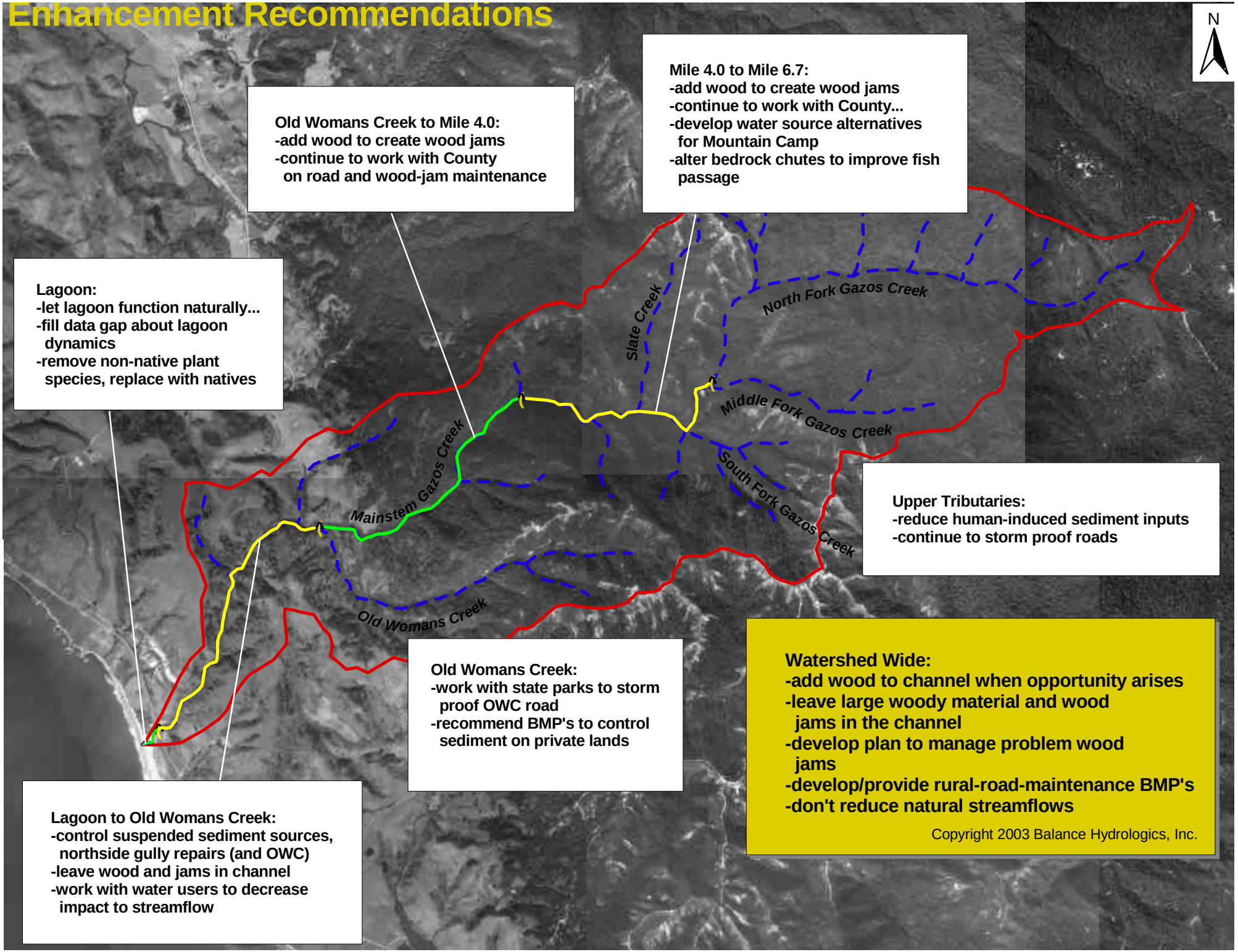
Upper Tributaries:
- generally above migratory barriers
- sediment enters channel from landslides and dirt roads
- road stewardship is improving

Old Womans Creek:
- large source of suspended sediment, including post-storm turbidity
- low habitat value for salmonids
- wet season use of OWC road causes turbidity

Lagoon to Old Womans Creek:
- good escape cover and pool development
- conditions are negatively impacted by excess fine sediment from OWC and north-side gullies
- floodplain is in good equilibrium with the channel

Watershed Wide:
- large wood and wood jams are important for sediment dynamics and fish habitat
- there is too much fine sediment and it is a problem
- baseflow is higher than most streams, but is still limiting to steelhead

Enhancement Recommendations



Gazos Lagoon (includes the mouth of Gazos Creek at Gazos State Beach upstream to Highway One):

Findings:

- The lagoon is a small, relatively simple system compared to other Central Coast lagoons
- The estuary lacks a saltwater transition during the spring (small smolts can have difficulty transitioning)
- the lagoon has potential to raise steelhead.

Recommendations:

- Maintain the natural summertime sandbar; no artificial breaching without further study of habitat impacts
- Maximize inflows and depth of a freshwater summertime lagoon for steelhead rearing habitat
- Use signage to educate public on importance of sandbars/lagoons for steelhead
- Fill data gap: conduct lagoon monitoring (including water quality and freshwater conversion rates) and install water quality monitoring device in lagoon
- Maintain sufficient flow during drought years, especially during springtime smolt outmigration

Lagoon to Old Woman's Creek confluence

Findings:

- Steelhead rearing & spawning habitat is negatively affected by excess fine sediment, especially from Old Woman's Creek and gullies on North side of Gazos Creek in Cloverdale Road area
- Pumping from shallow wells (<100 feet deep) within creek alluvium reduces stream flow
- Gullies are present on North side upslope (Peninsula Open Space Trust & California Department of Parks and Recreation property adjacent to Cloverdale Ranch). There has been a large-scale loss of topsoil from historic flax farming and cattle grazing. POST is addressing gullies on Cloverdale Ranch
- A relatively wide flood plain exists and is in equilibrium with the channel
- Spawning and rearing habitat are at high risk due to stored sediment in Old Woman's Creek.

Recommendations:

- Develop and implement a restoration plan for north side upslope gullies on State Park property
- Reduce sedimentation and erosion from Old Woman's Creek watershed
- Emphasize importance of leaving LWM in lower Gazos reach due to sediment threats from Old Woman's Creek.

Old Woman's Creek (OWC) tributary

Findings:

- Severe channel incision is present.
- OWC is a significant source of suspended sediment for Gazos Creek downstream of the confluence.
- There is a high potential for OWC to move laterally - hence, future increases in sedimentation of Gazos Creek below the confluence is likely.
- OWC Road receives a great deal of use year-round and is another significant source of sediment. The road requires 4WD during the wet season.
- Low habitat value is present for salmonids yet steelhead were reported previously abundant

Recommendations:

Overall goal: Reduce suspended sediment in Gazos Creek from Old Woman's Creek

- Reduce erosion attributable to roads and other land uses
- Treat existing gullies
- Decommission skid roads with potential for direct delivery to Old Woman's Creek
- Provide watershed residents with road and land use BMPs
- Conduct a thorough geomorphic characterization of Old Woman's Creek
- Stabilize lower Old Woman's Creek to reduce sediment delivery to Gazos Creek

Confluence with Old Woman's Creek to road mile 4.0

Findings:

- Relatively good rearing habitat is present, including a large amount of wood scour-formed pools and escape cover
- Spawning is a problem for coho in many years here due to a mobile bed and fine substrate
- Spawning is not a limiting factor for steelhead here
- The reach lacks sufficient LWM (primarily for winter refuges, especially upstream of mile 3.0)
- Mile 3.0 to 4.0 is a transitional region for channel stability

Recommendations:

- Actively add wood to trap sediment; drop trees into the creek near other LWM away from the road
- Any LWM management affecting fish passage should include an interdisciplinary team (fish biologist, geomorphologist, hydrologist)
- Where drainage facilities (including ditches and culverts) are necessary, manage them to ensure they function properly

Road mile 4.0 to extent of anadromy (~mile 6.7)

Findings:

- This is the core area for coho: spawning habitat is better than the rest of Gazos & there are good pools, substrate, escape cover and canopy cover
- Few large wood jams are present; the reach lacks sufficient wood
- Large amounts of fine sediment limit coho spawning and rearing habitat
- There is larger substrate and a more stable bed
- This reach is generally an incised channel; the flood plain is out of equilibrium
- There is a high amount of sediment delivery from South Fork

Recommendations:

- Include the same recommendations for LWM as in previous section's recommendations
- Preserve baseflow; develop water source alternatives for Mountain Camp that minimize impact to baseflow

The following tributaries were not investigated in depth, primarily due to lack of access. Therefore, the findings and recommendations listed for each tributary are based on:

- Historical data;
- Current knowledge of the tributary; and
- General watershed knowledge or knowledge of adjacent watersheds

Slate Creek

Findings:

- Old timber roads parallel the channel
- Habitat is of low value for steelhead and coho due to low flows and bedrock chutes

Recommendations:

- Reduce sediment inputs
- Purchase land or conservation easements from willing sellers
- Conduct an assessment of erosion-risk attributable to roads

North Fork

Findings:

- Old timber roads are present adjacent to channel
- Resident rainbow trout have been observed in the lower section

Recommendations:

- Reduce sediment inputs

- Decommission unused timber roads adjacent to stream channel
- Purchase land or conservation easements from willing sellers
- Conduct an assessment of erosion-risk attributable to roads

Middle Fork

Findings:

- Fine sediment enters the channel from the dirt road
- San Mateo County Public Works Department recently completed road improvements to reduce sedimentation
- Channel gradient becomes very steep
- Middle Fork has limited habitat value for steelhead and is unsuitable for coho due to complete fish barrier & steep gradient

Recommendations:

- Continue best management practices necessary to reduce erosion and consequential sedimentation of the stream attributable to roads managed by San Mateo County Public Works Department
- Purchase land or conservation easements from any willing sellers
- Conduct feasibility study to decommission portions of the road where it constricts the channel

Bear Gulch

Findings:

-
- An erosion-risk assessment of Barranca Knolls Road was completed (funded by the road association) by William Lettis and Associates (2002).
- Barranca Knolls Road needs stormproofing to minimize sedimentation.
- Natural barriers (a log jam and a waterfall) to fish passage are present approximately 1000 feet from the confluence with the mainstem.

Recommendations:

- Storm-proof Barranca Knolls Road according to best management practices published in the "Handbook for Forest and Ranch Roads" (Weaver and Hagans, 1994).

Next Steps- Prioritized Project List

The overarching goal of the Gazos 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 Gazos 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 Gazos 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.

Acknowledgements

Many individuals and groups have participated in the Gazos Creek Watershed Assessment over the last two years and thanks are owed to all. We are grateful for the generous assistance from:

Coastal Watershed Council Gazos Creek Volunteers & Program Manager Tamara Doan:

Mr. Gary Allen
Ms. Toni Danzig
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Ms. Kristen Falcon
Mr. Tex Houston
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Mr. Mike Powers
Ms. Roxanne Rothafel
Ms. Kate Schroeder
Mr. Andrew Sellman
Mr. Scott Sokal
Mr. Jim Rourke
Mr. John Wade
Mr. Larry Walsh

Mr. Michael Sullivan, UC Santa Cruz Intern
Ms. Michelle Leicester, San Jose State University
Ms. Toni Danzig and the Coastal Watershed Council Board of Directors
Redwood National & California Department of Parks and Recreation Watershed Restoration Department staff:

Ms. Terry Spreiter, Supervisory Geologist
Mr. Neal Youngblood, Geologist
Mr. Mike Sanders, Geologist

Mr. Jay Franke, Twin Parks Watershed Restoration Roads Consultant
Mr. Brian Steen and the Sempervirens Fund
Mr. John Wade and Pescadero Conservation Alliance
Ms. Deborah Chirco-MacDonald
Dr. Chris Brinegar, San Jose State University
Ms. Lisa Ekers and County of San Mateo Department of Public Works Department

II. GAZOS 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 Plan

The purpose of the Watershed Assessment and Enhancement Plan was to synthesize both historic data and assessment data to create a comprehensive salmonid restoration plan based on these findings. The primary objectives of this assessment were (1) to identify physical and chemical habitat constraints in the Gazos Creek Watershed for coho salmon and steelhead and (2) to provide prioritized restoration recommendations for enhancement of these habitats.

Background

In 2001, the Coastal Watershed Council received funding from the State Coastal Conservancy and the California Department of Fish and Game to conduct a comprehensive watershed assessment and enhancement plan for coho and steelhead habitat within the Gazos Creek watershed. Gazos Creek, one of the last viable coho salmon habitats south of San Francisco, is located in southern San Mateo County, ten miles south of the town of Pescadero (Figure 1). The creek's 11 square mile watershed encompasses approximately 16 miles of drainages. Originating in the Santa Cruz Mountains, the three forks of Gazos Creek drop down steep narrow canyons through redwood-Douglas fir and tanoak forest into the lower watershed. Surrounding the lower riparian zone, the landscape includes rolling grassland hills, coastal scrub and agricultural lands. A coastal lagoon with public access adjacent to Highway One is present at the mouth of the creek.

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 proactive, non-regulatory landowner participation.

In addition to the Technical Team members, several other ad hoc groups participated in the Gazos Assessment and Enhancement Plan.

Two Public Meetings were held at the Pescadero Conservation Alliance's Gazos Mountain Camp. Mailings were sent out to all watershed landowners before the meetings and press releases were distributed to the Half Moon Bay Review, the San Mateo County Resource Conservation District and the Santa Cruz Mountains Bioregional Council. Technical Team members presented methods, findings, and recommendations to the group and responded to questions. Approximately twenty-five people attended each meeting.

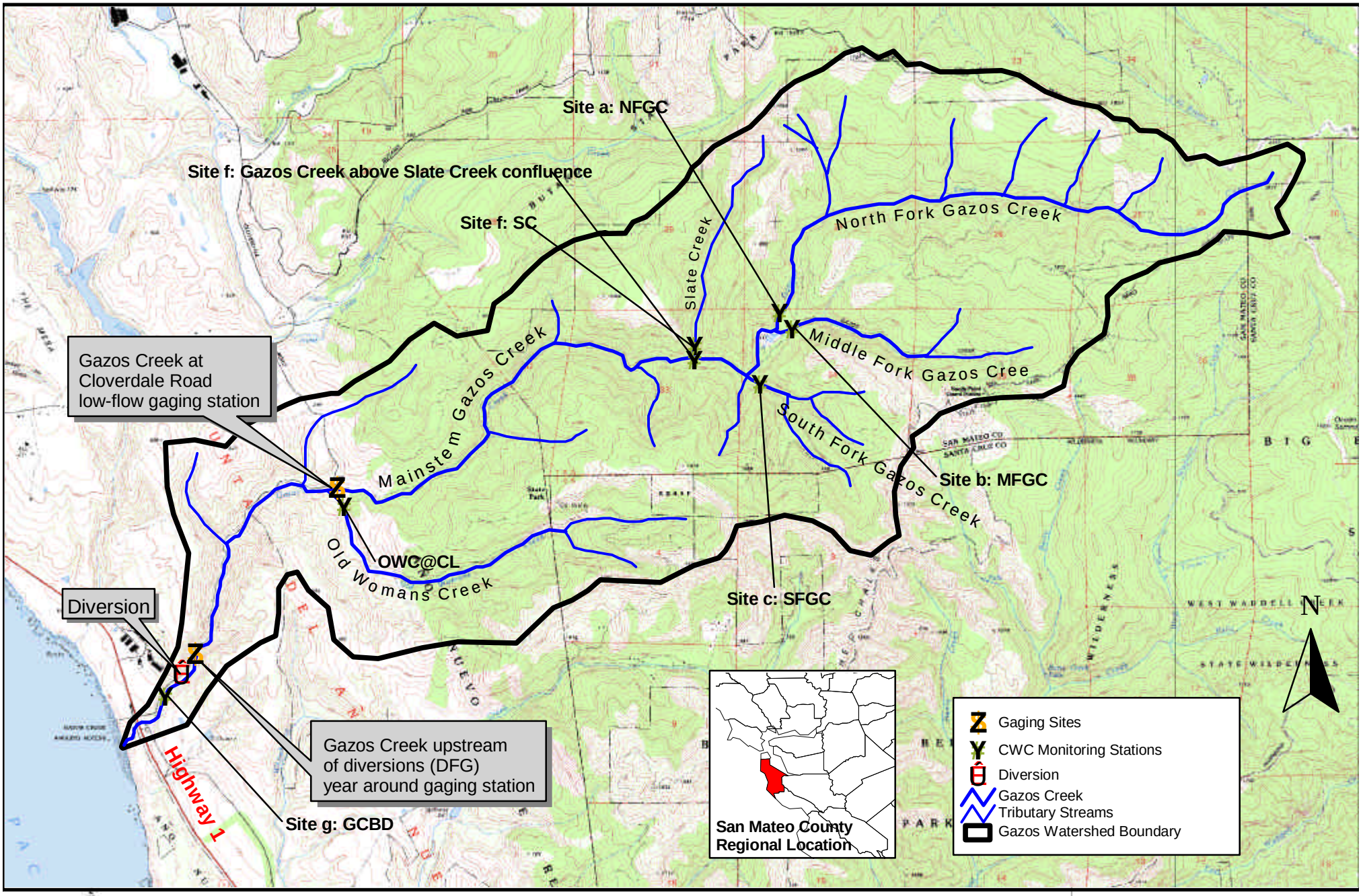
During the first Public Meeting, attendees were invited to join the Public Advisory Group, or PAG. Several individuals, primarily residential landowners and working lands managers within the Gazos watershed, volunteered to participate in the PAG. PAG members reviewed Assessment methods, findings and recommendations. The group convened twice during the project to review assessment materials, ask questions and to provide input. The PAG recommendations are included in Section III, Community Priorities.

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, 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 proactive, non-regulatory landowner participation.

Technical Team Members

Ms. Maya Conrad, Project Manager	Coastal Watershed Council
Mr. Shawn Chartrand, Project Manager	Balance Hydrologics
Mr. Jonathan Owens, Hydrologist	Balance Hydrologics
Mr. Donald Alley, Fisheries Biologist	D.W. Alley and Associates
Dr. Jerry Smith, Fisheries Biologist	San Jose State University
Ms. Toni Danzig, Ecologist	Toni Danzig, Restoration Ecologist
Ms. Kate Goodnight, Project Manager	State Coastal Conservancy
Mr. Marty Gingras, Associate Fisheries Biologist	California Dept. of Fish & Game



Balance Hydrologics, Inc.

Gazos Creek Watershed, San Mateo County, California.

Gazos Creek watershed showing major streams and its position between Butano and Waddell Creek basins. Locations of gages and monitoring sites are shown

Public Advisory Group

Mr. Peter Twight, Forester	Redwood Empire/Burch Properties
Mr. John Wade, Director	Pescadero Conservation Alliance/Gazos Mtn. Camp
Mr. Randy Bennett, Resident	Bear Gulch
Mrs. Debbie Bennett, Resident	Bear Gulch
Mr. Thompson Brooks, Resident	Old Woman's Creek
Mr. Jim Rourke, Volunteer	Coastal Watershed Council
Mr. Eric Huff, Forester	Big Creek Lumber/Slate Creek
Mr. Red Marchi, Landowner	Lower Watershed

Finally, resource agency technical advisors were requested to participate in the Technical Advisory Committee, or 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 Joanne Kerbavas, District Ecologist	California California Department of Parks and Recreation
Ms. Lisa Ekers, Natural Resource Engineer	San Mateo Co. Dept. of Public Works
Ms. Jennifer Nelson, Fisheries Biologist	Cal. Dept. of Fish and Game
Mr. Marty Gingras, Fisheries Biologist	Ca. Dept. of Fish and Game
Ms. Kate Goodnight, Project Manager	State Coastal Conservancy

Concurrent Projects

Other restoration and resource management efforts have been underway within the Gazos Creek watershed; most have been funded by the California Department of Fish and Game.

Most closely associated with the Assessment and Enhancement Plan is a telemetered stream gage located in the lower Gazos Creek watershed (Appendix H). The gage monitored flow from October 2001 through March 2003 and allowed interested parties to determine the creek stage via telephone or the World Wide Web. Peninsula Open Space Trust (POST) owns Cloverdale Ranch, which abuts lower Gazos Creek on the northern side. In 2001, POST completed a series of gully restoration projects that were contributing sediment into Gazos Creek. The County of San Mateo storm proofed the unpaved upper Gazos Road during the fall of 2002 to reduce chronic sediment inputs into Gazos Creek.

The Bear Gulch road association privately funded a road assessment and erosion reduction plan conducted by William Lettis and Associates. With assistance from Big Creek Lumber, the plan has been optimized and funds are being sought for implementation of prescriptions.

Finally, California Department of Parks and Recreation recently received funding from the California Department of Fish and Game to conduct a road inventory and sediment reduction plan for all roads within San Mateo County: all California Department of Parks and Recreation land within the Gazos Creek watershed will be included as part of this survey.

Table 1. Concurrent Projects within Gazos Creek Watershed

Project	Lead Group	Purpose	Timeline
Gazos Telemetered Gage	Coastal Watershed Council	To establish a rating curve for Gazos creek & allow remote access of creek stage	Final report completed
Cloverdale Gully Restoration	Peninsula Open Space Trust	To treat existing grassland gullies and reduce sediment to Gazos Creek	Completed in 2001
Upper Gazos Road Stormproofing	County of San Mateo Dept. of Public Works	To reduce erosion and sedimentation of Gazos Middle Fork	Work completed in November 2002
Barranca Knolls Road	Bear Gulch Road Association	To evaluate Barranca Knolls road and develop an erosion reduction plan	Work completed in 2002
San Mateo California Department of Parks and Recreation Road Inventory	San Mateo District California Department of Parks and Recreation	To evaluate all roads within the San Mateo California Department of Parks and Recreation and develop erosion reduction plans	2003-2004

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 limited the extent of data collected.

A. Fishery Assessment

The fishery assessment (**Appendix** A) included four main tasks:

1) Habitat typing for steelhead and coho salmon
2) Inventory of streambank erosion
3) Inventory of salmonid passage impediments for spawning
4) Inventory of large woody material in the wetted channel

Classification of Habitat Types and Measurement of Habitat Characteristics

The purpose of habitat analysis was to characterize the primary reaches used by coho salmon and identify limiting factors for coho and steelhead. Reach designations used for habitat typing extended throughout known steelhead and coho habitat and were previously established by Dr. Jerry Smith (Figure 2). Reach delineations were based primarily on changes in geomorphology and gradient, with changes in entrenchment and channel type. Approximately 5.5 miles of the lower 6.7 miles of Gazos Creek from Highway 1 to the steep bedrock chute beyond the Middle Fork confluence were surveyed and habitat typed.

Habitat types were classified according to the categories outlined in the California Salmonid Stream Habitat Restoration Manual (Flosi and others 1998). A modified CDFG Level III habitat inventory method was used. All habitat units were classified according to habitat type and their lengths were measured. Pools are the primary habitat for coho salmon and yearling steelhead in Gazos Creek, and have the greatest potential for enhancement. All pool units were measured for maximum depth, mean depth and mean width, with visual estimates of dominant substrate composing the tail of the pool (or glide at the tail of the pool), percent fines for the pool and embeddedness at the tail for many pools. Every third to fifth pool unit (depending on time constraints), beginning with the first pool encountered in the reach, was additionally measured for escape cover and canopy closure, with a visual estimate of cobble embeddedness for cobble larger than 6 inches (150 mm). Canopy closure was measured with a spherical densiometer. Percent deciduous/conifer canopy was visually estimated along with canopy closure. Other team members performed a more detailed survey of the riparian corridor.

For non-pool habitat types, the first encounter of each habitat type in the reach and every third to fifth habitat unit (depending on time constraints) of each type thereafter was measured for maximum depth, average depth, average width, embeddedness and escape cover. The scour objects that created pools were determined and tallied in each reach. In the wetted channel, all woody material at least a foot in diameter was inventoried by habitat for the number of logs/ rootwads found in the wetted channel, along with their species, estimated trunk diameter and length.

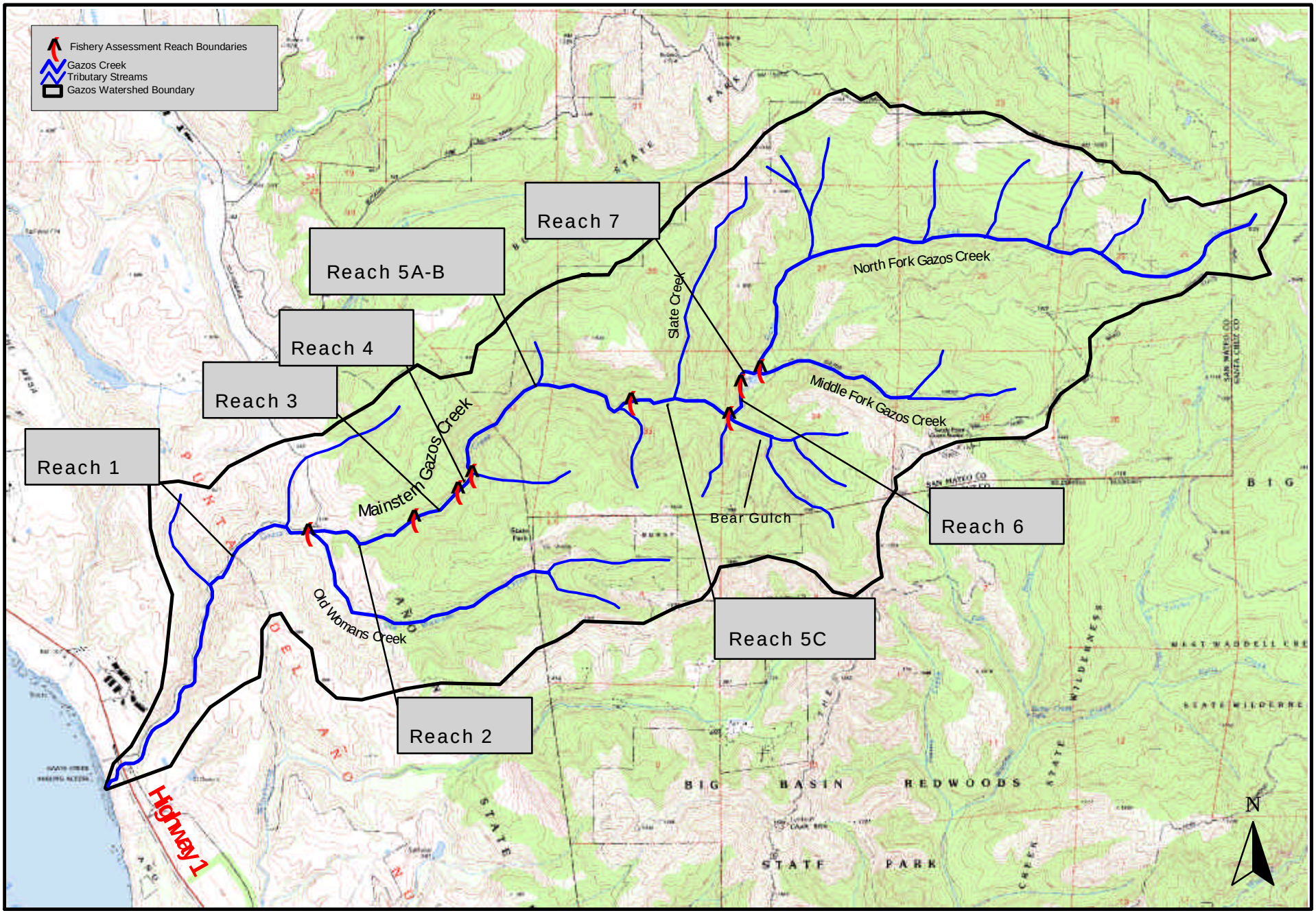
Inventory of Streambank Erosion

Locations of streambank erosion were measured and inventoried during the stream survey in each of the reaches up to the North and Middle Fork confluences. Streambank erosion sites were photo-documented and measured for length, average height, and percent vegetated. The erosion site was classified as active or inactive. The cause of the bank failure was stated, and a GPS reading was taken, if possible. The channel location was determined by hip chain measurement during the survey. Other team members documented sources of erosion in detail.

Inventory of Salmonid Passage Impediments for Spawning

The North Fork, upstream of the Middle Fork confluence, was surveyed for barriers to salmonid spawning migration. Parameters measured at chutes[1] that created passage impediments

[1] Chutes in Gazos Creek consist of bedrock ramps, which are generally flat, wide and consistently shallow.



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Gazos Creek Watershed, San Mateo County, California

Reach boundaries designated during fishery and habitat surveys are noted.
Reach boundaries designated by D.W. Alley & Associates, 2001.

included wetted channel width, length of the chute and maximum and average water depth on the day of survey.

At passage impediments that involved cascades and waterfalls, measurements were taken for the height of the jump from the water surface on the day of the survey and estimated for bankfull conditions. Other measurements were the maximum water depth and length of the approach to the jump on the day of the survey and estimates for bankfull conditions. The channel width on the day of the survey and at bankfull and estimated streamflow required for passage over the impediment were estimated. The locations of the passage impediments were measured with GPS, measured in distance and photo-documented.

Inventory of Large Woody Material in the Wetted Channel

During our survey work, all large woody material (1 foot or greater in diameter and 6 feet or greater in length) in the low flow (wetted) channel was measured and counted in the mainstream, anadromous reaches of Gazos Creek. This included only wood actually in the water. Note was taken as to whether the wood had been cut or not. An in-depth inventory of large woody material adjacent to and within the channel was carried out by Leicester (Appendix G).

B. Distribution and Abundance of Steelhead and Coho in Gazos Creek

Gazos Creek has been sampled in late summer or fall by backpack electroshocker for steelhead and coho salmon since 1992. Eight to eleven sites have been sampled in Gazos Creek since 1998. At each site, the same individual habitats were sampled, if possible, so that year-to-year site densities are an index to annual differences in spawning success and rearing conditions. However, since the primary reason for the sampling was to determine the distribution and abundance of coho, the sampling has been biased towards the pools that coho heavily use.

C. Geomorphic Assessment

Balance Hydrologics used three main approaches to assessing the geomorphology and sediment dynamics (Appendix B) in the Gazos Creek watershed:

1. Inventory of major sediment sources within creek channels and upland areas. The inventory included landslides, bank failures, and gullies.
2. Measurements of bedload- and suspended-sediment discharge at our gaging station to calculate a sediment budget for water year 2002.
3. The resurvey of ten cross-section profiles at a site that had been initially surveyed in the summer of 1998. That particular site was where a woody jam had been removed during May of 1998. The initial survey was performed to allow evaluation of changes to the channel morphology over time.

The first two tasks are parallel methods of calculating a sediment budget for the watershed. The third task was designed to allow evaluation of changes to the channel morphology following removal of the log jam. The information from those cross sections also aided us in evaluating more general geomorphic patterns in the Gazos Creek channel.

D. Hydrologic Assessment

Historic streamflow data for Gazos Creek was reviewed and analyzed. Balance Hydrologics staff installed and operated two temporary gaging stations[2], which continuously recorded water level[3], water temperature and specific conductance to evaluate baseflow characteristics and water quality (Appendices C and H). Additionally, staff conducted streamflow calibration measurements and supervised Coastal Watershed Council staff and volunteers collecting low flow streamflow (using the 6/10 method) measurements and basic water quality data at seven additional locations in the watershed (Figure 1). The following table presents general information for these monitoring stations:

[2] The upstream gage was operational from June 19th to November 16th of 2001 and was referred to as the GCCR gage while the downstream gage has been operational since October 2nd, 2001 and is referred to as the GCDFG gage.

[3] Through field observations of streamflow and water level, the continuous records of water level for both gaging stations was used to calculate streamflow at fifteen minute intervals over the periods of operation.

Table 2. Flow monitoring locations

Site I.D. and Name	Drainage Area at Site	General Location
Site a: North Fork Gazos Cr.	~ 2.13 square miles	~ 500 feet upstream of Middle Fork confluence
Site b: Middle Fork Gazos Cr.	~ 1.17 square miles	~ 200 feet upstream of mainstem confluence
Site c: South Fork Gazos Cr. (a.k.a. Bear Gulch)	~ 0.93 square miles	~ 300 feet upstream of mainstem confluence
Site d: Cloverdale Road Bridge (same as GCCR gage)	~ 8.0 square miles	At the Cloverdale Road Bridge and ~ 200 feet upstream of the bridge (GCCR gage)
Site f: Slate Creek and Gazos Creek above Slate Creek	~ 1.0 square miles	Slate Creek: in between Gazos Creek and Gazos Creek road Gazos Creek: just upstream of Slate Creek confluence
Site g: Gazos Creek downstream of diversions	~ 11.4 square miles	~ 1000 feet downstream of diversions
Site h: Gazos Creek (a.k.a. sum site)	~ 4.3 square miles	Immediately downstream of confluence with South Fork

Finally, Balance level-surveyed a cross section through the GCDFG gaging station where high water marks from 1982, 1998, 2000, 2001 and 2002 were preserved in the floodplain.

E. Riparian Vegetation Survey

Several indices of vegetation health were assessed during the Vegetation Survey:

1) Canopy cover - absence or presence
2) Dominant type - tree, shrub, herbaceous ground cover
3) Density - as a percentage
4) Community type - e.g., alder/willow riparian forest, coast redwood/tanoak riparian forest
5) Invasive non-native species

Following the review of aerial photographs, maps and other relevant documents, a field survey was conducted to document and field check the information contained in the documents. Sixteen survey points along the length of Gazos Creek and its tributaries were sampled. Only those areas where written access agreements were obtained were assessed.

Within the riparian area, generally described as 150' on either side of the center of the channel, transect sample plots of a 50-meter radius were established, flagged, and mapped. All information was recorded on project data forms. Between transects, any sites where degraded areas, invasive plant species or species of concern were noted and their locations recorded. Other randomly selected sites were selected to sample beginning at an area of good access or obvious change in vegetation; this was accomplished by entering the creek and stopping every 100’.

The assessment of canopy cover and density utilized the U.S. Forest Service standardized releve protocol and the California State Fish and Game Rapid Bioassessment protocol.

Within the established transect, 50-meter plot lines were measured. At 10-meter intervals recordings were made of individual species, community type, height, percentage of cover (using Spherical Densiometer), and relative density. Within the channel, the presence or absence of overhanging vegetation types were noted. Any species of concern and communities of concern were noted. Any non-native invasive species were also recorded.

F. Road and Land-use Survey of Gazos Creek Watershed

A road evaluation was conducted utilizing the resources and budget available. A thorough road assessment will be conducted on all California Department of Parks and Recreation lands in San Mateo County (recently funded by the California Department of Fish and Game) in 2003 or 2004. Additionally, the Bear Gulch road association hired William Lettis and Associates to conduct a road assessment and an erosion reduction plan on Barranca Knolls Road (know then as Bear Gulch Road) during the summer of 2001.

For this assessment, aerial photographs were evaluated for the entire watershed by dividing the watershed into the following major subwatersheds:

North Fork
Middle Fork
Bear Gulch (South Fork)
Mainstem
Slate Creek
Old Woman's Creek

A geographic information systems (GIS) map was developed by plotting roads viewed in aerial photographs from 1953, 1973, and 1993. Based on results from aerial photo analysis, subwatersheds were ranked according to density of roads, area of exposed ground, and proximity of roads to drainages. Next, ground level reconnaissance occurred in areas where CWC staff had access permission (California Department of Parks and Recreation property and Sempervirens Fund property). Staff geomorphologists from Redwood National and California Department of Parks and Recreation conducted initial reconnaissance with CWC staff of mainstem, Middle Fork, and Old Woman's Creek drainage within the California Department of Parks and Recreation boundary; they briefly evaluated the North Fork remotely using aerial photographs.

A road inventory was conducted within the State Park portion of Old Woman's Creek. Protocols used include the draft California Department of Fish and Game Chapter 9 Upslope Assessment and Restoration Practices (Pacific Watershed Associates 2001), and Redwood National and California Department of Parks and Recreation Watershed Restoration Department methodologies.

WATERSHED CONDITIONS

Watershed conditions for Gazos Creek are summarized below based on historical and general existing conditions. Sections C through I summarize the following conditions:

1) Fisheries
2) Geomorphology
3) Hydrology
4) Riparian Vegetation
5) Road and land-use
6) Steelhead and coho abundance
7) Large woody debris within the riparian corridor

Historical Land-use Conditions

The Gazos Creek watershed has a long history of timber harvest and agriculture since the 1870's. Roads were built to provide access to timber, mills and rural homes. Since the late 1800's, a network of roads, including skid and haul roads, has been developed within the watershed. A brief history of land use to present day within the various regions of the watershed is described below.

Within the lower elevations, from Cloverdale Road west to the ocean, the area surrounding Gazos Creek has been used for agriculture and cattle grazing stemming back to the turn of the century. From Cloverdale Road east, the Cloverdale Ranch (5600 acres) was acquired in the 1990s and is currently being managed by the Peninsula Open Space Trust.

Old Woman's Creek, the lower southern tributary of the Gazos Creek Watershed (Plan Figure 2) was once a favored spot for fishing in the early 1900's (Conant 1998). At present, steelhead habitat is poor, at best, but some rearing habitat may be available (Nelson 1994, Smith 2002.).

From the late 1860's through the turn of the century, Gazos Creek watershed was logged in a boom or bust fashion utilizing steam donkey engines and oxen (Conrad and Meyers 1997). During this time, the majority of the watershed was heavily cut, primarily by clear cutting. In 1867, the first steam shingle mill, the Burch and Steen Shingle Mill, was established at the mouth of Slate Creek (Conant, 1998). Shortly thereafter, the Pacific Lumber and Mill Company was opened at the confluence of the North Fork and mainstem of Gazos Creek. Since that time, approximately ten milling operations have been established along the creek for short periods of time (Stanger, 1967).

During the turn of the century, many of the logging operations lasted only a few years. Economic depressions and unfulfilled promises of a railroad connecting Santa Cruz to San Francisco led to the demise of most of the mills within the Gazos Creek region (Stanger, 1967). In lieu of the railroad, a makeshift port at nearby Pigeon Point was used to transport lumber including railroad ties headed for Hawaii, but could not replace the capabilities of a railway. Apparently, lumber could be transported as cheaply from the Puget Sound (in Washington) to

San Francisco as it could from the Santa Cruz Mountains to Santa Cruz. By the 1940's, only one mill site (formerly the Pacific Lumber and Mill site) remained in Gazos Creek watershed, but soon ceased operations.

After a period of dormancy, timber interests were rekindled in the North Fork of the watershed. J.C. Ainsley purchased 1800 acres (Conrad and Meyers, 1997) along the North Fork and mainstem of Gazos Creek in the 1940's. In the 1950's, a road was built up the North Fork to access the trees in the upper reaches of the drainage and was subsequently logged. Although some of the last stands of old growth remained in this portion of the watershed, it was substantially cut over in the 1950's (Conrad and Meyers 1997). By the 1960's, an extensive network of timber roads had been built within the North Fork watershed.

Within the headwaters of the Middle Fork, 2600 acres, including the large mill site, were purchased by Paul Hanna in the late 1950's and named the Gazos Creek Tree Farm (Conrad and Meyers 1997). Hanna, a professor of education at Stanford University, became a pioneer of sustained yield harvesting and progressively managed the tree farm until the early 1980's. Redwood Empire now manages the tree farm. Since 1984, ten timber harvests within this parcel have occurred.

From 1965 through 1968, the mill site on Hanna's Tree Farm was converted into a summer athletic camp that was run by Stanford University. The old millpond, which diverts water from the Middle Fork (visible on both topographic maps and aerial photos), was converted into a recreational swimming and boating area. In 1986, the camp was sold to Agape Christian Team and operated as a summer camp. In 1990, the Pacific Culture Foundation, a Taiwanese business collective, purchased the camp and renamed it the Villa Cathay. The camp was purchased by the Sempervirens Fund in 1997, and deeded to the California California Department of Parks and Recreation in 2000. At present, the camp is leased by the Pescadero Conservation Alliance, an organization that intends to operate the camp as an environmental camp and restoration center.

Today, only fragments of residual old growth stands and remnants of the historic mills remain within Gazos Creek watershed. With California Department of Parks and Recreation,Peninsula Open Space Trust, private timber companies and Sempervirens Fund and a few rural residents as the primary landholders within the watershed, the Gazos Creek area is relatively unaffected by urban development.

Existing Conditions

Gazos Creek flows through deep canyons developed in "chalk rock" –fractured mudstones of the Santa Cruz formation. Streams draining the chalk rock are sustained by seepage of cool, low-salinity, slightly alkaline waters, rich in naturally occurring phosphates and other nutrients. Sustained seepage emanates from the deep fractures through multi-year droughts. The unusual setting of the "chalks" offers a more resilient environment for salmonids than do the sandy or decomposed granite watersheds elsewhere in the Santa Cruz Mountains. Waddell and Gazos Creek are primarily chalk rock watersheds; chalks underlie half of the Scott and San Vicente watersheds. All of the streams south of San Francisco which support coho are within the

chalkrocks. And, in the chalks, there are no streams with drainages larger than 5 square miles which do not support coho.

Gazos Creek watershed has five main tributaries or branches (Figure 1):

- Mainstem
- Old Woman's Creek
- Slate Creek
- Bear Gulch/South Fork
- Middle Fork
- North Fork

A brief description of each tributary, including the mainstem of Gazos Creek, follows.

Mainstem

The mainstem of Gazos Creek drains into the Pacific Ocean just west of Highway One. The paved portion of Gazos Creek road borders six miles of the low gradient channel to the north and ends at the Gazos Mountain Camp. In addition to the named tributaries, several perennial springs and small waterways also flow into Gazos Creek along this stretch.

Old Woman's Creek

The upper portion of Old Woman's Creek subwatershed is privately owned by a small number of landowners. From the San Mateo County line to the northwest, the land is owned by California Department of Parks and Recreation as part of the Ano Nuevo State Reserve. For years, this subwatershed has been described as heavily silted and delivers large amounts of sediment into Gazos Creek (Smith, 1996; Nelson 1994). Although salmonid habitat within Old Woman's Creek is currently described as poor, anecdotal evidence suggests that good steelhead fishing was available in the early 1900s (Conant 1998).

Slate Creek

Slate Creek is a small perennial tributary that enters Gazos Creek from the north. A defunct logging road parallels the creek on the east approximately 30 meters upslope.
A sizable landslide composed of Santa Cruz mudstone obliterated the road approximately 200 meters north of Gazos Creek Road. Within the channel, benchmarks remain indicative of a turn of the century roadbed probably used when oxen were used to haul logs (Youngblood, pers. comm.). Indeed, a mill site was present in 1867 at the confluence of Slate Creek and Gazos Creek.

South Fork/Bear Gulch

The South Fork, or Bear Gulch, drains the upper southwestern portion of the watershed and includes residents of Barranca Knolls Road. Several large naturally induced landslides are present within this subwatershed. In recent years, the road association has privately pursued road stormproofing to minimize sedimentation of Bear Gulch.

Middle Fork

The dirt portion of Gazos Creek Road parallels the Middle Fork from the entrance of the Mountain Camp to the Sandy Point Guard Station in Big Basin Redwoods State Park. Once considered a substantial sediment contributor to Gazos Creek, the County of San Mateo has recently implemented several measures to reduce chronic erosion including closing the road to winter travel and storm proofing the road with several best management practices (Appendix E). Ownership in this reach includes private timber lands and a few rural residential parcels.

North Fork

The main artery of the Gazos Creek is the North Fork, which increases 1800' in elevation over 4.3 miles from the confluence to the headwaters (CDFG, 1994). The majority of this section was logged, primarily from 1950-1980. Most of this drainage is still privately owned timber lands although the northwestern corner of the headwaters is now part of the Butano State Park.

A. Fisheries Assessment

Previous Findings Related to the Fishery Resource

Gazos Creek is inhabited by both coho salmon (Federally listed as Threatened; State listed as Endangered) and steelhead (Federally listed as Threatened). Only 1 of 3 coho year classes (1993, 1996, 1999, 2002) is known to be present in Gazos Creek. With two of its three year-classes extirpated or very weak, the Gazos Creek coho population is at risk of extinction.

Because similar situations exist in adjacent watersheds, little help may be expected from natural strays of those watersheds to restore these year classes in Gazos Creek. Weak or absent year classes have resulted from severe droughts and floods over the past 18-25 years (Smith 1994; 2001b).

Juvenile coho had been captured almost exclusively in relatively deep, complex pools of Gazos Creek until 2002 (Smith 2001b; 2002). However, in 2002 coho densities were four times the 1999 density. They were found at all sampled sites below the chute at the beginning of Reach 7 (Figure 2), in pools widely varying in complexity and depth, as well as in some glides (Appendix F), although they were least abundant downstream of Old Woman's Creek. Woody debris was important in creating pool complexity and scour.

Densities of young-of-the-year (YOY) steelhead tend to increase with more summer baseflow in smaller Central Coast stream reaches where two years are required to reach smolt size and spawning success is not limiting (Alley 2001a; Alley et al. 2003). This is because steelhead may utilize fastwater habitat that is more abundant in wetter years. However, annual sampling since 1992 has shown wide year-to-year variation in coho abundance in Gazos, Waddell and Scott creeks, south of San Francisco Bay (Smith 2001a), and it is not obvious that the differences are attributable to annual differences in summer baseflow. According to Smith (2001a), these wide differences in annual abundance occur because the restricted early spawning period, single spawning attempt, and rigid ages of smolting and spawning (Shapovalov and Taft 1954) make them susceptible to drought, floods or other disasters within small watersheds (Smith 1994). Even so, baseflow in the spring greatly influences food abundance and growth of juvenile coho in pools, with more growth expected with higher spring baseflow.

Generally, the highest overall YOY steelhead abundance at most sampling sites in Gazos Creek had been in years of highest summer streamflow, 1995, 1998 and 1999**,** thus making summer baseflow an important factor for this species. Yearlings, which prefer deep, complex pools have their numbers generally controlled by the availability of structures that scour pools and create escape cover. Another limiting factor may be severe winter storms, which can wash juveniles out to sea. Production of smolt-sized yearlings is very critical to determining numbers of returning adult steelhead.

Fishery Habitat Characteristics

The habitat survey in 2001 (**Appendix A**) came 3 years after the high El Niño storm flows and a long history of logjam maintenance (Smith 2002) in locations where jams might threaten the adjacent road.

Channel Typing

Channel types determined by Dr. Jerry Smith for reaches of the mainstem were as follows; Reach 1 (C5), Reach 2 (C4), Reach 3 (B4c), Reach 4 (B4c), Reach 5A (B4c/F4), Reach 5B (B4c), Reach 5C (B4c), Reach 6 (B1), Reach 7 (A1) and above Reach 7 on the North Fork

(B3) (Figure 2). Channel types were determined according to the Rosgen method (Appendix A).

Wood Inventory and Pool Formation

In 2001, pools formed by woody debris dominated the pool habitat in 4 of the 7 anadromous salmonid reaches of mainstem Gazos Creek and in the South Fork (Bear Gulch). In the mainstem, 184 of 327 inventoried pools (56%) were scoured and formed by woody debris. Leicester (2002) found that pools and backwaters were primarily formed by relatively scarce, large conifer logs and rootwads. In the South Fork (Bear Gulch), 9 of 42 were woody debris pools (21%). Cut logs and cut stumps comprised a significant portion of the large woody debris in the low-flow channel. Many rootwads originating from old growth redwoods presumably cut down for lumber early on still remain in the stream channel. Because in-channel woody debris is responsible for such a significant portion of the salmonid rearing and overwintering habitat in Gazos Creek, management of the factors that influence its supply to the channel is critical.

Wood and Coho Success

Because coho fry tend to emerge from the gravels earlier than steelhead, spring storms can wash them from stream reaches lacking in backwaters or other complex habitats provided by woody material. The high densities of coho found in 2002 at all sites (Appendix F) underscored the great potential for coho production when spawning success is high and spring fry survival is good due to early fall/winter storms and the absence of later storms.

Large woody material was a major source of scour for pool development in Reaches 1-5C and a major provider of escape cover in pools utilized by coho salmon and steelhead.

Wood and Rearing Habitat Quality

Water depth and the amount of escape cover in pools are the two most important habitat parameters for determining summer rearing habitat quality. Woody material and escape cover in pools throughout Gazos Creek were generally higher than have been observed in either the San Lorenzo River or Soquel Creek watersheds (**Appendix A**). The more escape cover, the better the habitat quality. Coho juveniles need greater complexity and cover than steelhead because coho are uncommon in bedrock pools having limited cover, and coho greatly benefit from overwintering shelter provided by in-channel wood.

Large woody material in the wetted channel of Reach 1 was primarily deciduous hardwood in origin. Large woody material in the wetted channel of the middle reaches (2-6) of Gazos Creek, and overall, was primarily coniferous with cut redwood stumps and logs being a significant proportion in Reaches 5A-B and 5C, along with old-growth redwood rootwads. Considerable cut wood had collected above the low-flow (wetted) channel, some of which was within the bankfull channel and some of it was in the flood plain (having been deposited by past large flood flows).

In the lower 7 of 8 mainstem reaches in 2001, wood-scoured pools made up between 35% and 74% of the pool habitat per reach. In Reach 5C, where the frequency of large pieces of wood was highest, averaged mean pool depth was also highest of any reach in Gazos Creek. Average water depth in Gazos Creek ranged between 1.2 and 1.5 feet in Reaches 1-5C, while maximum depth ranged between 1.7 and 2.0 feet in those reaches. Regarding habitat quality, the deeper the pools the better they are for rearing. When water depth becomes 2-3 feet deep, it offers cover value itself. For small Central Coast streams, such as Gazos Creek, average pool depth of 1.2 feet and maximum pool depth of 2.0 feet are probably sufficient. Fastwater habitat in Gazos Creek was too shallow to provide habitat for smolt-sized juveniles (greater than 3 inches Standard Length) and provided very limited habitat for young-of-the-year steelhead.

Water Temperature

Water temperatures were adequately cool for coho and steelhead juveniles in summer, 2001. Based on data from continuous water temperature monitoring by Balance Hydrologics, Inc. in 2001, minimum daily temperatures in Reach 1 were in the 13-14ºC range during the summer, with maximum daily temperatures in the 16-18ºC range. These were cooler temperatures than existed in much of the San Lorenzo and Soquel Creek watersheds (Alley 2001a; 2001b).

Sediment Impairment

In 2001, the streambed was heavily sedimented, especially in pools (45-80% fine sediment) of the streambed in Reaches 1-5C and the South Fork) and spawning glides (30-40% fine sediment). Optimal percent fine sediment in pools of Central Coast streams would be 50% or less, though levels found in Gazos Creek were pretty typical of the region. As fine sediment

is reduced in spawning gravel, survival of salmonid eggs and embryos is increased. Spawning glides with 25-35% fines is pretty typical of Central Coast streams, which are usually sediment impaired.

Habitat Potential in the Lagoon

The Gazos Creek estuary is generally small and shallow, offering no saltwater transition between the Creek and the ocean. A concern is that if too much streamflow is diverted in dry years, the sandbar may close prematurely and block smolt out-migration. The sandbar typically remains open until late summer; this is potentially caused by artificial breaching (Smith personal communication).

After sandbar closure and freshwater conversion, the lagoon may offer good habitat for juvenile steelhead, though no fish sampling has been done. However, only a relatively small and shallow lagoon (3 feet deep) is formed. An estimated 0.5 cfs streamflow would likely convert the lagoon to freshwater adequately over a two-week period, providing significant steelhead habitat as long as summer inflow is protected.

Old Woman's Creek

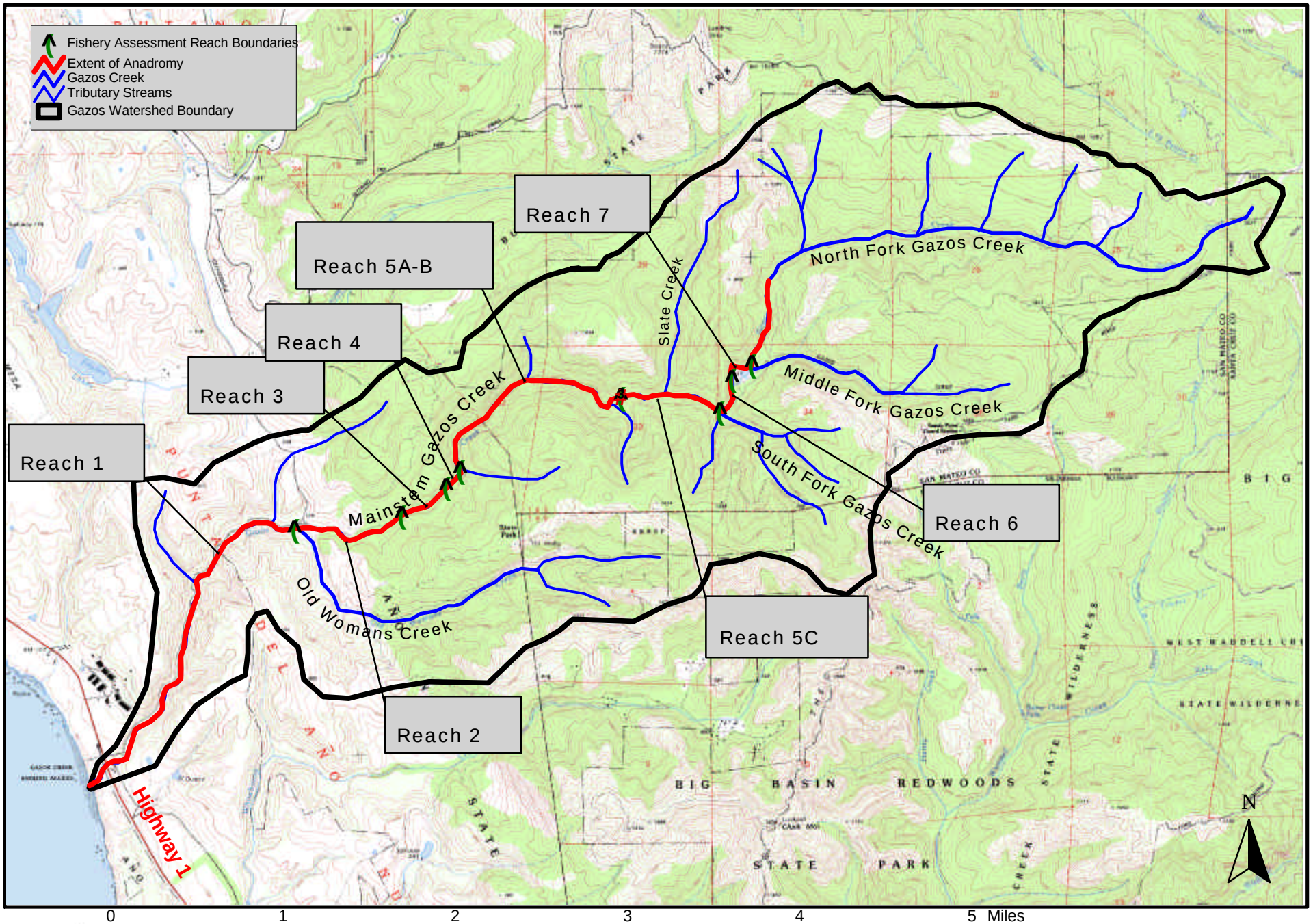
Study of Old Woman's Creek was beyond the project scope. However, Nelson (1994) surveyed approximately 0.7 mile of the creek. Rearing and spawning habitat was considered marginal, yet steelhead were present throughout the reach. Instream cover in pools was limited as undercut banks (36%), small woody debris (24%) and boulders (13%). Percent canopy closure was 91%.

Extent of Anadromy

The extent of anadromy for steelhead under most conditions is to the chute (BN-1) on the North Fork at channel mile 6.7 just upstream of the Middle Fork confluence (Figure 2). Adult steelhead may migrate beyond BN-1 when conditions are optimal, with the absolute barrier to anadromy being the large chute (BN-2) at approximately 6.9 miles from Highway 1, 1,300 feet upstream of BN-1.

The absolute barrier to coho salmon adult migration appeared to be at channel mile 6.5 from Highway 1, at the beginning of Reach 7 (adjacent to where the Mountain Camp tennis courts once stood). Another wide chute (the "South Fork Chute") existed 160 feet downstream of the South Fork (Bear Gulch) confluence at channel mile 6.0. It was 25-40 feet wide and 58 feet long, possessing a few scour holes 4-5 feet in diameter. South Fork Chute may be a significant salmonid passage impediment during drought due to its width, potentially blocking access to approximately 0.44 miles of habitat in the mainstem plus 0.17 miles of habitat in the South Fork that exist upstream before other bedrock chutes are encountered.

The Middle Fork is inaccessible to anadromous salmonids due to a 20-foot bedrock falls at its mouth. The South Fork (Bear Gulch) had a short reach without passage impediments to a chute at channel mile 0.17 (BN-1). A complete barrier to spawning migration was observed at a logjam (BN-5) situated at the confluence of an unnamed tributary, 0.3 miles from the mouth.



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Extent of Anadromy and Fishery Assessment Reaches, Gazos Creek Watershed, San Mateo County, California

Extent of anadromy in Gazos Creek is depicted by the red line while fishery assessment reach boundaries are designated with the text boxes and circle markers. Reach boundaries designated by D.W. Alley & Associates, 2001.

B. Distribution and Abundance of Steelhead and Coho in Gazos Creek

Steelhead and coho sampling has been conducted within Gazos Creek for over a decade by Dr. Jerry Smith. A summary of findings (**Appendix F**) for steelhead and coho young-of-the-year (YOY), yearlings, and adults is provided below. Comparisons to adjacent streams and limiting habitat factors are also provided.

Gazos Creek Steelhead YOY

YOY steelhead show little growth in late summer. Fish tend to be somewhat larger downstream, possibly due to slightly warmer water and earlier fry emergence from the gravels downstream. Regardless of the site, most YOY steelhead in the stream are less than 75 mm long after one summer; few Gazos Creek steelhead probably smolt as yearlings. YOY at upstream sites (Reaches 3-7, Figure 2) on Gazos Creek have generally shown little variation in growth from year to year, despite substantial differences in summer stream flow. At sites downstream of Old Woman's Creek (sites 1-2), YOY sizes have varied from year to year (Figure 4). However, the changes were apparently unrelated to summer stream flow; fish were smallest in 1998, the wettest sample year. The amount of fine sediment in and on the channel bed may be a major factor in fish growth downstream of Old Woman's Creek. In 1998 logjam removal and a late storm resulted in a surface coating of silt in lower Gazos Creek (Smith 1998c). Similarly, in several other years (1996, 1997 and 1999) late storms resulted in substantial very fine sediment from Old Woman's Creek coating much of the channel downstream (Smith 1996b, 1998a, 1999).

Highest YOY steelhead abundance overall in Gazos Creek and at most individual sites has been in the years of highest summer stream flow, 1995, 1998 and 1999. Higher summer stream flow probably results in better YOY summer feeding and late summer survival. In addition, higher stream flows allow YOY steelhead to make greater use of run and riffle habitats, which are mostly too shallow by late summer in low flow years. YOY steelhead abundance downstream of Old Woman's Creek has generally been substantially below that of upstream sites. Although flows are generally somewhat higher, channel substrate is sandier and frequently coated with more silt downstream of Old Woman's Creek. Substrate quality may be reducing YOY steelhead by reducing food for rearing fish and/or by reducing spawning attempts or success at downstream sites.

Among and within sites YOY steelhead abundance has generally been lower in very shady locations (canopy closures of 95+%). This is presumably because algae and aquatic insect abundance are lower, and because sight feeding on drifting insects is difficult for steelhead in very shady habitats. Sites downstream of Old Woman's Creek are often very densely shaded by alders, which may partially account for lower YOY steelhead abundance there. Individual habitats that were more open (<90% canopy closure) usually had substantially higher YOY steelhead densities than similar densely shaded habitats.

Mean densities have been generally lower than in Scott and Waddell creeks, which are larger streams, but have been similar to upstream and tributary habitats in those two watersheds. The relatively high, stable abundance of YOY steelhead over the years in all three streams indicate that adult steelhead numbers and spawning success have probably not been a problem. However, the relatively low YOY numbers at the upper two sites on Gazos Creek in 2001 (Table 13) may indicate poor adult access or spawning success, due to lack of late winter storms.

Gazos Creek Steelhead Yearlings

Yearling steelhead abundance has shown no consistent patterns among sites in Gazos Creek (Table 13). Even sites with generally low YOY abundance, such as downstream of Old Woman's Creek, have usually had yearling abundance similar to other sites. The high proportion of yearlings among captured steelhead reflects the over-representation of pools in sampled habitats throughout the stream.

Year to year changes in yearling densities have varied by more than a factor of 2 (6-14 per hundred feet), but tended to be lower at most sites and overall for Gazos Creek between 1997 or 1998 and 2000 (Table 1). Similar declines have occurred in Scott and Waddell creeks between 1997 and 2000 (Smith 2000b), and suggest a common cause or causes. Winter storms were particularly severe in 1997, 1998, 1999 and 2000, which may have substantially reduced overwinter survival of juvenile steelhead. However, there were two severe storm periods in 1995, but yearlings were relatively abundant in all three streams in that year (Appendix F., Smith 1998a and 2000b). In addition to winter storms, the recent wet years have had increased spring stream flows, which may have increased spring growth by yearlings, resulting in smolting by a higher proportion of yearlings than during drier periods. The winter of 2000-2001 was relatively mild (which might have increased yearling survival), and spring stream flows declined quickly (which should have reduced spring growth and early smolting). Gazos Creek yearling

abundance in fall 2001 rebounded and was relatively high due to either or both of these two factors. However, yearling abundance again declined in 2002. This was possibly because of moderate, but clear, spring streamflows, resulting in good spring growth and smolting by yearlings.

Gazos Creek Coho

Only 1 in 3 coho year classes (1993, 1996, 1999, 2002) is now present on Gazos Creek. Another (1992, 1995, 1998) was very weak, but was absent in 2001. The third year class (1997, 2000) is also missing. The situation is similar on Waddell Creek, where one year class has been somewhat common (1993, 1996, 1999, 2002), one is very weak (1992, 1995, 1998, 2001), and one is missing (1994, 1997, 2000). This wide variation in coho year-to-year abundance (1-2 orders of magnitude) in the three streams apparently represents the impacts of severe droughts and floods over the last 18-25 years (Smith 1994c, 2000b). The 2002 year class was expected to be good in the three streams, but high adult returns and ideal (early) timing of winter storms resulted in unusually abundant juvenile coho in 2002. Overall coho density was quadrupled compared to 1999 in Gazos Creek and more than doubled in Scott Creek.

Since all local coho streams show a similar pattern, weak or absent year classes cannot presently be restored by strays among adjacent streams. Restoring year classes might be possible if the Scott Creek populations are gradually rebuilt by returns of hatchery-reared precocial fish.

In 1993 hatchery-reared fry from Scott Creek were planted in Gazos Creek at several locations upstream of Old Woman's Creek (Cloverdale Road). Except for fish of unknown origin in 1993, the overwhelming majority of juvenile coho captured in Gazos Creek prior to 2002 have been from sites between miles 4.4 and 5.3. Apparently in most winters the mobile streambed in Gazos Creek results in lower redd survival downstream of about mile 4. In 2002 the storms were fortuitously restricted to the start of coho migration and spawning, and coho were able to successfully spawn and rear throughout the stream. Spawning success and early fry survival appear to be more important than summer rearing habitat for Gazos Creek coho.

Adult coho apparently do not ascend the high gradient habitat adjacent to the Mountain Camp (mile 5.4+). Even in 1999, when juvenile coho were abundant downstream, no coho were caught in a deep complex pool near the bottom of the steep bedrock chutes. Similarly in 2002 juvenile coho were abundant downstream of the chutes, and several were present in the pool at the base of the chutes, but coho were absent from pools within the chutes.

Within sites on Gazos Creek prior to 2002, coho have been captured almost exclusively in relatively deep, complex pools. The relatively abundant coho in Gazos Creek in 2002 used a wider variety of rearing habitats, including shallow pools, glides and deeper runs. In 1998 on Gazos, Scott and Waddell creeks most of the scarce juvenile coho captured were at or near logjams that would have protected newly emerged fry from the heavy spring flows that occurred that year (Smith 1998b). Coho sizes in 2002 generally decreased upstream in Gazos Creek, as has usually occurred for steelhead. Presumably, cooler water temperatures and later fry emergence are responsible for this pattern. Within sites, coho, which emerge earlier, were generally larger than YOY steelhead.

C. Geomorphic Assessment

Sedimentation and channel instability impair habitat of small populations of endangered coho salmon and threatened steelhead. Many landslides, gullies and bank failures contribute sediment to the creek, thereby affecting the fish habitat. The purpose of the geomorphic assessment was to describe and quantify the sources of sediment, the transport of sediment through the watershed, and the interaction between the channel and its floodplain.

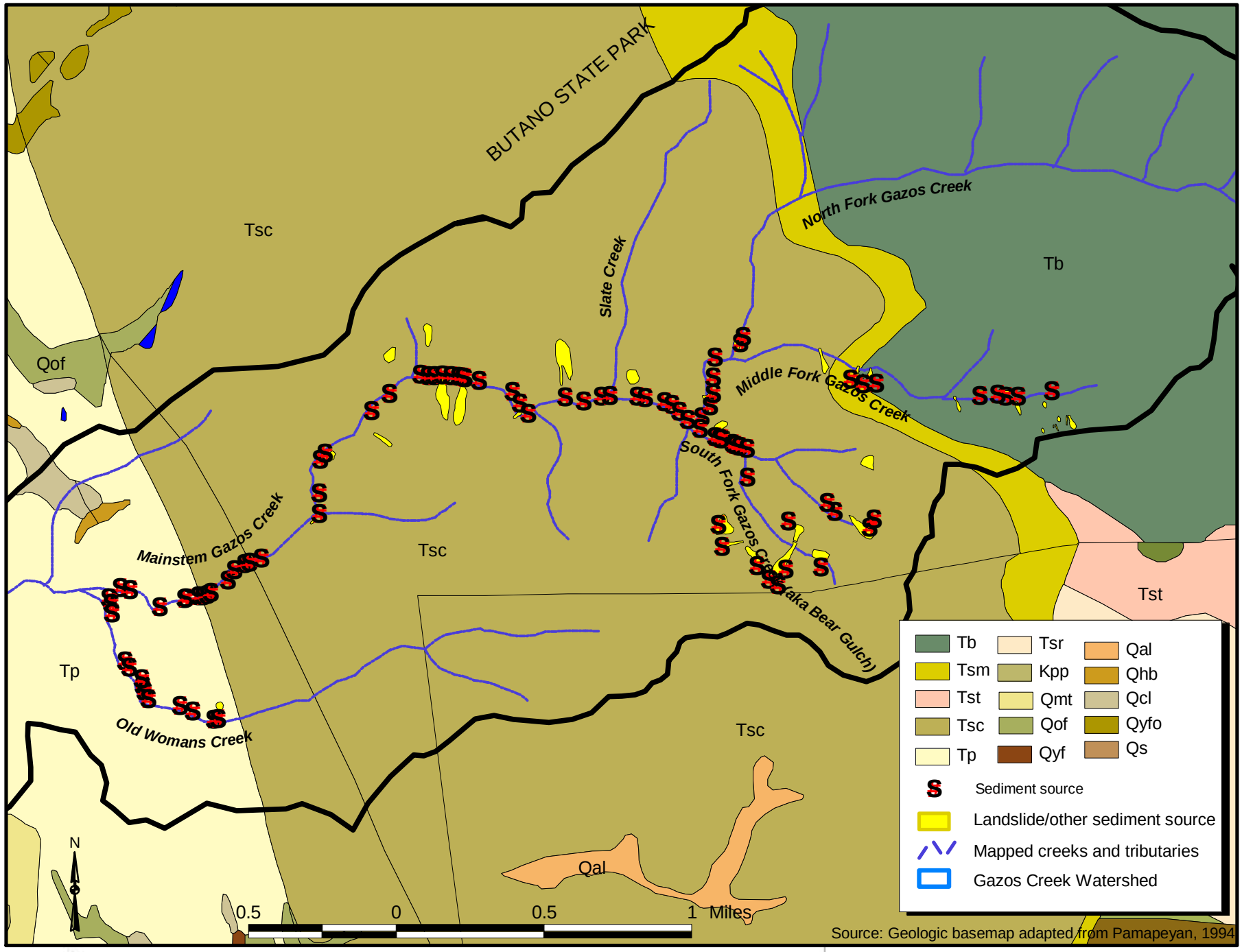
Field work consisted of three types of data collection: 1) the inventory and measurement of sites of major sediment sources and depositional areas, 2) the measurement of bedload and suspended sediment discharge at Balance's gaging station and at other locations, and 3) the resurvey of ten cross sections first surveyed during 1998. These field tasks gave us a coherent view of the geomorphology and sediment dynamics of the Gazos Creek watershed.

The first frame of the geomorphic picture is the relationship of "bankfull" flow to "bankfull" morphology. The lower 2.5 miles of Gazos Creek has a channel morphology that just allows inundation of the floodplain during 1.5- to 2-year floods. From mile 3 upwards, the mainstem of Gazos Creek has a channel shape that does not allow inundation of the floodplain until about two to three feet above the level of the 1.5- to 2-year flood.

The second frame of the geomorphic picture is the relationship of sediment sources to sediment storage. Sediment sources far outweigh sediment storage. The primary source of sediment to the creek is mainly landslides, based on the sediment sources that were surveyed. Sediment is stored behind wood jams and in floodplain terraces; however, based on the inventory and observations, much less sediment is stored behind wood jams now, than was stored behind wood jams prior to the 1998 removal of jams.

The third frame of the geomorphic picture is the degree of sediment discharge in the watershed during water year 2002. At the gaging station, measurements show that the sediment in motion is about 45 % (again be consistent in whether you use % or percent) bedload and 55 % suspended load. The measured sediment load for water year 2002 was about 10,000 tons, or converted to a landscape lowering rate, equals about 0.14 millimeters per year. This value is at the low end of the range of long-term uplift rates for the local Santa Cruz Mountains region. Sediment-discharge measurements also reveal that Old Woman's Creek contributes an inordinately high amount of suspended sediment compared to the rest of the watershed. Observations corroborate this finding, and add that high turbidity continues in Old Woman's Creek well after a storm, when other creeks are running clear again. One impact of this persistent turbidity is to decrease the value of fish habitat in Gazos Creek downstream of Old Woman's Creek.

The assessment findings create a picture of geomorphology and sediment dynamics in Gazos Creek which allow us to recommend adding wood to certain instream areas. Creating wood jams in the upper portion of the mainstem of Gazos Creek will serve multiple functions to improve fish habitat: the wood jams will trap sediment behind them; increase refuge and pool habitat for fish; and bring the channel into a closer relationship with the floodplain.

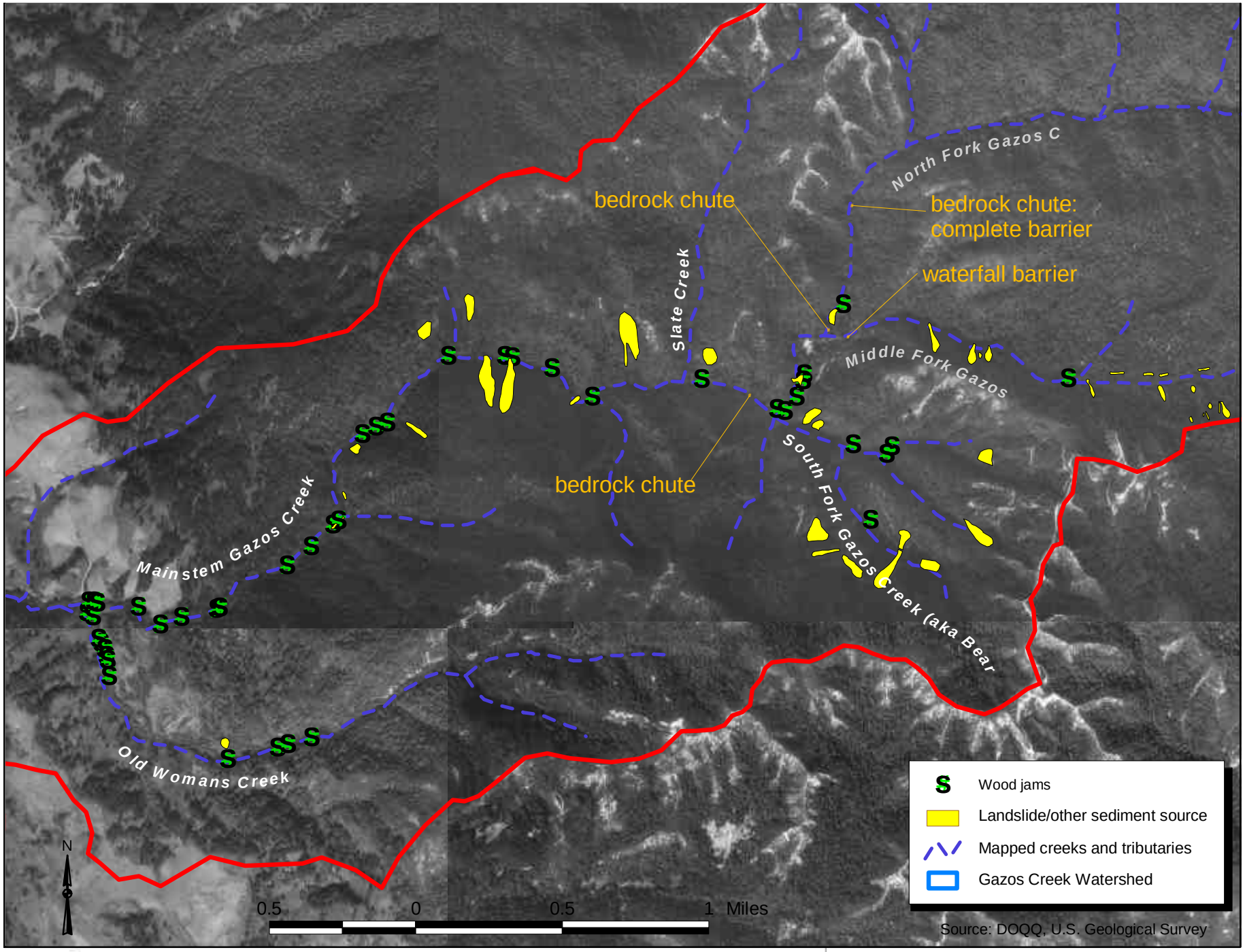


Balance Hydrologics, Inc.

Figure Location: c:\gis\santacruz\gazos.apr

Locations of inventoried sediment sources with a geology overlay: Gazos Creek watershed.

Most landslides seem to occur in the mudstone "Tsc" portion of the watershed.

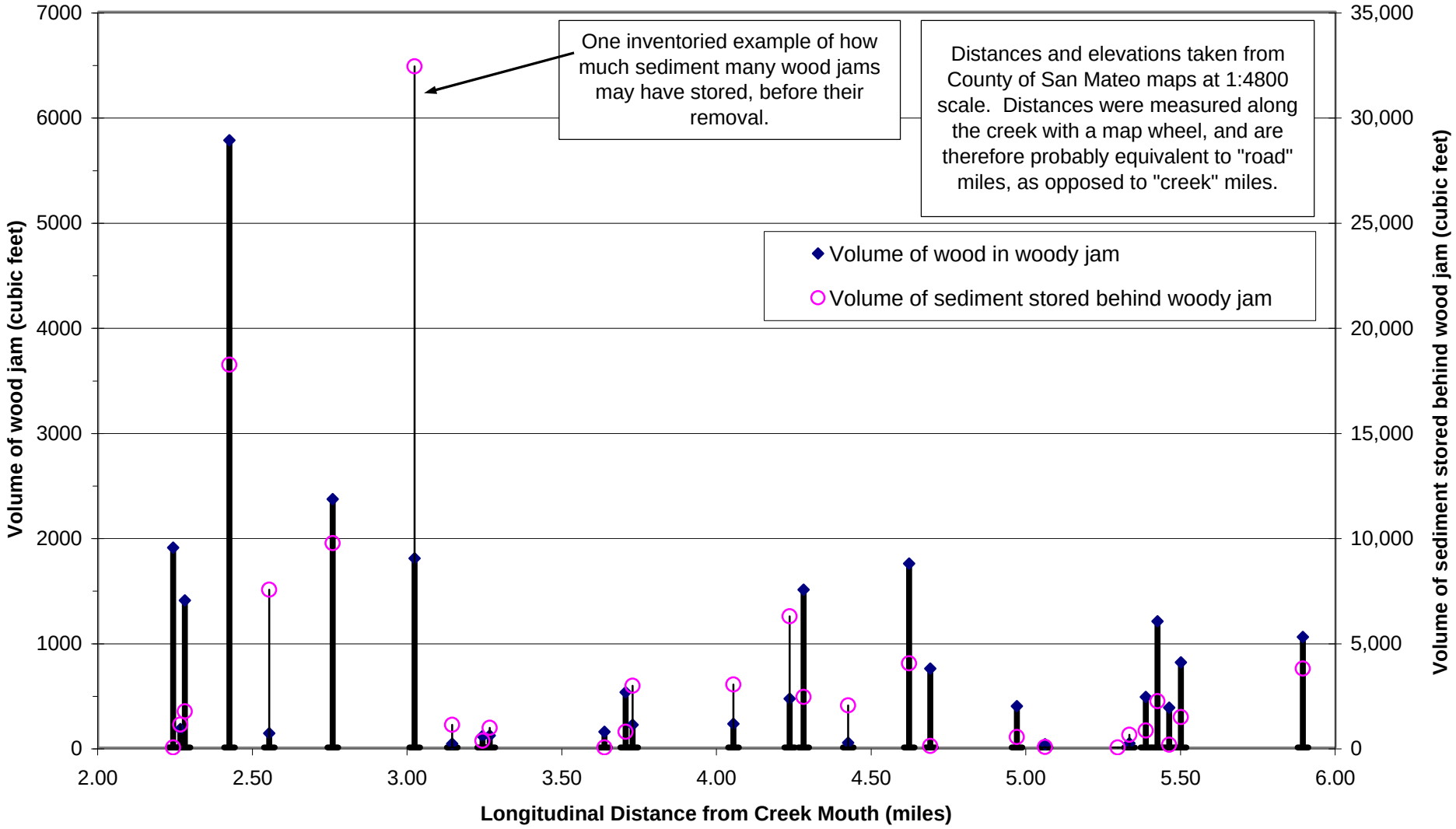


Balance Hydrologics, Inc.

Figure Location: c:\gis\santacruz\gazos.apr

Locations of inventoried wood jams: Gazos Creek watershed.

The locations are shown as dots, the magnitude of the wood jams in Figure 6 and detailed in Appendix B.



Balance Hydrologics, Inc.

Wood jam location, size, and amount of sediment stored: Gazos Creek upstream of Cloverdale Road. Generally, wood jams are not storing significant amounts of sediment in relation to the magnitude of sediment sources.

Sediment inventory volume and mass calculations:
Gazos Creek watershed

	Net Sediment Source Volume	Sediment Density	Net Sediment Source Mass	Sub-watershed Area	Average date of source inititation	
	(cub. feet)	*(tons/cu.m)*	*(metric tons)*	*(sq. miles)*		
Old Womans Creek	213,624	1.75	10,587	1	1988	
Gazos Creek (up to Middle Fork)	1,419,991	1.5	61,931	3	1987	
Bear Gulch	1,519,850	1.5	66,286	0.7	1984	
Middle Fork Gazos Creek	352,800	1.75	17,485	0.7	1956	
51% of the inventoried source sediment is bedload size material			156,290	5.4	1983	subtotal of *inventoried* sediment sources
Uninventoried sections of the watershed:						
Old Womans Creek (private portions)			36,849	0.7		(based on Bear Gulch and Old Womans)
Gazos Creek (below Cloverdale Road)			15,881	1.5		(based on Old Womans Cr.)
Bear Gulch (private, un-inventoried portions)			21,780	0.23		(based on Bear Gulch)
Middle Fork Gazos Creek (private portions)			11,740	0.47		(based on Middle Fork)
North Fork Gazos Creek (private)			53,205	2.13		(based on Middle Fork)
other tribs like Slate Creek (private)			85,225	0.9		(based on Bear Gulch)
change in bed storage, Gazos Cr. main stem			7,850	0.013		(based on repeated cross-section surveys)
		Total	**388,820**	11.3		
		+/-	**150,000**			

Notes:

"Net" sediment source volume = sediment sources - sediment storage, and includes bedload and suspended load sediment.

Sediment mass from "uninventoried sections of the watershed" sections was scaled by sub-watershed area and then scaled by rates from a sub-watershed of similar geology and steepness.

Our estimate of uncertainty of the calculated total is subjective and takes many sources of uncertainty into account.

We asssume that these estimates are lower than the actual sediment sources, because we did not record every sediment source that we saw (small sources were excluded), and we did not account for many upland areas because we mainly focused on the creek channels.

Dissolved sediment mass is not explicity accounted for in this table, but is assumed to be small during wet years, when most sediment is transported.

Sediment density (Hecht and Golling, 1982) for this purpose is the bulk density of the sediment sources, which are sometimes soil and sometimes bedrock, and assumes 30% porosity.

"Average date of source initiation" is weighted by the volume of the sediment source and is based on those sources to which we assigned a date; the average date reflects the balance between recently activated sediment sources (usually 1998) and older sediment sources (often 1982 and 1956).

Percent bedload was estimated individually for each sediment source in the field; the average is again weighted by the size of the source.

Water Year: 2002

Stream: Gazos Creek
Station: 0.5 miles upstream from mouth
County: San Mateo County, CA

Form 2. Annual Sediment-Discharge Record

WY 2002 Daily Suspended-Sediment Discharge *(tons)*

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	
1	0.0	0.0	68.2	29.2	0.2	0.3	0.1	0.0	0.0	0.0	0.0	0.0	
2	0.0	0.0	1875.6	1260.6	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	
3	0.0	0.0	282.4	499.1	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	
4	0.0	0.0	61.8	160.0	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	
5	0.0	0.0	18.7	50.7	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	
6	0.0	0.0	8.6	26.2	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.0	
7	0.0	0.0	5.0	15.0	0.7	0.9	0.1	0.0	0.0	0.0	0.0	0.0	
8	0.0	0.0	3.4	9.6	2.0	0.6	0.1	0.0	0.0	0.0	0.0	0.0	
9	0.0	0.0	3.0	6.4	0.7	0.4	0.1	0.0	0.0	0.0	0.0	0.0	
10	0.0	0.0	2.2	4.5	0.4	0.7	0.1	0.0	0.0	0.0	0.0	0.0	
11	0.0	0.1	1.7	3.1	0.3	0.5	0.1	0.0	0.0	0.0	0.0	0.0	
12	0.0	7.3	1.3	2.4	0.3	0.4	0.1	0.0	0.0	0.0	0.0	0.0	
13	0.0	0.1	1.1	1.9	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	
14	0.0	0.0	15.7	1.5	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	
15	0.0	0.0	3.2	1.3	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	
16	0.0	0.0	1.9	1.1	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	
17	0.0	0.0	3.8	0.9	1.2	0.5	0.1	0.0	0.0	0.0	0.0	0.0	
18	0.0	0.0	2.8	0.7	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	
19	0.0	0.0	3.1	0.6	1.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	
20	0.0	0.0	82.3	0.5	3.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	
21	0.0	0.0	200.2	0.5	2.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
22	0.0	0.0	105.4	0.4	1.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	
23	0.0	0.0	60.0	0.3	1.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	
24	0.0	0.3	21.3	0.3	0.8	0.6	0.0	0.0	0.0	0.0	0.0	0.0	
25	0.0	0.0	9.4	0.3	0.6	0.4	0.0	0.0	0.0	0.0	0.0	0.0	
26	0.0	0.0	5.4	0.4	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	
27	0.0	0.0	3.3	0.3	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	
28	0.0	15.9	4.6	0.4	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	
29	0.0	365.2	8.9	0.4		0.2	0.0	0.0	0.0	0.0	0.0	0.0	
30	0.0	2.7	31.3	0.3		0.2	0.0	0.0	0.0	0.0	0.0	0.0	**Qss Annual**
31	0.0		83.2	0.2		0.1		0.0		0.0	0.0		
TOTAL	0	392	2979	2079	19	10	2	0	0	0	0	0	**5,481**
Max.day	0	365	1876	1261	3	1	0	0	0	0	0	0	**1,876**

WY 2002 Daily Bedload-Sediment Discharge *(tons)*

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	
1	0.0	0.0	81.7	19.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
2	0.0	0.0	1373.0	1045.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
3	0.0	0.0	346.6	563.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
4	0.0	0.0	54.0	192.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
5	0.0	0.0	10.8	40.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
6	0.0	0.0	3.8	16.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
7	0.0	0.0	1.8	7.9	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	
8	0.0	0.0	1.1	4.4	0.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
9	0.0	0.0	0.9	2.6	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
10	0.0	0.0	0.6	1.6	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
11	0.0	0.0	0.4	1.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
12	0.0	4.5	0.3	0.7	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
13	0.0	0.0	0.2	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
14	0.0	0.0	10.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
15	0.0	0.0	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
16	0.0	0.0	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
17	0.0	0.0	1.4	0.2	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
18	0.0	0.0	0.9	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
19	0.0	0.0	1.1	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
20	0.0	0.0	89.2	0.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
21	0.0	0.0	244.7	0.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
22	0.0	0.0	114.7	0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
23	0.0	0.0	51.3	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
24	0.0	0.1	12.8	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
25	0.0	0.0	4.3	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
26	0.0	0.0	2.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
27	0.0	0.0	1.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
28	0.0	18.4	1.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
29	0.0	331.8	4.0	0.1		0.0	0.0	0.0	0.0	0.0	0.0	0.0	
30	0.0	0.9	26.6	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	**Qbed Annual**
31	0.0		80.5	0.0		0.0		0.0		0.0	0.0		
TOTAL	0	356	2523	1899	5	2	0	0	0	0	0	0	**4,784**
Max.day	0	332	1373	1046	1	0	0	0	0	0	0	0	**1,373**

Daily values are based on calculations of sediment discharge at 15-minute intervals.
Multiple sediment-discharge rating curves were used for different periods of the year and ranges of flow.
Daily values with more than 2 to 3 significant figures result from electronic calculations. No additional precision is implied.

Total annual sediment discharge (suspended- plus bedload-sediment discharge)
WY 2002: 10,265 *tons*

Balance Hydrologics, Inc. 900 Modoc Street, Berkeley, CA 94707 (510) 527-0727; fax: (510) 527-8532

Calculation of sediment yield from landscape lowering rates: Gazos Creek watershed, water years 1998 to 2002

Water Year	Landscape lowering rate Corte Madera Creek	Landscape lowering rate Los Trancos Creek	Lowering rate for Gazos Creek based on Corte Madera Creek	Lowering rate for Gazos Creek based on Los Trancos Creek		Sediment Yield for Gazos Creek based on average of Los Trancos and Corte Madera Creeks	
	(mm/yr)	*(mm/yr)*	*(mm/yr)*	*(mm/yr)*		*(m.tons)*	
1998	3.8	0.27	*4.8*	*1.5*		*246,417*	
1999	0.33	0.11	*0.41*	*0.64*		*41,187*	
2000	1.13	0.067	*1.4*	*0.39*		*71,111*	
2001	0.041	0.017	*0.052*	*0.10*		*5,916*	
2002	0.11	0.025	**0.14**	**0.14**		**11,211**	
			6.8	2.8		**375,842**	**Total (5-year period)**
			(mm)	*(mm)*	**+/-**	**150,000**	
						(metric tons)	

Notes:

Landscape lowering rates for Gazos Creek scaled from water year 2002 value by rates in Corte Madera Creek; we note however, that equating lowering rates from Corte Madera Creek to Gazos Creek is a very rough approximation.

Sediment yields for previous years of Gazos Creek scaled from water year 2002 value by lowering rates.

Sediment yields for Gazos Creek include dissolved load; dissolved load should be a minimal factor during wet years, although it can be a significant factor during normal or dry years.

Our estimate of uncertainty of the calculated total is subjective and takes many sources of uncertainty into account.

Values with more than two significant figures are the the result of electronic calculations and do not imply increased precision.

D. Hydrologic Assessment

Very little previous work has been conducted to describe and document the hydrologic characteristics of Gazos Creek; that work which has been completed consists of point measurements of streamflow at various locations in the watershed from 1971 through 1993 and basic water quality monitoring during 1998. This current hydrologic assessment has been conducted in an attempt to fill-in existing data gaps and to address the following four critical hydrologic questions:

1. What are the rates and sources of low flows in Gazos Creek?
2. What is the basic quality of surface water, particularly at lowest flows?
3. What are the dominant discharges, or channel-forming flows?
4. What are the very large peak flows of the past 50 years?

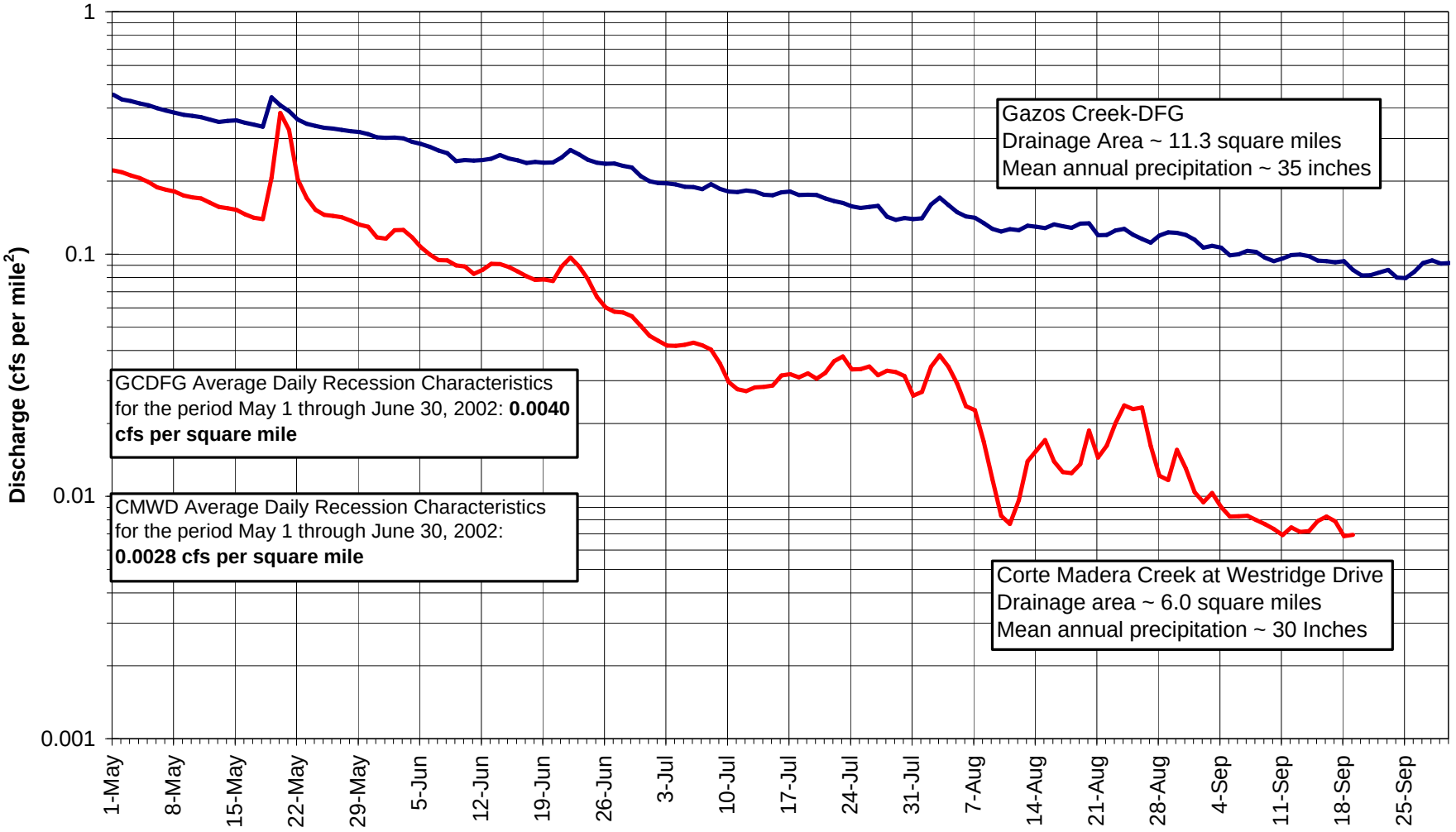
To answer these critical questions, Balance Hydrologics staff (1) installed and operated two temporary gaging stations[4] which continuously recorded water level[5], water temperature and specific conductance, (2) worked with Coastal Watershed Council staff and volunteers to collect streamflow and basic water quality data at seven additional locations in the watershed and (3) level-surveyed a cross section through the GCDFG gaging station where high water marks from 1982, 1998, 2000, 2001, and 2002 were preserved in the floodplain.

[4] The upstream gage was operational from June 19th to November 16th of 2001 and was referred to as the GCCR gage while the downstream gage has been operational since October 2nd, 2001 and is referred to as the GCDFG gage.

Rates of low flows in Gazos Creek are high when compared to other regional streams of similar drainage area and roughly similar watershed average mean annual precipitation; low flows in Gazos Creek during water years 2001 and 2002 ranged from 2 to 30 times greater than corresponding flows in Corte Madera and San Geronimo Creeks. Relatively high low flow rates in Gazos Creek are extremely important to preserve for salmonid habitat. Regionally, water years 2001 and 2002 were characterized as average to slightly below average years for rainfall totals. The magnitude of low flows originating from each of the three upper watershed tributaries is unclear at this time due to a limited dataset. The data that was collected, however, indicates that the magnitudes of flows from each tributary can be dynamic at possibly the daily level. Basic water quality parameters of Gazos Creek were found to be appropriate for salmonids during 2001 and 2002.

At the two gaging stations, summertime daily average water temperatures ranged from 9 to 18 degrees Celsius while daily average specific conductance ranged from 240 to roughly 410 mmhos per centimeter (at 25 degrees Celsius). The daily maximum water temperature recorded at the GCDFG gage in water year 2002 was 19.1 degrees Celsius. The channel-forming flow or bankfull flow was calculated at the GCDFG gage as 840 cfs; the calculation was based on the peak water level recorded during water 2002- a year which resulted in bankfull flow on many regional streams. Additionally, the high water level from 2002 occurred at the first distinct break in slope on the channel bank-a break which was interpreted in the field as being the morphologic bankfull surface. Peak flows from high water levels for water years 1982 and 1998 were calculated to be 4,280 and 2,970 cfs, respectively. Five miles north of Gazos Creek in the Pescadero basin, water year1998 resulted in the peak flow of record at the USGS gaging station followed by water years 1956 and 1982. It is unclear how water year 1956 compares to 1982 or 1998 in the Gazos Creek watershed due to a lack of preserved high water marks and first hand accounts of flood levels.

[5] Through field observations of streamflow and water level, the continuous records of water level for both gaging stations was used to calculate streamflow at fifteen minute intervals over the periods of operation.



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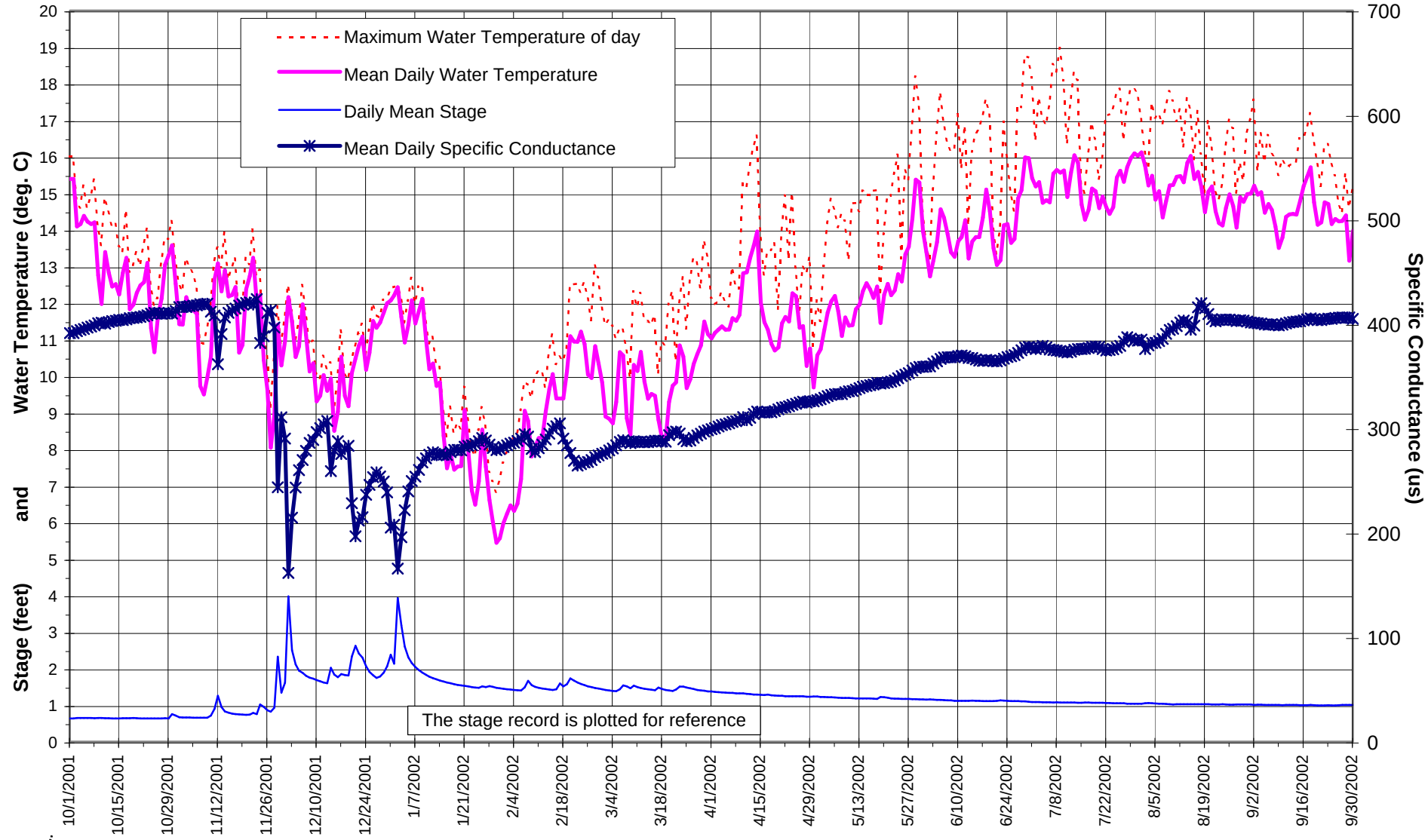
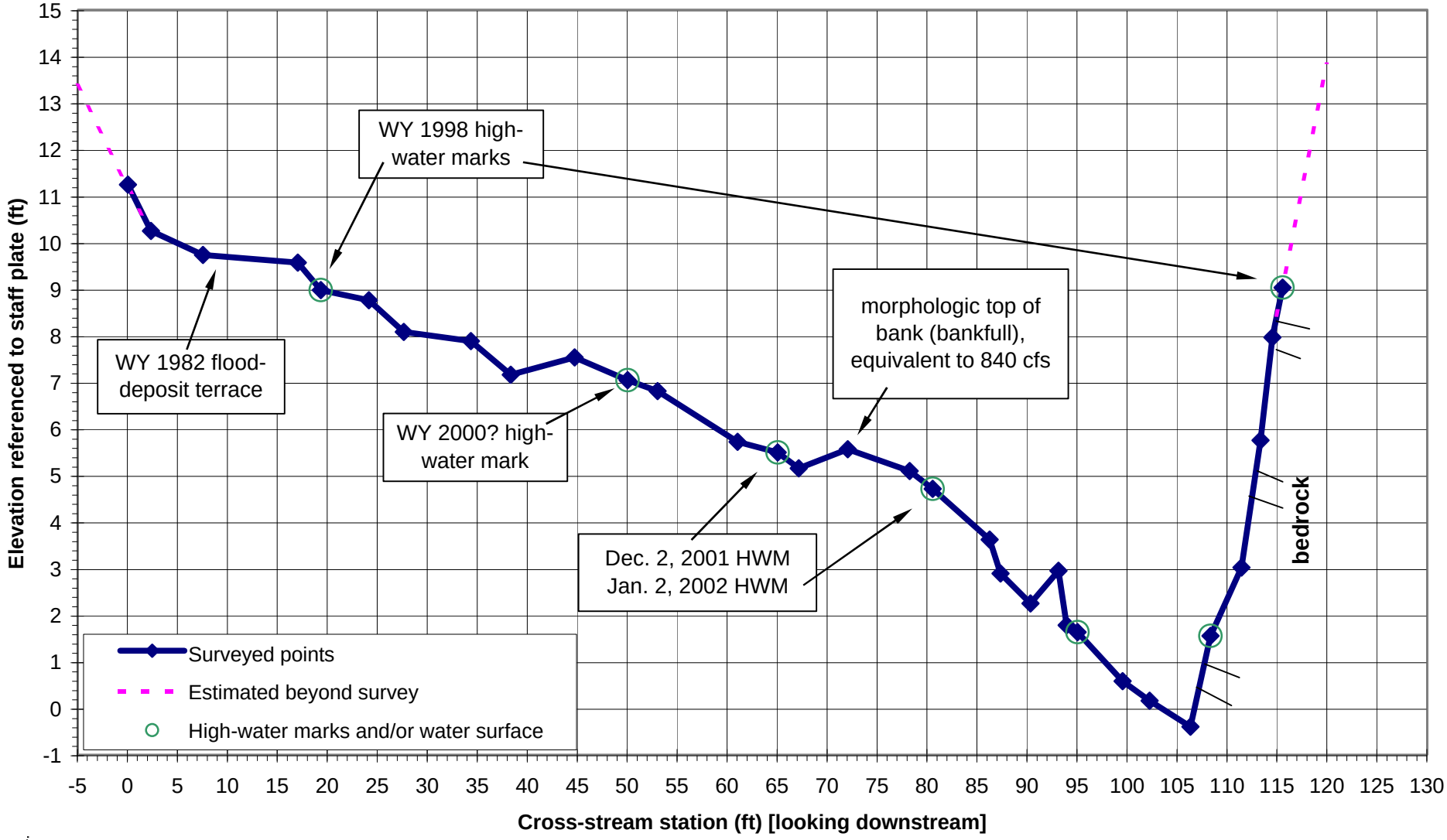
Baseflow recession curves for the Gazos Creek Department of Fish and Game telemetered gage (heavy line) and Corte Madera Creek at Westridge Drive (light line), May 1st through September 30, 2002. Rates of baseflow recorded at GCDFG in water year 2002 varied from 1.1 to 15 times greater than those recorded at CMWD for the same period but recessed at slightly greater rates.



Balance Hydrologics, Inc.

Daily water temperature and specific conductance: Gazos Creek above Highway 1, water year 2002. Specific conductance is a measure of the amount of dissolved minerals in the water.

most report figures.xls, Fig6



Balance Hydrologics, Inc.

Cross-section survey plot: Gazos Creek, about 1/2 mile upstream of Highway 1. Survey performed 1/17/02 at the gaging station (also referred to as Site e or GCDFG). We calculated bankfull flow to be about 840 cfs at this site, where "morphologic bankfull" and "recurrence-interval bankfull" (1.5- to 2-year flood) seem to be in agreement.

E. Riparian Vegetation Survey

A review of aerial maps and archival materials indicated that no significant changes in vegetation have occurred in the Gazos Creek riparian area during the last 30 years. Prior to that time, significant upslope areas were logged and skid roads left in place. The field surveys indicate invasive weedy species have occupied and continue to occupy disturbed areas, primarily plantains, periwinkle, broom and pampas grasses. These species are present on bare ground where slips have occurred or roads are still in place, as well as along the shoulders of currently used roads.

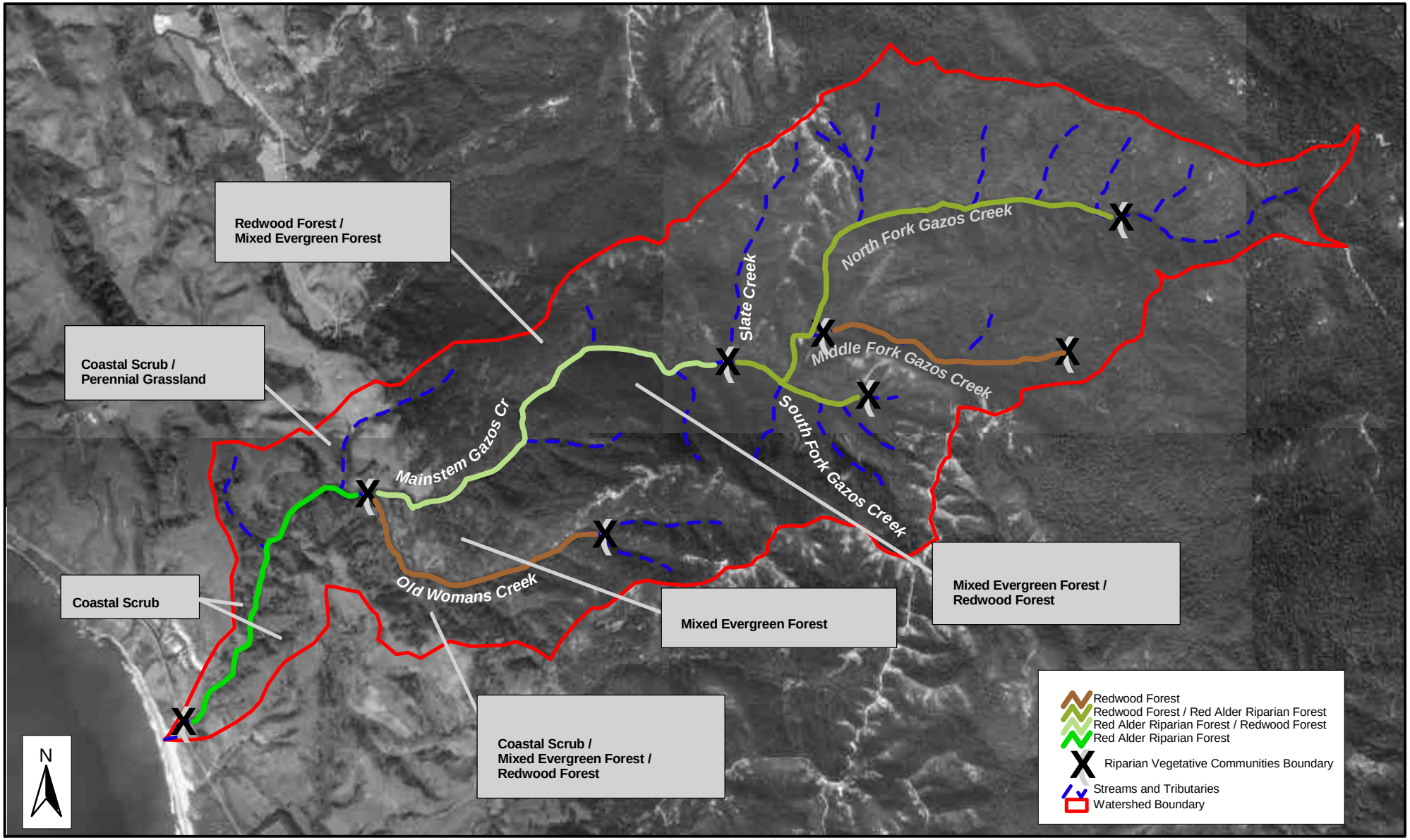
Primary plant communities

Within the riparian corridor five primary plant communities are present with many transitional patterns: 1) From the upstream end of the lagoon to one half mile upstream, poison oak is dominant from the water's edge to the top of the streambank and upland. There is no tree canopy within this stretch of the riparian area; 2) Upstream of the single residence, the plant community becomes more diverse and is dominated by Central Coast Riparian Scrub (scrub oak, willow, and California bay with a mixed understory of poison oak and blackberry); 3) From approximately Road Mile 1.3 to Site K (approximately road mile 3), a red alder riparian and mixed evergreen forest is dominated by live oak, alder and buckeye with a sparse understory of shrubby plants, primarily red elderberry, poison oak, ferns and blackberry. At Old Woman's Creek, red alder riparian forest persists but the community reflects some of the continued human presence with plum trees, Himalayan blackberries and European grasses as well as periwinkle and forget-me-not. 4) From Site K up through the Mountain Camp area, the red alder riparian corridor is dominated by 40' to 60' alder, mature oak, redwood and Douglas fir trees, sparse undergrowth, and shrubby vegetation. Continually moist stream banks are occupied by several species of fern and rushes.

Canopy Cover

Sixteen locations were sampled with a 50'radius from a randomly selected central point within the riparian corridor. This method indicates that the average cover within the corridor ranges from a low of 16% to a high of 98% with the mean being 64%. There are few areas within the corridor that are without cover but these are rare occurrences. Bank undercuts with overhanging rootwads and shrubs provide cover and shade in most places where no large trees are present. The stream banks provide other vegetation such as fern, elk-clover, and thimbleberry.

Additional riparian canopy closure data were collected as part of the fisheries habitat survey and are summarized here for comparison. The riparian canopy closure was typical of small Central Coast streams and upper reaches of larger watersheds, with generally increasing stream shading in an upstream direction. Reach averages from limited frequency measurements ranged from 52% (Reach 1) to 85% (Reach 7) on the mainstem, with the South Fork near 75% (Reach 8). In 2001, the overall mean canopy closure for all of the reaches combined was 65% (n=77). The optimal condition is to have the least canopy closure while maintaining water temperatures within the acceptable range for



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Gazos Creek Watershed Riparian and General Forest Canopy Map.

Colored lines refer to vegetative make-up of the riaprian corridor
while the text boxes refer to the vegetative make-up of the highlands.

coho salmon and steelhead. In this regard, tree canopy in Gazos Creek was likely optimal. The zone of more frequent coho use (Reaches 5A-B to 6) was more shaded than downstream, with approximately 75% average canopy closure in 2001. Canopy closure over Gazos Creek was provided primarily by deciduous riparian forest (alder/willow/big leaf maple, coastal live oak) in Reaches 1 and 2, about half deciduous and half evergreen (conifer/bay laurel/tanoak) forest in Reach 3 and primarily conifer/bay laurel/tanoak in Reaches 4-7. The South Fork was dominated by evergreen forest (Reach 8).

Density

Tree density indicates that downstream of Old Woman's Creek Bridge most sites are occupied by trees of 6' or less DBH (diameter breast height) and the density ranged from 32 to 40 trees per 1,000 square ft. Upstream of Old Woman's Creek Bridge the trees are more mature and of larger species such as oak and Douglas fir. The DBH averaged 8 – 14" and the density was considerably less ranging from 18 to 30 trees per 1,000 sq.ft. In and around the Mountain Camp area the density increases to 40-50 trees of 12" DBH per 1,000 sq.ft. with some specimens measuring 18 – 26" DBH.

Invasive Species

Although the Gazos Creek watershed is relatively undeveloped and uninhabited, it has a wide diversity of invasive plant species. Distribution vectors include wind, water, roadways, human intervention, and to a lesser extent, birds and mammals. The most common invasives found in the watershed are listed below:

- *Hypericum canariensis*, a member of the St. Johnswort family is abundant from Gazos Creek road both south and north to the area at the top of the west-facing slope of the hill facing Hwy 1. A graduate student at San Jose City College is studying this plant.

- *Cortaderia jubata* (pampas grass) is evident in all draws from the beach inland and in scattered upslope areas. Becoming more evident along the Gazos Creek road right-of-way from Hwy 1 to Cloverdale Road with scattered sparse occurrences along the road shoulders.
- *Vinca major* (periwinkle*)* is also evident beginning in the area just east of Hwy 1 along the Gazos Creek Road right-of way and occupies areas up to 200' in diameter in some places. There are heavy occurrences approximately 1.0 miles inland, 500' upstream of Old Woman's Creek Bridge and at Slate Creek.
- *Cytisus scoparius* (Scotch boom). Although there are sporadic areas of growth alongside the road, the majority appears in dense patches upstream of Gazos Creek Road at Slate Creek and on the inboard side of the road at Site U.
- *Mentha pulegium* (pennyroyal) has recently become evident in the ditch areas along Cloverdale Road from the intersection with Gazos Creek Road north approximately 2.0 miles. This is a highly invasive species and will spread through the waters in the ditch into Gazos Creek very quickly.
- *Myosotis latifolia* (forget-me-not) abounds throughout the disturbed areas where there is no native ground cover. It can also be found on sandbars in mid-stream and along the riparian corridor in areas without native cover.
- *Plantago coronopus* (plantain) occurs along the disturbed roadside areas

F. Road and Land-use Survey of Gazos Creek Watershed

Varying levels of road surveys were completed for the Gazos watershed based on available resources and access. The main regions are discussed by subwatershed below.

North Fork

Due to lack of access permission, no field surveys were conducted within the North Fork. However, aerial photo reconnaissance was conducted. The majority of the North Fork area was harvested, primarily in the 1970s and 1980s. A main haul road parallels the creek and eventually connects to the Butano Fire Trail/Johansen Road connector. It is likely that adjacent skid roads are present. The steepness in slope and close proximity to the creek, indicate that potential for road failure and direct sediment delivery to the creek is high. Although the North Fork does not provide coho habitat, identifying sediment sources and limiting sediment delivery here could be extremely important to minimize sedimentation in the mainstem.

Middle Fork

The Gazos Creek Road, which parallels Gazos Creek becomes a dirt road at the Pescadero Conservation Alliance Mountain Camp at mile 6.7. A handful of rural residential parcels and timberlands are accessed from the dirt road but its primary use is for recreation purposes as a connector to Big Basin Redwoods State Park. In some places, the road is not more than fifteen feet from the channel and has direct sediment transport into the creek. An inboard ditch is also present along most of the dirt road.

Due to sedimentation and erosion associated with the road, the San Mateo County Public Works Department (Public Works) now restricts winter vehicular access from October through April yet mountain biking use is still prevalent. In further efforts to minimize the negative impacts of the dirt road, the Public Works Department completed road improvements on one mile of unpaved road to reduce sedimentation to Middle Fork Gazos Creek (Lisa Ekers, personal communication). California Department of Fish and Game and the County of San Mateo provided funding for this project. A total of twenty seven rocked rolling dips, two 18" culvert replacements, one culvert installation, 4,000 lineal feet of outsloping, and berm removal were completed in early November 2002. Portions of the road may be rocked in the near future.

Bear Gulch (South Fork)

An unpaved road provides access for rural residential landowners and timber lands from Gazos Creek Road. This unpaved road winds up to the ridge where it connects with Johansen Road. A site reconnaissance performed in November 2001 with members of the Bear Gulch road association indicated a need for a road inventory and stormproofing recommendations. The road association hired William Lettis and Associates to conduct a road inventory and develop an erosion reduction plan. Based on inventory recommendations, the road association is currently pursuing funding to implement road upgrades to minimize erosion and sedimentation.

Mainstem

Several skid roads are present upslope (north) of Gazos Creek Road from approximately mile 3 to mile 5. Ground-truthing of this area was completed in winter 2001. Although many remnant skid roads remain and the road network has changed drainage patterns, extensive fill failure or erosion was not observed. Additionally, potential for direct delivery of sediment to the creek is very low due to the presence of Gazos Creek Road between the skid network and Gazos Creek. The primary result of the change in drainage patterns appears to be a dispersal of water that is not negatively impacting Gazos Creek. Therefore, extensive road inventory surveys were not conducted in this area.

Few roads were detected in aerial photos along the south side of Gazos Creek. During field reconnaissance, signs of historic logging pre-dating heavy equipment use (1950s) are present: mill remains, a splash board dam, evidence of steam donkey logging, and remnants of an old haul road that parallels the creek channel are apparent. These logging practices did not alter the landscape to nearly the same magnitude that pre-Forest Practice Act heavy equipment logging did (Neal Youngblood, personal communication). Additionally, much of the work that occurred in this area is over 100 years old and excessive failures adjacent to the mainstem were not observed. Therefore, the impacts observed within the mainstem, compared with other areas in the Gazos Creek watershed, did not warrant an in-depth road inventory as part of this watershed assessment.

The County-maintained Gazos Creek Road was not inventoried because, during the time of data collection, the County was preparing to conduct a road inventory using a private contractor.

Slate Creek

A defunct logging road parallels Slate Creek to the east approximately 30 meters upslope. Only the Sempervirens Fund portion was surveyed in the lower subwatershed. A sizable landslide has obliterated the road approximately 200 meters north of Gazos Creek Road. Along the roadbed, occasional slumping is evident, probably during 10-year and greater storm events, and has delivered sediment into Slate Creek.

Within the channel, benchmarks indicate the remains of a turn of the century roadbed probably dating from when oxen were used to haul logs (Neal Youngblood, personal communication). Indeed, a mill site was present in 1867 at the confluence of Slate Creek and Gazos Creek. Many cut old growth logs still remain on the hillslopes or in the channel; it is unclear why so many logs were cut but not removed for milling. A portion of the creek contained exposed bedrock. Downstream of the exposed bedrock portion, sedimentation and deposits from the landslide were apparent in the channel.

Although a thorough road inventory is needed, if the road is no longer used, decommissioning could be a straightforward restoration project.

Old Woman's Creek

Sources have listed Old Woman's Creek as a major sediment contributor to Gazos Creek (Smith, 1996; Nelson, 1994). During winter storms, the mainstem of Gazos Creek is visually much more turbid downstream of the Old Woman's Creek confluence than it is upstream. Based on aerial photo analysis, Old Woman's Creek drainage contains the highest concentration of roads built and/or utilized between 1953 and 1993, compared to other areas evaluated within the Gazos Creek watershed. From evaluation of aerial photos, high erosion potential exists in the upper portion of the drainage but no access was granted to evaluate this area of the drainage.

During the 1940s and 1950s, logging was the most intense within the middle and upper portions of the subwatershed, with roads prevalent on both sides of the northern ridge that divides Old Woman's Creek and the Gazos mainstem. Two primary roads were used historically, the existing Old Woman's Creek Road and the northern ridge road. Although portions of the northern ridge road are overgrown today, the majority of the road is still visible in the 1993 aerial photos. By the early 1970s, an expansion of logging increased the road network into the uppermost portion of the watershed, throughout much of Section 4 in the Franklin Point Quadrangle. All the roads found in the 1953 Old Woman's Creek data are still visible in the 1973 aerial photo. By 1993, many of the smaller skid roads within the mid-section of the subwatershed are barely visible. A widened road and slope failures are apparent in the steeper sections of the headwaters associated with the ridge road. More roads are seen to branch off this ridge road.

A road inventory was conducted on 1.7 miles of California Department of Parks and Recreation property along lower Old Woman's Creek Road.

Road Inventory and Technical Assessment of Old Woman's Creek road survey

At present, the unpaved road that parallels Old Woman's Creek is the primary road for vehicles to access the State Park and private properties within the subwatershed. Several skid and haul roads are associated with the primary access road. The two main sources of chronic and episodic sedimentation to Old Woman's Creek within California Department of Parks and Recreation property are the unpaved road and skid and haul roads between the unpaved road and Old Woman's Creek.

The Old Woman's Creek Road was not originally built for winter travel, yet it receives a relatively high volume of travel year-round. Steep terrain and infrequent and inadequate road drainage are the primary causes of sedimentation to Old Woman's Creek from the unpaved road. During the 2001 spring, less than ten functioning culverts over 1.7 miles of road were present. The inboard ditch, necessary due to the steepness of the area, is clogged in several locations and increases the diversion potential in many places. A total of forty-seven sites were inventoried. Seven of the sites inventoried are skid roads adjacent to Old Woman's Creek Road but work was not proposed for these sites. The remaining sites are directly associated with Old Woman's Creek Road.

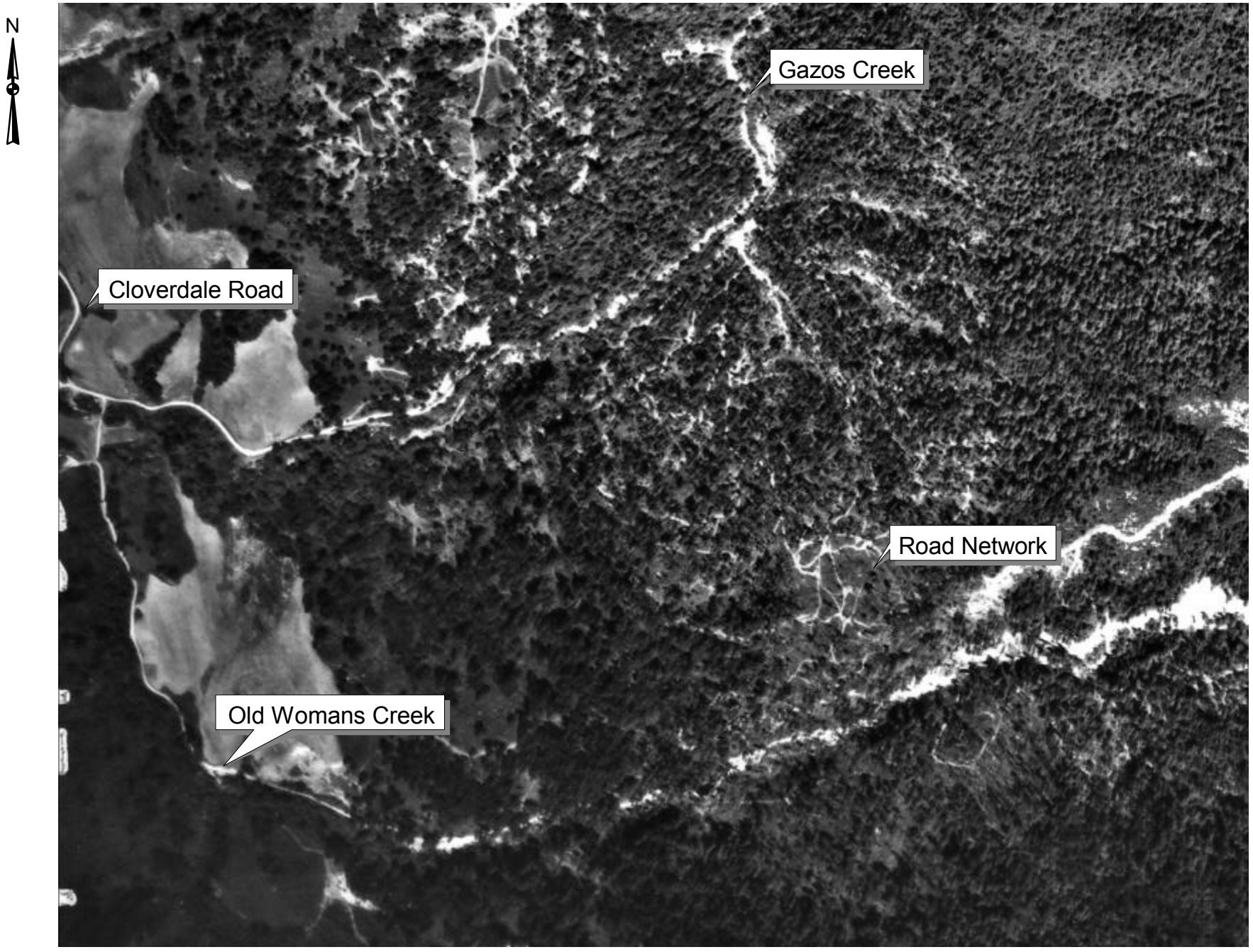
Based on the inventory (Table 12), the site types inventoried included the following:

- 1 landslide
- 4 stream crossings
- 5 road bed issues
- 6 ditch-relief culverts
- 7 skid roads
- 33 road-related drainage issues

There is a severe lack of drainage relief along the State Park portion of Old Woman's Creek road, especially on the upper 0.8 miles of road surveyed from the County line where the terrain is extremely steep.

Chronic surface erosion accounts for a large proportion of sediment delivery to Old Woman's Creek. Using the following calculation (Pacific Watershed Associates 2001): The total amount of surface erosion that will be delivered to Old Woman's Creek over a 10 year time period was calculated at 665 yds^3.

Conservative calculations for potential episodic sediment delivery totaled 17,035 cubic yards. Sediment volumes per site should be verified during the California Department of Parks and Recreation road inventory.



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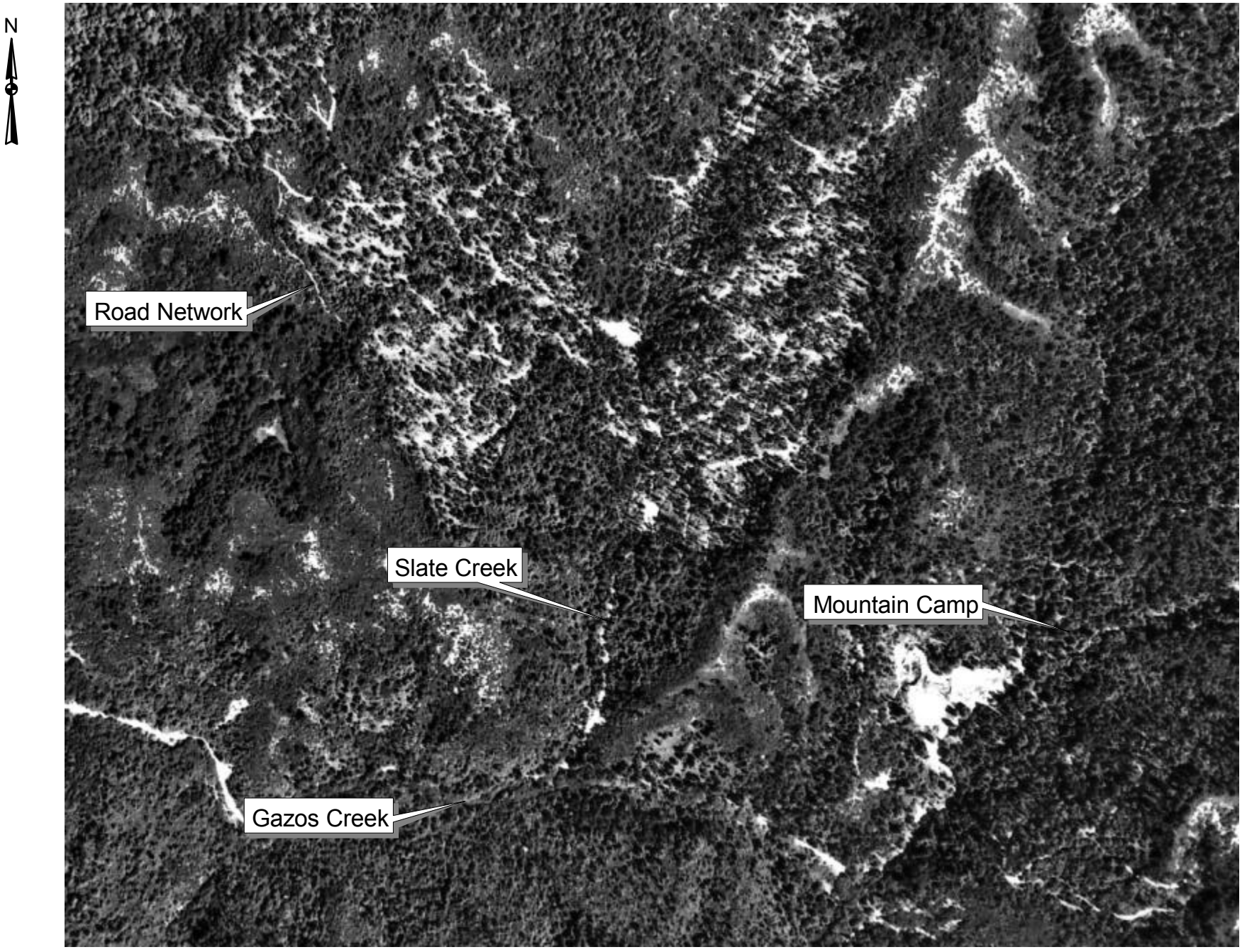
Aerial photograph from 1953 showing road network of woods roads in the Old Womans Creek and Cloverdale Road portions of the Gazos Creek watershed.

Temporary woods roads built mainly for forestry purposes provided ready sources for soil erosion.



Balance Hydrologics, Inc.

Aerial photograph from 1953 showing road network of woods roads in the Slate Creek and Mountain Camp portions of the Gazos Creek watershed.

Temporary woods roads built mainly for forestry purposes provided ready sources for soil erosion.

FINDINGS, RECOMMENDATIONS AND LIMITING FACTORS

Assessment findings were developed through a thorough interdisciplinary evaluation that included:

4) Historical data review
5) Field studies
6) Data analysis

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, providing input and prioritization on recommendations.

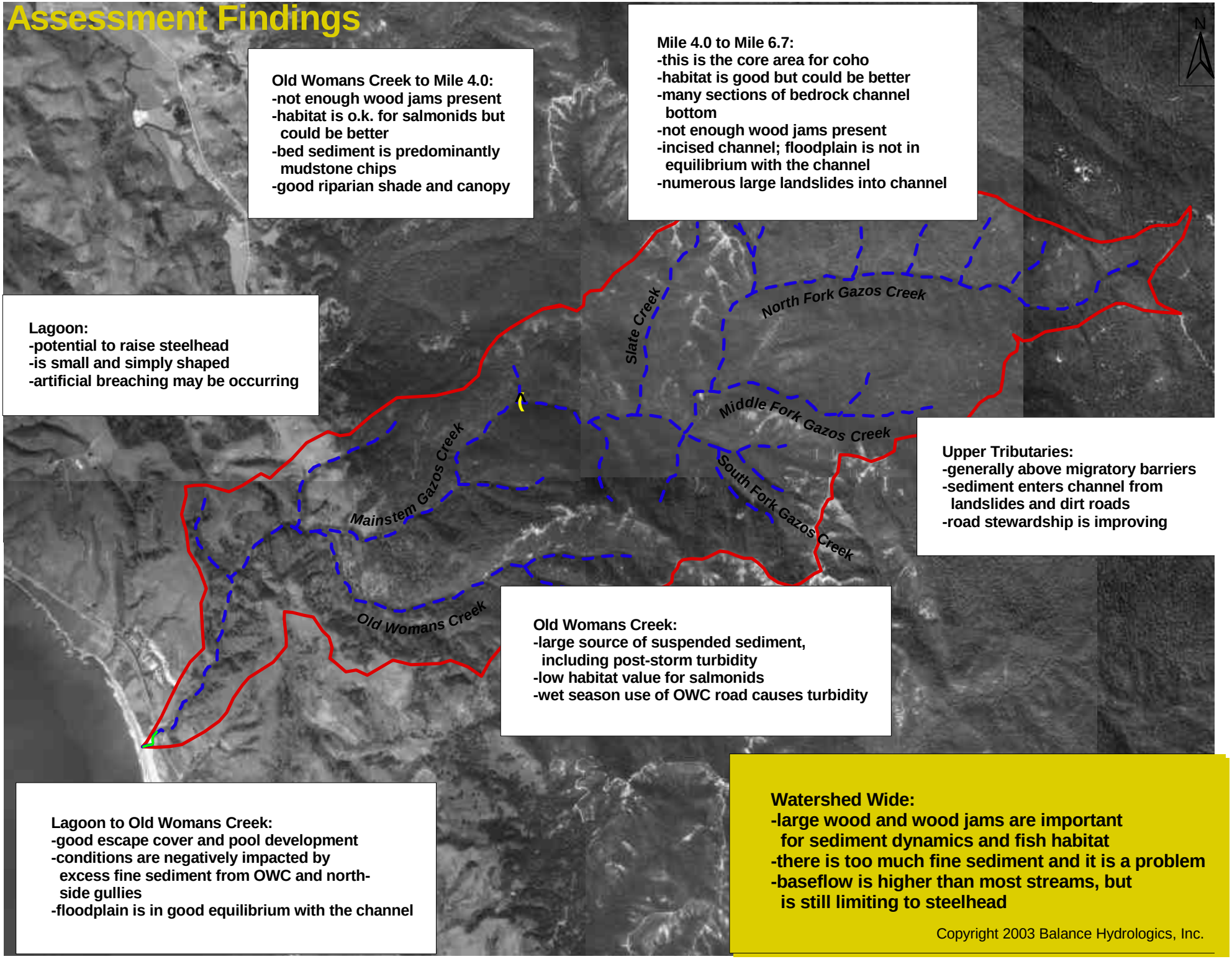
The assessment findings were divided into reaches based on salmonid habitat available (Figure 2).

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

Findings:

- Fine sediment is the primary problem throughout the watershed
- Gazos Creek has higher baseflow (estimated at 1 cfs) during normal water years compared to other Central Coast watersheds
- Although baseflow is better than most streams south of San Francisco Bay, it is a limiting factor for steelhead in Gazos Creek.
- Temperature is acceptable for coho and steelhead
- Water quality, with the exception of turbidity, is acceptable for coho or steelhead in Gazos Creek
- Numbers of young of the year steelhead are higher during wet years.
- 2002 was a record year for coho spawning in Gazos Creek, Scott Creek and Waddell Creek

Assessment Findings



Old Womans Creek to Mile 4.0:
- not enough wood jams present
- habitat is o.k. for salmonids but could be better
- bed sediment is predominantly mudstone chips
- good riparian shade and canopy

Mile 4.0 to Mile 6.7:
- this is the core area for coho
- habitat is good but could be better
- many sections of bedrock channel bottom
- not enough wood jams present
- incised channel; floodplain is not in equilibrium with the channel
- numerous large landslides into channel

Lagoon:
- potential to raise steelhead
- is small and simply shaped
- artificial breaching may be occurring

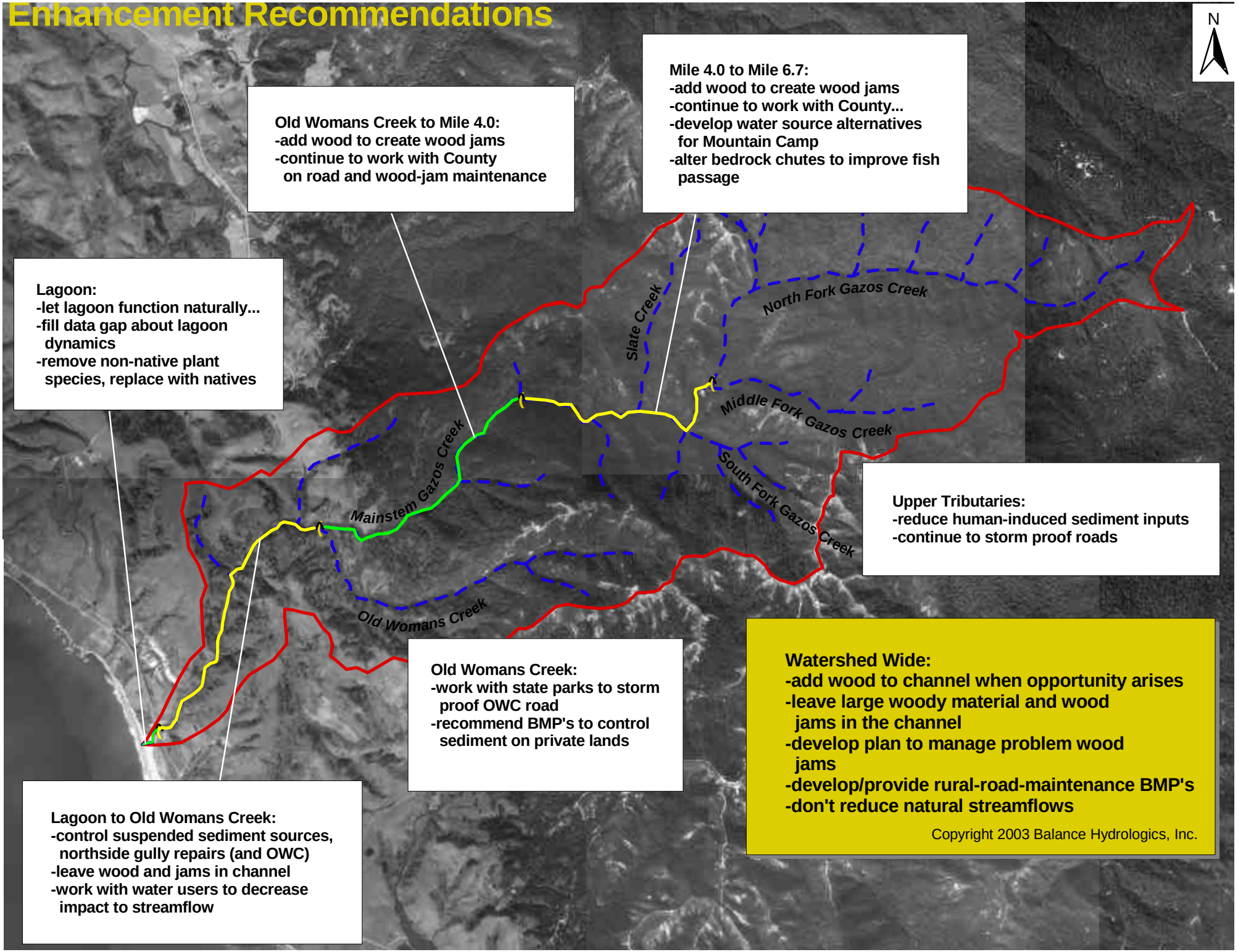
Upper Tributaries:
- generally above migratory barriers
- sediment enters channel from landslides and dirt roads
- road stewardship is improving

Old Womans Creek:
- large source of suspended sediment, including post-storm turbidity
- low habitat value for salmonids
- wet season use of OWC road causes turbidity

Lagoon to Old Womans Creek:
- good escape cover and pool development
- conditions are negatively impacted by excess fine sediment from OWC and north-side gullies
- floodplain is in good equilibrium with the channel

Watershed Wide:
- large wood and wood jams are important for sediment dynamics and fish habitat
- there is too much fine sediment and it is a problem
- baseflow is higher than most streams, but is still limiting to steelhead

Enhancement Recommendations



Recommendations:

- Maintain an ecologically-functioning riparian corridor that includes the 100-year floodplain.
- Coordinate with the San Mateo County Public Works Department on project development and implementation

Develop/provide rural road and land maintenance best management practices (BMPs) for all private landowners and public landowners (e.g.: nonnative plant removal, erosion control, road winterization)

- Preserve natural flows:
  Summer baseflows should be maximized where possible.
  Create off-stream winter harvest water storage for current diversions
- Provide information to landowners regarding development and cost-sharing programs for private wells
- Develop a management plan on proper instream large wood management techniques.
  - Leave large woody material (LWM) instream
  - When the opportunity arises, manipulate wood to enhance instream habitat with input from a qualified interdisciplinary team (fisheries biologist, geomorphologist, and hydrologist)
- Survey Gazos Creek every year or, at a minimum, after wet years (~5-10 years) for: fish barriers, barrier modification assessment, and fish habitat enhancement opportunities.
- Provide information to landowners regarding benefits of conservation easements

Gazos Lagoon (includes the mouth of Gazos Creek at Gazos State Beach upstream to Highway One):

Findings:

- The Gazos Creek lagoon is small and relatively simple compared to other Central Coast lagoons
- The lagoon has the potential to raise steelhead but there is no saltwater transition in the estuary during the spring which limits the smoltification process of steelhead
- Artificial breaching of the lagoon may be occurring
- Gazos Beach is infrequently posted by San Mateo County Environmental Health Department indicating water quality is not a primary issue
- Nonnative plant species such as German ivy and cape ivy are present upstream of Hwy 1 on the south side. German ivy can kill native riparian trees.

Recommendations:

- Maintain the natural summertime sandbar; nno artificial breaching without further study of habitat impacts

- Maximize inflows and depth of a freshwater summertime lagoon for steelhead rearing habitat and maintain sufficient flow during drought years, especially during springtime smolt outmigration
- Determine minimum flow requirements to provide steelhead habitat
- Use signage to educate public on the importance of sandbars and lagoons for steelhead
- Fill data gap: conduct lagoon monitoring (including water quality and freshwater conversion rates)
- Install water quality monitoring device in the lagoon
- Remove nonnative invasive plants and replace with deciduous native trees (e.g. willows, alders)
- Monitor for native vegetation regeneration and return of invasive plant species

Lagoon to Old Woman's Creek confluence

Findings:

- Steelhead rearing habitat is negatively affected by excess fine sediment, especially from Old Woman's Creek and gullies on the north side of Gazos Creek in the Cloverdale Road area
- Aquatic insect production is limited by fine sediment (interstitial spaces and attachment sites are reduced)
- Higher rates of suspended sediment are present compared to other areas in the watershed, which negatively impacts spring feeding of salmonids
- Gullies are present on North side upslope (Peninsula Open Space Trust and California Department of Parks and Recreation property adjacent to Cloverdale Ranch). There has been a large-scale loss of topsoil from historic flax farming and cattle grazing. POST is addressing gullies on Cloverdale Ranch.
- Poor spawning habitat exists throughout the reach due to excessive fine sediment
- Spawning and rearing habitat are at high risk due to stored sediment in Old Woman's Creek.
- There is a relatively wide flood plain and the flood plain is in equilibrium with the channel.
- Good escape cover and pool development are present relative to other reaches
- Gazos Creek maintained flow during an extreme drought year (1976)
- Pumping from shallow wells (<100 feet deep) within the creek alluvium reduces stream flow
- There are several locations where the existing road is undercut by the channel.
- The majority of large woody material (LWM) is hardwood (1-2' diameter breast height, or DBH)
- Nonnative invasive plants are present upslope, include pampas grass and exotic grasses, which have a very shallow root mass and do not hold the soil in place. Cape ivy is present within the riparian corridor
- Riparian canopy is primarily deciduous and averages 85% cover.

Recommendations:

- Reduce sedimentation and erosion from Old Woman's Creek watershed (see Old Woman's Creek section):
    - Conduct further studies of Old Woman's Creek (cross-sections, general geomorphic characterization, longitudinal profiles) to determine sediment reduction options
    - Recommend BMPs on California Department of Parks and Recreation lands and roads to reduce sedimentationRecommend BMPs in the Old Woman's Creek watershed for private residential lands to reduce sedimentation
    - Develop and implement a restoration plan for north side upslope gullies on State Park property
- Control road-related sediment sources
- Conduct further water user education (e.g. time of extraction, amount of extraction, etc.)
- Acquire water rights from willing sellers
- Acquire land or conservation easements from willing sellers
- Leave naturally-occurring LWM in the lower Gazos Creek reach to mitigate sediment threats from Old Woman's Creek.
- Adding additional wood to this reach is a low priority because a) LWM will need to be imported from other areas and b) LWM is more likely to be transported during high flows
- Develop European nonnative grasses eradication and native revegetation plan for Cloverdale Ranch and California Department of Parks and Recreation lands to reduce gully erosion

Old Woman's Creek (OWC) tributary

Findings:

- OWC is a significant source of sediment for Gazos Creek downstream of the confluence.
- Severe channel incision is present in this reach.
- There is a high potential for OWC to move laterally - hence, high sedimentation of Gazos Creek below the confluence is likely.
- OWC Road receives a great deal of use year-round and is a significant source of sediment. The road requires 4WD during the wet season.
- OWC has persistent turbidity following storms (even small storms).

Low habitat value is present for salmonids yet steelhead were reported previously abundant

- Pools are shallow and sandy.
- The lower valley near the confluence (0.5 mile reach) is inundated with flood deposit sediment (possibly from 1956).

- The lower portion of OWC contains mostly same-sized (and probably even-aged) riparian trees. This is problematic because they will die at the same time causing widespread bank instability.
- Based on aerial photo evaluation, the highest concentration of roads are present within OWC compared to other watershed reaches and tributaries.
- Historic gullies and skid roads are failing on California Department of Parks and Recreation property.
- 1993 aerial photos show a large amount of exposed ground in the upper watershed indicating a change over time.
- Baseflow is probably not a substantial component of overall Gazos Creek flow

Recommendations:

Overall goal: Reduce suspended sediment in Gazos Creek from Old Woman's Creek

- Reduce erosion attributable to roads and other land uses
- Treat existing gullies
- Decommission skid roads with potential for direct delivery to Old Woman's Creek
- Provide landowners with road and land use BMPs to reduce sedimentation
- Conduct a thorough geomorphic characterization of Old Woman's Creek to prioritize sediment reduction
- Stabilize lower Old Woman's Creek to reduce sediment delivery to Gazos Creek

Confluence with Old Woman's Creek to road mile 4.0

Findings:

- Relatively good rearing habitat is present in this reach, including a large amount of wood scour-formed pools and escape cover
- Spawning is a problem for coho in many years here due to a mobile bed and fine substrate
- Spawning is not a limiting factor for steelhead here
- Gazos Creek Road constrains the channel in some locations and requires increased maintenance and log jam management
- Steep banks are present
- The lower portion of the reach has a relatively large number of log jams
- There is a lot of smaller wood (small diameter and short length) outside the low flow channel
- The reach lacks sufficient LWM (primarily for winter refuges, especially upstream of mile 3.0)
- If enough LWM was still present, the channel would still be in equilibrium and there would be better fish habitat
- In terms of hydrology, this is an overall gaining reach

- At mile 3.0, the substrate changes from an alluvial to bedrock bed (the bedrock increases upstream and very little bedrock is present downstream of mile 3.0)
- Mile 3.0 to 4.0 is a transitional region for channel stability and vegetation types
- High embeddedness (>50%) of (what) occurs, but this is not a limiting factor to fish densities
- Cobbles and boulders are scarce
- There are upland landslides and bank failures present
- There is good riparian canopy and amount of shade present

Recommendations:

- Add wood actively to trap sediment and improve habitat
    - Drop trees into the creek near other LWM away from the road
    - Monitor any LWM restoration projects
    - Any LWM management affecting fish passage should include an interdisciplinary team (fish biologist, geomorphologist, and hydrologist)
- Preserve shallow ground water (no future wells)

- Where drainage facilities (including ditches and culverts) are necessary, manage them to ensure they function properly
- Remove slide debris deposited on the road and transport it away from riparian areas as soon as possible in accordance with San Mateo County standards
- Remove nonnative invasive plants (including periwinkle, French broom and others)

Road mile 4.0 to extent of anadromy (~mile 6.7)

Findings:

- This is the core area for coho
- Rearing habitat is good
- There are good pools, substrate, escape cover and canopy cover
- Spawning habitat is better in this reach than in the rest of Gazos Creek
- There is larger substrate and a more stable bed
- Much more bedrock areas on the channel bottom are present compared to other reaches
- There is less escape cover compared to downstream but it is still relatively good
- Few large wood jams are present and overall, the reach lacks sufficient wood
- There are a lot of small loose pieces of wood
- Large amounts of fine sediment limit coho spawning and rearing habitat, as well as aquatic insect food production
- There is a high amount of sediment delivery (both suspended sediment and bedload) from the South Fork
- This reach is generally an incised channel; the flood plain is out of equilibrium

- There is one potential barrier (bedrock chute) downstream of the South Fork during drought years
- There are some shallow landslides with restoration potential on the mainstem
- The Mountain Camp contains an off stream pond; water diversion into the pond can be significant during drought years
- There are red-legged frogs, nonnative fish and nonnative vegetation present in the pond
- Nonnative plants present include periwinkle, Scotch broom, English ivy and forget-me-nots

Recommendations:

- Include the same recommendations for LWM as in the previous section
- Preserve baseflow, including developing water source alternatives for Mountain Camp that minimize impact to baseflow
- Repair shallow landslides where feasible

The following tributaries were not investigated in depth, primarily due to lack of access. Therefore, the findings and recommendations listed for each tributary are based on:

- ❖ Historical data;
- ❖ Current knowledge of the tributary; and
- ❖ General watershed knowledge or knowledge of adjacent watersheds

Slate Creek

Findings:

- Habitat is of low value for steelhead and coho due to low flows and bedrock chutes
- Old timber roads parallel the channel
- An unstable landslide on the east side of Slate Creek transects an old timber road approximately 0.1 miles upstream from the confluence
- Nonnative invasive plants (forget-me-nots, periwinkle) are present

Recommendations:

- Reduce human-induced sediment inputs
- Decommission unused timber roads adjacent to stream channel
- Purchase land or conservation easements from willing sellers
- Conduct an assessment of erosion-risk attributable to roads
- Remove nonnative invasive plants

North Fork

Findings:

- Old timber roads are present adjacent to channel
- Resident rainbow trout have been observed in the lower section

Recommendations:

- Reduce human-induced sediment inputs
- Decommission unused timber roads adjacent to stream channel
- Purchase land or conservation easements from willing sellers
- Conduct an assessment of erosion-risk attributable to roads
- Remove any nonnative invasive plants present

Middle Fork

Findings:

- The tributary is not accessible to coho and steelhead due to a barrier at the Mountain Camp bridge near the confluence
- Middle Fork has limited habitat value for steelhead and is unsuitable for coho due to the steep gradient

- Fine sediment enters the channel from the dirt road; the road constricts the channel in several locations
- San Mateo County Public Works Department annually closes the road to public use from October through April to reduce motorized vehicular use during the wet season
- San Mateo County Public Works Department recently completed road improvements to reduce sedimentation
- Channel gradient becomes very steep

Recommendations:

- Continue best management practices necessary to reduce erosion and sedimentation of the stream caused by the County dirt road
- Purchase land or conservation easements from willing sellers
- Conduct feasibility study to decommission portions of the County road where it constricts the channel

Bear Gulch

Findings:

- An erosion risk road assessment of Barranca Knolls Road was completed (funded by the road association) by William Lettis and Associates (2002)
- Barranca Knolls Road needs stormproofing to minimize sedimentation
- Natural barriers (a log jam and a waterfall) to fish passage are present approximately 1000 feet from the confluence with the mainstem.

Recommendations:

- Stormproof Barranca Knolls Road according to best management practices recommended in William Lettis report to minimize sedimentation
- Provide watershed residents with road and land BMPs
- Work with landowners to evaluate potential sediment issues on private lands

DATA GAPS

Due to lack of access on private lands, limited duration of the assessment studies, and limited resources, there are gaps in the data collected during the Gazos Creek assessments. We hope these data gaps will be addressed in the future when funding and resources become available. The following list of data gaps is provided to steer future watershed investigations:

- Fish sampling:

  Bear Gulch

North Fork
Lagoon (summer sampling)
Mainstem (winter and spring sampling)

- Fish habitat surveys:

  Old Woman's Creek
  North Fork

- Road inventory and sediment reduction plans:

  North Fork
  Slate Creek
  Mainstem
  Old Woman's Creek

- Gully restoration monitoring on Cloverdale Ranch
- Lagoon water quality monitoring
- Multi-year stream gaging

III. ACTION PLAN

COMMUNITY PRIORITIES

Landowners within the Gazos Creek watershed, though few in number, have a strong commitment to their land and the Gazos Creek region in general. During public meetings and public advisory group meetings, several individuals shared their goals and concerns for the watershed. During the initial stage of the watershed assessment, many individuals shared concerns for how the data might be used or interpreted by others outside of the watershed assessment process. Both the California Department of Fish and Game and the State Coastal Conservancy have emphasized that this enhancement plan is to provide landowners and stakeholders with recommendations and projects that encourage voluntary implementation, rather than enforcing regulatory action.

In recent years, concerns have grown among Gazos Creek landowners over protecting property rights due to situations they have observed in adjacent communities and the fact that they are surrounded by publicly owned lands. Although there is no current threat that landowners will be forced out of their ownership, many feel pressure from soaring coastal real estate prices and associated land purchases by developers and land preservation groups, alike. Several PAG members were uncomfortable with recommending land purchases in the enhancement plan. They felt that it was important to stress that recommending land acquisitions within the watershed was merely one option.

Finally, some residents wondered if, by the time the enhancement plan was completed, funding would still be available to actually implement the recommended projects. As of this writing, there are several sources of funding available through the California Department of Fish and Game, the Regional Water Quality Control Board, the Coastal Conservancy, and others, due to the recent passage of several water quality and watershed protection bond acts. Project proponents should contact staff at these agencies to discuss potential funding.

PAG Recommendations

During PAG meetings, PAG members suggested additional recommendations for the enhancement plan. An important point PAG members stressed is that more landowners might be willing to become involved in restoration projects, especially for projects that require collective action or cost-sharing, if California Department of Parks and Recreation, CDFG or the County undertook some demonstration projects first.. Additionally, demonstration projects conducted on public lands first will help encourage private landowners to take similar steps.

After discussion of the findings and recommendations in Section II, the PAG provided some additional recommendations and emphasized the importance of certain recommendations. PAG recommendations included:

1) Add wood to the creek to increase salmonid habitat
2) Reduce silt from Old Woman's Creek
3) Repair road repairs completed on Old Woman's Creek Road in 2000 that failed
4) Identify landowner incentives for implementing best management practices
5) Identify road alternatives to Old Woman's Creek Road (e.g.: the historic ridge road to the east of Old Woman's Creek)
6) Repair unpaved road along the Middle Fork (this was completed in November 2002)
7) Repair some of the large landslides (e.g.: Bear Gulch)
8) Design County road repairs before failure (preventative maintenance)
9) Decrease the time it takes to repair storm-related County road damage
10) Provide information regarding conservation easement development
11) Provide information regarding development and cost-sharing programs for private wells

RESTORATION GOALS AND OBJECTIVES

The overarching goal of the Gazos Watershed Enhancement Plan was to develop restoration recommendations and projects to enhance the quantity and quality of salmonid habitat available. With this in mind, several objectives were established while the project list was created:

- 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
- Time frame of implementation should be clearly stated (long-term or short-term)
- Habitat enhancement should be quantifiable

PRIORITIZED PROJECT LIST

The technical team developed a list of prioritized projects to enhance both steelhead trout and coho salmon based on the recommendations. 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 Gazos Creek watershed. We have proposed these projects with the idea that implementation would occur within the next ten to fifteen years.

Table 5 lists the projects, descriptions and priority ranking. Several high priority projects (ranked 1 or 2) are detailed as conceptual plans in Section II to facilitate future implementation and are described more fully than the other projects.

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, 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:

Table 5. Prioritized Restoration Project List for Gazos Creek Watershed

Project No.	Project Title and Description	Priority
1	Reduce erosion on lower Old Woman's Creek Road (implement CWC's 2002 SB271 stormproofing plan)	1.0
2	Be receptive to people who might want to sell water rights, develop resources to purchase water rights from willing sellers	1.0
3	"Create additional starter wood jams" (5 separate LWM addition projects) include monitoring to modify method	1.0
4	Stormproof "Barranca Knolls" Road	1.0
5	Build off-stream reservoir to store winter flow to reduce reliance on baseflow diversions	1.3
6	Purchase land from willing sellers (North Fork, Slate Creek, and Middle Fork)	1.3
7	Conduct erosion-risk assessments on private roads in North Fork, Slate Creek, and Middle Fork	1.4
8	Develop road network stormproofing and/or decommissioning plan for private portion of Old Woman's Creek drainage	1.5
9	Conduct roads assessment on California Department of Parks and Recreation lands	1.5
10	Wood-jam management round table (workshop for LWM management w/Co DPW & California Department of Parks and Recreation)	1.6
11	Develop gully treatment plan for gullies draining off of California Department of Parks and Recreation land adjacent to Cloverdale Road	1.7
12	Conduct erosion-risk assessment for roads on private lands	1.7
13	Reduce sedimentation attributable to gullies Ca Dept of Parks and Recreation land near Cloverdale road	2.0
14	Plant riparian trees in floodplain of Old Woman's Creek	2.0
15	Lagoon outreach/signage (steelhead habitat importance)	2.2
16	Operate telemetered stream gaging station (long-term)	2.3
17	Implement conservation easements with willing landowners	2.3
18	Purchase land from willing sellers (North Fork, Slate Creek, and Middle Fork)	2.5
19	Conduct feasibility study for geomorphic characterization of lower Old Woman's Creek reconstruction	2.6
20	Landowner BMP outreach (roads and landsliding issues)	2.7
21	Develop conservation easements with willing landowners (North Fork, Slate Creek, Bear Gulch, and Middle Fork)	2.8
22	Eradicate non-native fauna and flora from Mtn Camp pond	3.0
23	Develop fish-passage improvements to increase extent of anadromy in upper mainstem	3.2
24	Lagoon monitoring (water quality/gage)	3.3
25	Stabilize shallow landslides	3.8
26	Non-native invasive plants removal	4.0
27	Develop water source alternative for Mountain Camp (e.g. nonriparian well)	4.0
28	Provide educational seminar and materials for water users	5

1) Create starter wood jams

***Description*:** Add starter logs for wood jams to mainstem Gazos Creek in the target reaches, or add large logs to existing wood jams.

***Purpose*:** Large logs are intended to serve as nucleation points to catch smaller wood to form wood jams.

***Conditions*:** At locations where the creek meanders away from the road, and where access is easy for equipment. Permission from the landowners will be needed, particularly if logs will be derived from standing wood on site.

***Benefits*:**

- Wood jams provide slow-water habitat for fish. Wood jams provide deeper pool habitat for fish. Wood jams provide overhanging and cover habitat for fish.
- Wood jams trap sediment, which buffer pulses of high sediment contributions.
- Trapped sediment raises the bed level of the creek, which includes more spawning sized gravel, and allows deeper pool formation.
- The raised bed level brings the channel into better equilibrium with its floodplain, which allows increased trapping of fine sediment on the floodplain, without interfering with the transport of coarse sediment in the channel.
- A small wood jam might trap up to 5,000 cubic feet of sediment; a larger wood jam might trap up to 30,000 cubic feet of sediment. Depending upon the number of wood jams, this much sediment could be a significant portion of sediment production from landslides and bank failures in the watershed.

***Details*:**

- The high-priority locations are in the mainstem of Gazos Creek upstream from mile 3 to the extent of anadromy, because few large wood jams are there, and because that area seems to be the important area for coho spawning and rearing.
- Initially at about 4 to 8 pilot locations, where monitoring will occur to assess effectiveness and modify techniques.
- At about 50 or more locations eventually.
- Old stumps can also be effective additions, particularly for anchoring other logs.
- Wood jams are not expected to last forever, we expect that logs may wash downstream and/or be caught at other wood-jam sites.
- Specific placement of the logs will be site dependant, but should consider:
  - sufficient length of log (about 20 feet) extending out of the channel to provide non-floating weight to help keep the logs in place;
  - at least two or three large and long logs per location (min. 2-ft diam., 40 feet, preferably redwood);
  - logs could be hauled to the site or felled at the site from standing wood;
  - logs should be placed at locations where there is naturally a pool downstream and sediment accumulation (like a riffle) upstream; and

• placement should minimize bank scour, and can take advantage of bedrock banks or large wood already in an alluvial bank that provide more resistance to scour.

- Logs should not be secured with cables, chains, reinforcing bar, or other like restraints.
- Some logs may be available from a restoration project near San Gregorio a short distance to the north.

Lead Agency or Group: San Mateo County Department of Public Works, California California Department of Parks and Recreation, local watershed group

Cost Estimate for approximately 5 wood jam locations:

Locations and Plans	$ 2,000
Construction	$ 10,000
Monitoring	$ 5,000

Monitoring should include the following elements made just after the wood is placed and then sequentially after several wet seasons:

1) three monumented cross-section surveys upstream and three downstream from the placed wood;
2) longitudinal profile survey extending at least 200 feet upstream and downstream from the placed wood;
3) qualitative description of amount of wood and sediment caught by the placed wood, and bank scour associated with the placed wood; and
4) site photographs to document changes.

2) Wood-jam management round table

***Description*:** Cooperative seminar with County Road staff, California Department of Parks and Recreation road staff, biologists, and geomorphologists to discuss and plan how to deal with wood jams that might be threatening roads and/or bridges.

***Purpose*:** Agree on basic ideas on how to deal with wood jams; develop better communication and contingency planning before an "emergency" arises; devise a set of instructions or guidelines that staff can follow.

***Conditions*:** A meeting to discuss and confirm ideas, and then a real live wood jam to adjust.

***Benefits*:**

- Wood jams that threaten roads or bridges can be dealt with in a quick and efficient manner.

- County and California Department of Parks and Recreation road staff can feel like they can do their job without unduly distressing endangered species.
- Wood jams that threaten roads or bridges can be adjusted without being totally removed, so that benefits of wood jams can be maintained.

***Details*:**

- Regulatory staff should participate also, such as Environmental Protection Agency, California Department of Fish and Game, Regional Water Quality Control Board.
- Identify a mechanism to communicate meeting material to those who will actually be doing the work.
- If existing wood jams can be found in the Gazos Creek, or other watersheds, those could be adjusted during non-emergency conditions with team members on site to ground truth ideas developed at the indoor portion of this seminar.
- Hold a short, refresher meeting each fall to prepare for the upcoming wet season.
- Identify a way to perpetuate this information into the future, since large wood jams may only need to be adjusted every ten or twenty years, and memories and people may fade.
- Develop a phone tree to request advice if necessary.

Lead Agency or Group: Coastal Watershed Council, San Mateo County of Public Works Department, California California Department of Parks and Recreation, or local watershed group

Cost Estimate: $5,000

***Monitoring* :**

1) Photographs, qualitative descriptions, and measurements of wood jam height, pool depth, and amount of sediment stored behind the wood jam; these should be repeated each year that the jam remains in place.

3) Long-term telemetered gaging station

***Description*:** Continue/resume operation of the stream gaging station that Balance Hydrologics, Inc. operated about ½ mile upstream from mouth of Gazos Creek. The data should be accessible by website or telephone.

***Purpose*:** To provide data for water users and researchers.

***Conditions*:** If funding can be found.

***Benefits*:**

- Water users can make knowledgeable decisions about diversion rates compared to streamflow.

- Researchers can find out about streamflow and water temperature to better plan their work (fish surveys for example).
- The flow data would be a valuable component in watershed monitoring, such as monitoring suspended-sediment levels.
- The flow data would be valuable in evaluating the performance of in-stream projects.

***Details*:**

- Data is updated to the website in real time, about every two hours.
- Monthly site visits are necessary for measurements and calibration.
- Use reliable brands of equipment with backup sensors.
- Contract with a consulting company to perform the work.

Lead Agency or Group: local watershed group, resource agency or Peninsula Open
Cost Estimate: $18,000 per year

4) Add bedrock "pot holes" to increase salmonid habitat

Description: Increase number of pot holes (a.k.a. ink wells) present at bedrock chutes; model new pot holes on existing pot-hole dimensions.

Purpose: To make upstream fish passage easier. The bedrock chutes are currently difficult, but not impossible, for fish to pass up them.

Conditions: If fishery biologists agree that this is a good idea.

Benefits:

- Pot holes disrupt the supercritical flow down the chute and provide deeper water for resting and jumping.
- They should also improve upstream fish passage at low flows.

Details:

- The first location should be in Gazos Creek mainstem a short distance (about 200 yards) below Bear Gulch (South Fork). The second location should be on Gazos Creek North Fork just above the Middle Fork. These locations are shown in Figure 5 of the geomorphology assessment.
- Locations may be judged on how much increased habitat they provide access to. Measure dimensions and map locations of existing pot holes in the chutes; the pot holes are about 1.5 feet in diameter and are about tow feet deep.
- Plot new locations to create a string of pot holes up one portion of the chute; the locations should probably alternate side to side somewhat.
- Implementation should be easy, two people, a few sand bags, and a jack hammer.
- Fish and Game representatives believe that permitting would be simple.

Lead Agency or Group: Local watershed group

Cost Estimate *per chute* (a total of 4 to 6 new potholes are needed):

Study and design	$ 1,500
Construction	$ 2,000
Monitoring	$ 500

Monitoring:

1) Measurements of the depth and size of the potholes should be made after construction, and then after a few years to assess whether the constructed pot holes are stable.
2) Fishery assessment to determine if more fish are able to pass up the bedrock chutes than previously.

5) Stabilize shallow landslides

Description: Identify and stabilize the soil on shallow landslides.

Purpose**:** To stabilize landslides that can be more easily revegetated. Landslides that have not lost their soil cover should be easier to revegetate than landslides that are down to bedrock.

Conditions**:** Finding a source of volunteer or low-cost labor such as a youth conservation corps group.

***Benefits*:**
- Stabilized landslides should contribute less fine sediment to the creek channels, thereby improving spawning conditions for fish.
- Repairing rills and gullies should reduce soil loss on the slopes.

***Details*:**
- Focus on slides that are close to creek or directly drain to creek.
- Techniques may vary depending on the site and on conditions. Techniques will be needed to deal with bare soil, rill erosion, and gullies.
- Emphasize the use of local and native materials in repairs; bare soil can be easily colonized by invasive exotics.

Lead Agency or Group: Watershed group, local community group, California California Department of Parks and Recreation or private landowner

Cost Estimate *based on a quarter-acre slide:*

Study and design	$ 2,000
Construction	$ 5,000
Monitoring	$ 2,000

***Monitoring*:**
1) Revisit the site after each wet season to qualitatively evaluate the degree of erosion.
2) Document with photographs
3) If a more rigorous approach is desired, a small sediment basin could be constructed in the drainage below the slide area. The volume of sediment coming off of the repaired slide could then be quantified.

6) Lower Old Woman's Creek Reconstruction

***Description*:** Regrade and revegetate the riparian zone of lower Old Woman's Creek

***Purpose*:** To stabilize vertical banks & provide a floodplain area for overbank flows.

***Conditions*:** This would be an extensive and expensive project. To reduce costs, it could be tied to the Old Woman's Creek Sediment Reduction project.

***Benefits*:**
- Stabilized and vegetated banks should contribute less fine sediment to the creek channels, thereby improving conditions for fish in the lower 2 miles of Gazos Creek.
- The reconditioned channel will have better opportunities for fish habitat which can restore the once abundant fish population.

- The channel will be in better equilibrium with its floodplain, which allows increased trapping of fine sediment on the floodplain, without interfering with the transport of coarse sediment.

***Details*:**
- Design a bankfull-equilibrium channel with a wide riparian floodplain.
- Incorporate sufficient structural elements (like redwood logs) within the channel to provide the hydraulic diversity to form natural features like deep pools, overhanging banks, and spawning riffles. Large structural elements would be appropriately placed about every 25 feet.
- Old Woman's Creek contributes a disproportionate amount of fine sediment and turbidity to the mainstem of Gazos Creek, both during high flows and following high flows when the Gazos is running clearer.
- The lower portion of Old Woman's Creek is characterized by vertical or near-vertical banks often up to ten feet high.
- The lower portion of Old Woman's Creek seems to have been deluged by deep sediment deposits, maybe in 1955.
- Currently the pool habitat is very poor for fish, although anecdotal evidence (Ed Conant) from the early 1900's recalls abundant fish in Old Woman's Creek.

Lead Agency or Group: California Department of Parks and Recreation

Cost Estimate:	Study and design	$ 30,000
	Construction and revegetation	$ 150,000
	Monitoring	$ 20,000

***Monitoring*:**
1) multiple monumented cross-section surveys (about ten);
2) longitudinal profile survey extending upstream and downstream from reconstructed reach;
3) qualitative description of geomorphic evolution of the reconstructed reach; and
4) site photographs to document changes.

7) Reduce Sedimentation Attributable to Old Woman's Creek Road

***Description*:** Implement road best management practices on Old Woman's Creek Road.

***Purpose*:** Reduce sedimentation and erosion to Old Woman's Creek

***Conditions*:** This would be an expensive project initially but would reduce maintenance costs and reduce sediment delivery to Old Woman's Creek over time.

***Benefits*:**
- Reduced sedimentation to Old Woman's Creek and therefore reduced sedimentation to Gazos Creek.

***Details*:**

- Details are provided in Appendix H. Old Woman's Creek Sediment Reduction Proposal

Lead Agency or Group: California California Department of Parks and Recreation

Cost Estimate: $150,000-$200,000

MONITORING PROGRAM

Basic Approach

The Gazos Creek post-assessment monitoring plan has been developed to be legitimate, repeatable and useful. In an attempt to meet these criteria, we recommend using historic monitoring locations where appropriate, which in most cases have been appropriately monumented. We have suggested a list of monitoring report recipients to inform as many responsible and interested parties as possible and have provided direction on which parameters to monitor. The details of the monitoring program were specifically developed by addressing the watershed monitoring goals, which were developed by the watershed assessment team. The monitoring goals for Gazos Creek include:

A. Continue to build upon our understanding of the year to year variability in coho salmon *(Oncorhynchus kisutch*) and steelhead trout (*Oncorhynchus mykiss*) population dynamics,
B. Continue to increase our understanding of general physical watershed conditions with specific attention given to annual or flow-specific rates of bedload and suspended load sediment transport, annual rates of baseflow discharge and baseflow season[6] water temperatures,
C. To evaluate the effectiveness of any site-specific enhancement project which is implemented in the post-assessment period at the site- and reach-scale, and
D. To fill-in post- and pre-assessment monitoring data gaps.

Based on these four monitoring goals, a plan has been developed which should provide the data needed to address these goals. The monitoring plan consists of two distinct scales of monitoring as well as monitoring aimed at filling existing data gaps. The three types of monitoring suggested are:

1. General watershed conditions or health monitoring (physical and biological),

2. Project specific monitoring, and

3. Monitoring to fill existing data gaps

[6] Baseflow season is typically defined by the period June through September of any given year.

Monitoring of general watershed conditions or health in the post-assessment period allows us to assess changes in big picture watershed scale processes from conditions established and discussed in each of the Gazos Creek Watershed Assessment reports completed with this plan. Monitoring general watershed conditions is valuable because these conditions presumably represent the net product of countless interactions between hillslopes, the stream channel, the floodplain and any anthropogenic activities which impact these watershed component areas.

Project specific monitoring allows us to (1) evaluate the effectiveness of the repair or restoration approach and (2) assess upstream and/or downstream effects of any implemented enhancement project to the alluvial corridor. In the case where project specific projects entail the acquisition or leasing of land, monitoring for project effectiveness and associated impacts will require more care and detail than this monitoring plan provides. Project specific monitoring is valuable because it allows us to evaluate specific and/or general restoration approaches and change or better these approaches or designs where needed, such as in the event that a particular design has more negative than positive effects. Perhaps one of the largest contributions that can be made to the public and larger restoration community is to share successes and failures with other professionals such that the community can grow together and so that others may learn from those that have come before them.

Filling-in existing monitoring data gaps is important because it allows us primarily to (1) refine current hypotheses which were based on the existing knowledge and data base and (2) expand our current understanding of physical and biological watershed processes in Gazos Creek. Each of these three types of monitoring will be described in more detail below.

Our thinking behind this monitoring approach stems from the concept that watershed conditions and/or enhancement project effectiveness cannot be evaluated or validated by a mutual means of monitoring alone. For example, it would be problematic to suppose that implemented enhancement projects could be monitored for effectiveness from a static monitoring site located more than roughly 8 to 10 bankfull widths downstream of the project location or in any event upstream of the project location. Conversely, it would be equally problematic to believe that general watershed conditions could be assessed with monitoring data collected from locations where specific enhancement projects have been implemented due to the possible effect of site-related conditions exaggeration.

Watershed Conditions

Physical Conditions

Physical watershed conditions should be assessed in the future through collection of four types of data:

- basic water quality including water temperature and specific conductance,
- both suspended load and bedload sediment discharge,
- baseflow discharge, and
- channel cross-sectional level surveys.

These parameters should be monitored at an established location in the watershed which has served as a monitoring location in the past; a logical choice would be the site of the existing Gazos Creek Department of Fish and Game stream gage located roughly one half mile upstream of the lagoon. It is important to use established monitoring locations to collect future data so that comparisons can be made between future and historic data; failure to collect the data in the same locations could lead to misinterpretations as to trends in watershed conditions. In addition to the stream gaging location, repeat channel cross-sectional level surveys and a longitudinal profile should be completed at EPA site Q, also known as site 9S, for all 10 cross-section at this site. Channel geometry level-survey data has been collected at this site in 1998 and 2002. There are no other sites where cross-sectional or longitudinal data have been collected.

Monitoring of sediment discharge, baseflow discharge and basic water quality should occur every two to three years. Monitoring of these parameters will likely involve operation of a stream gage for an entire water year. Alternatively, operation of the gage only during baseflow months with sediment discharge and storm discharge measurements conducted during winter months and cataloged as instantaneous measurements of sediment discharge and streamflow discharge would also be useful. By using the later approach, future comparisons between only instantaneous measurements of sediment discharge at a given flow could be made- total sediment loads, however, could not be calculated. Re-measurement of channel cross-sectional and longitudinal geometry should be completed every three to four years, or if funding comes available every two years. In the event of a 5-year[7] or larger recurrence interval flood peak in Gazos Creek, all physical conditions monitoring should be implemented as soon after the flood peak as possible to capture immediate post-flood peak impacts to the system.

Salmonid conditions

Salmonid conditions in the watershed should be assessed in the future by conducting three types of assessments:

- fish sampling aimed at calculating species populations by developmental stage,
- inventory passage barriers, and
- inventory large wood in the channel.

Salmonid sampling and habitat characterization should be completed every two to three years, at the very minimum. Coho salmon population sampling should not occur less frequently than every three years due to their 3-year life cycle and the possibility of realizing the loss of the three year classes one year too late (in the event that sampling occurs at a frequency greater than once every three years).

[7] Despite the extreme potential for coastal variation in storm generated precipitation even at the scale of a few miles, the USGS gage on Pescadero Creek could be used to determine if a 5-year recurrence interval flood peak has occurred.

Enhancement-Specific Project Monitoring

We will provide basic effectiveness monitoring guidelines for several different types of enhancement projects developed and conceptualized by the assessment team and which the public advisory group commented on. We cannot provide monitoring criteria for all projects outlined in Section III because certain types of projects do not merit monitoring. For instance, projects 6 and 21 are focused on buying land or conservation easements from interested and willing land holders in the any of the upper watershed tributaries and Slate Creek. These types of projects do not warrant the development of a monitoring program at this point and time, but could in the future once parcels are bought and/or an easement is granted at which point the conditions of any parcel(s) could be assessed and a plan developed.

Below we will outline basic effectiveness monitoring for the following enhancement projects and types of enhancement projects:

- Large wood placement,
- Reduce sedimentation/erosion of Old Woman's Creek Road,
- Stormproofing of Barranca Knolls Road,
- Riparian tree planting along the channel,
- Stabilization of shallow landslides, and
- Removal of exotic, non-native flora.

Large wood placement along the mainstem of Gazos Creek (see Project 1)
Several general locations have been chosen for the placement of large wood into the active channel. These locations were chosen with care and most notably distance and orientation to Gazos Creek Road in mind. If large wood is placed in the channel, the immediate reach where the wood was placed should be monitored for the following:

- Pre-placement channel conditions: a longitudinal profile and several channel cross-sectional level surveys should be completed to document pre-placement channel conditions The channel bed and banks should be photographed and the condition of Gazos Creek Road at the site should be noted and photographed as well.

- Post-placement channel and road condition: a longitudinal profile and previously surveyed channel cross-sections should be measured immediately following wood placement. In general, the site should be visited after every major winter storm during the first post-placement winter to visually assess channel and road conditions. Thereafter, these measurements should be made at least once every three years and accompanied by be photo-documentation of channel and road conditions. If at any time it looks as if Gazos Creek Road is in jeopardy, contact the Coastal Watershed Council and the San Mateo County Department of Public Works. The Coastal Watershed Council should also be contacted if deleterious effects are evident upstream or downstream of the placed wood, such as an increased occurrence of channel bank failures.

Sediment Reduction for Old Woman's Creek Road (see Project 7)

Pre-storm proofing conditions of Old Woman's Creek should photo-documented (if not already completed) for ease of comparison once storm proofing has been completed. Once storm proofing has been implemented, the length of road storm-proofed should be walked after every major storm during the first and second post-implementation winters to assess drainage functioning of the road, condition of any culverts paying particular attention to whether culverts are jammed with debris and activity of previously identified road related bank failures. Additionally, suspended sediment discharge should be monitored at the mouth of Old Woman's Creek during the first and second post-implementation winters. Suspended sediment discharge should be monitored because 2 instantaneous measurements were conducted in the winter of 2002 from which comparisons of instantaneous rates of transport could be made.

Riparian tree planting projects

Riparian tree planting projects should be monitored for tree survival rates at periods of at least 1, 2, 4 and 8 years from the date of planting. Additionally, during the first post-planting winter, locations where planting occurred should be visited following major storm to again assess tree survival rates.

Stabilization of shallow landslides

Shallow landslides which are stabilized should be monitored during the first and second post-implementation winters for landslide stability and level of activity. Pre-implementation landslide conditions should be photo-documented for comparison sake during these first two post-implementation winters. If stabilized landslides become active or experience large-scale failure during these first two winters the design engineer and construction company should be notified immediately so that the landslide can be assessed by the design team for design flaws or unaccounted for site conditions.

Removal of exotic, non-native flora

Locations where exotic, non-native flora is removed should be periodically monitored for re-emergence of the eradicated floral species as well as successes of native flora re-growth and re-emergence.

Communicating Monitoring Results (move this section to the end)

Interested individuals, agencies or groups need to be able to obtain and use the data collected. Hence, much of the value of the study rests upon disseminating the data, both during data collection and once monitoring reports are prepared.

During data collection

Information can be disseminated *during the period of study* through (a) on-going Coastal Watershed Council programs, (b) reports made available to the larger regional technical

community through groups such as Blue Circle, and (c) filings of mitigation monitoring reports with the State Clearinghouse. Additionally – and importantly – data collected may be made available to San Mateo and Santa Cruz County, such as the San Mateo County Public Works Department.

Monitoring reports:

Annual reports will be readable documents. The reports will summarize the observations as well as the field and laboratory results for each of the sampling stations or locations. Maps presenting the results should be included. Text will also include brief discussions of how the observed values compare with goals and standards of the Enhancement Plan and the Monitoring Program (goals outlined above in this chapter). The annual monitoring reports should be written in a manner that they may serve as a basis for discussion by others as how to further enhance the presentation and dissemination of future monitoring data. Additionally, copies of annual monitoring reports should be provided to long-lived collections or repositories where interested individuals may reasonably seek the information in the years to come. We believe these include:

- San Mateo County RCD
- Santa Cruz County RCD
- San Mateo County Department of Public Works
- San Mateo County Planning Department
- County of Santa Cruz Planning Department
- County of Santa Cruz Environmental Health Division
- City and County Library system collections at:
    - Santa Cruz
    - Half Moon Bay
- UC Santa Cruz, Special Collections
- UC Santa Cruz, Science Library
- California State University, Monterey Bay
- UC Berkeley Water Resources Archives
- Association of Monterey Bay Governments
- California Regional Water Quality Control Board, Central Coast Region
- State Water Resources Control Board
- California Department of Fish and Game, Monterey office
- Monterey Bay National Marine Sanctuary
- Coastal Watershed Council
- Watershed councils, other agencies and land conservancies requesting monitoring-program archival status

Interested neighborhood or other project cooperators (such as landowners providing access to the sampling team) should be able to request and obtain annual monitoring report in summary, full, electronic, or hard-copy forms.

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IV. TECHNICAL APPENDICES

A. FISHERY ASSESSMENT

B. GEOMORPHIC ASSESSMENT

C. HYDROLOGIC ASSESSMENT

D. ROAD AND LAND-USE SURVEY OF GAZOS CREEK WATERSHED

E. RIPARIAN VEGETATION SURVEY

F. DISTRIBUTION AND ABUNDANCE OF STEELHEAD AND COHO IN GAZOS CREEK

G. DISTRIBUTION, SPECIES COMPOSITION AND ABUNDANCE OF TREES & LARGE WOODY DEBRIS ADJACENT TO & WITHIN GAZOS CREEK

H. OLD WOMAN'S CREEK SEDIMENT REDUCTION PROPOSAL

I. GAZOS CREEK TELEMETERED GAGE REPORT