San Pedro Creek Watershed Assessment and Enhancement Plan

Prepared by
San Pedro Creek Watershed Coalition

SAN PEDRO CREEK WATERSHED ASSESSMENT AND ENHANCEMENT PLAN

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This project represents the work of numerous individuals, including members of the San Pedro Creek Coalition; representatives from the City of Pacifica; hydrogeomorphological and biological consultants; San Francisco State University (SFSU) students and faculty; and Pacifica residents. Laurel Collins, Paul Amato, Donna Morton, and Jerry Davis developed the multiphase San Pedro Creek Geomorphic Analysis, assisted by SFSU students Kirsten Leising, Patrick O'Connor, Rachel Kanewske, Bill Withington, and Lisa Scianamblo. Mike Vasey conducted the Vegetation Analysis of the San Pedro Creek Lower Riparian Zone and Upper Watershed, assisted by Eugenie MontBlanc, Mike Fadden, Erika Kean and Tom Parker. Vivian Matuk, Bernard Halloran, Jerry Davis, Christine Chan and Carmen Fewless analyzed the water quality of The San Pedro Creek, assisted by SFSU students Patrick O'Connor, Lenka Cohn, Craig Jung, Juan Ochoa, and others. Jeff Hagar conducted the Steelhead Habitat Assessment, assisted by Monet Monaghan. Paul Jones provided help, guidance and support to develop this Assessment and Enhancement Plan, as well as leadership in an important restoration project – a bridge replacement in the county park – with the support of San Mateo County Parks personnel Mike Fritz, Doug Heisinger, Jess Gilley, and others. Jerry Davis, Jeff Johnson, and Erika Kean developed the Geographic Information System (GIS) database for the watershed, supported by SFSU's Institute for Geographic Information Science and its staff Tim Reed and Debra Dwyer. The City of Pacifica, especially Scott Holmes and Kris Krow, provided the Coalition with assistance and continuous support during the length of the project. Vivian Matuk provided coordination and document compilation. And finally, the project depended most heavily on the project management leadership of Christine Chan.

1. INTRODUCTION

This section describes the origins of the San Pedro Creek Watershed Coalition, the Coalition's purpose and the multidisciplinary approach used to develop the San Pedro Creek Watershed Assessment and Enhancement Plan.

1.1. San Pedro Creek Watershed Coalition

The San Pedro Creek Watershed Coalition arose from a convergence of concerns about and interest in the creek by an array of citizens with many backgrounds. Long-time residents remember times when the creek abounded with Steelhead Trout and even Coho Salmon, the latter said to have populated these waters as recently as 1950. These citizens and the new arrivals in the suburbs that covered the valley bottom saw a dramatic increase in flooding; for many years, the creek's flooding problems have dominated the community's awareness of the stream. Related bank erosion problems have also plagued creek-side residents, and from these two concerns a flood control project, addressing problems in the lower-most reaches, is now approaching completion. Several citizens active on the Flood Control Committee have remained interested in the creek, and wonder what the next phase will be.

Creekside residents have a unique perspective and interest in the creek. Some, like Roger Mascio and Bill Bassett, have made it a personal quest. Facing the loss of property in his back yard, but nobly more concerned about the fish, Bill observed that Steelhead were concentrating below bridge culverts and other barriers, especially at the Capistrano bridge fish ladder just upstream of his home. Others, like Charlie and Stephanie Benoit, have taken on the role of creek observers, noting every time they see it flow with a new color of paint dumped by a contractor somewhere upstream.

Another concern, especially at the creek's outlet at Pacifica State Beach, has been water pollution. In 1996, Bernie Halloran, Ph.D., a Linda Mar surfer and faculty member in the Department of Medicine at UCSF, convinced the Pedro Point Surf Club to begin a water-testing program, to determine whether ocean pollution was contributing to illness among

Pacifica's surfers. Water samples from the creek were tested at San Francisco's Oceanside Water Pollution Control Plant. The results showed that levels of total coliforms exceeded water quality maximums set by the San Mateo County health department 10-25% of the time, especially during winter rainstorms. Maximum coliform bacteria counts in the surf were eight times too high, with coliform levels up to 11 times higher than county Health Department limits near the mouth. Representatives from the Surf Club and Bernie Halloran notified the San Mateo County Health Department and met with Brian Zamora, Director of Public Health and Environmental Health Services of San Mateo County. The health department consequently posted the creek mouth as unsafe for human use (Wilkinson and Halloran 2001). Other residents, including Paul Jones, a Pacifica resident and environmental scientist with the EPA, found similar results in independent testing; Jones found that levels of E. coli and enterococcus exceeded safe limits (Wilkinson and Halloran 2001). Jerry Davis and Nancy Wilkinson, Pacifica residents and SFSU Geography professors, became interested in water quality issues at San Pedro Creek when their children developed flu-like symptoms after playing in the water at the creek's mouth.

Other citizens and scientists had been observing the expansion of invasive exotic plant species along the creek, even in San Pedro Valley County Park. Representatives from the park's volunteer group participated in community stewardship activities, attempting to eradicate some of the more invasive species, like Cape Ivy, from sections of the park. The Coalition's first Coordinator, Tricia Zimmerman, an SFSU Biology graduate student, helped organize an eradication project along the lower South Fork, which involved a team of dedicated park volunteers. Mike Vasey, a botanist at San Francisco State University, has become an expert on the watershed's riparian and upland vegetation communities. Park rangers contributed their knowledge of Steelhead spawning areas and known barriers to their migration within the park.

Starting in late 1998, these people came together to form a Watershed Coalition, bringing together agency representatives from the City of Pacifica, County Parks, the North Coast County Water District, the State Regional Water Quality Control Board, the US EPA and others, with scientists from nearby San Francisco State University and UC San Francisco, and devoted creekside residents. The Coalition with its inspired team of professionals and concerned citizens began to organize an extensive multi-disciplinary investigation of San Pedro Creek.

In spring 1999, the Coalition identified its goals at a series of public meetings. These include:

- Maintaining the watershed ecosystem through monitoring and adaptive management programs.
- Restoring the geomorphic function, native flora and fauna, and water quality to the maximum extent possible.
- Promoting awareness of critical watershed issues through ongoing programs of educations and community involvement.
- Working with the public and private sectors to promote and facilitate watershed protective measures.

The collaborative efforts of technical professionals, landowners, residents, students, districts and agencies have been the key to current successes of the Coalition. This multi-disciplinary approach will also be important to implement the Assessment and Enhancement Plan. Although the San Pedro Creek Watershed Coalition in just one example of the many community based watershed groups in existence today, their story is an example of the activities individuals are engaging in to protect and enhance their local watersheds. In January of 2001, the San Pedro Creek Watershed Coalition received 501 (c) 3 non-profit organization status.

The current structure of the organization includes:

Board
Jerry Davis, SFSU Geography (President)
Eulalia Halloran, Educator (Vice President; Chair, Education and Outreach committee)
Nancy Wilkinson, SFSU Geography (Secretary/Treasurer; Publications Director)
Bernie Halloran, UCSF Medicine (Chair, Water Quality Committee)
Mike Vasey, SFSU Biology (Chair, Non-Native Invasive Species Committee)

Staff
Chris Chan (Projects Coordinator)
Vivian Matuk (Watershed Coordinator)

Committees

- **Water Quality**
  - Bernie Halloran
  - Vivian Matuk
  - Christine Chan
  - Carmen Fewless
  - Paul Jones
- **Non-native Invasive Species**
  - Mike Vasey, Chair
  - Paul Jones
- **Education and Outreach**
  - Eulalia Halloran, Chair
  - Nancy Wilkinson
  - Patricia Delich
  - Vivian Matuk
  - Christine Chan
  - Jeri Flinn
- **Political Action**
  - Eulalia Halloran
  - Pete DeJarnatt
- **Geomorphology**
  - Jerry Davis, Chair
  - Paul Amato
  - Doug Eberhardt
- **Fish**
  - Ralph Larson, Chair
  - Bill Bassett
  - Jess Gilley
- **Fund Raising**
  - Christine Chan
  - Vivian Matuk

Watershed Support Team

- Landowners/Residents (not including board members)

Community Groups

- Beach Coalition
- Pacifica Environmental Family
- Pacifica Land Trust

Universities

- San Francisco State University
- California State University of Hayward

Local Government

- Scott Holmes, Pacifica Department of Public Works
- Pete DeJarnatt, Pacifica City Council
- Kris Krow, Pacifica Department of Public Works
- Eulalia Halloran, Pacifica Open Space Committee

Districts

- North Coast County Water District
- Laguna Salada School District

County Agencies

- San Mateo County Parks
- San Mateo County Health Services Agency

Regional Agencies

- San Francisco Bay Regional Water Quality Control Board

State Agencies

- California Department of Fish and Game

Federal Agencies and Funding Sources

- US Environmental Protection Agency
- National Fish and Wildlife Foundation

1.2. Objectives of the San Pedro Creek Watershed Coaliton: The Watershed Plan

Consistent with the San Francisco Estuary Institute's Watershed Science approach, the newly formed San Pedro Creek Watershed Coalition recognized the need for research that would reveal past and present conditions of the watershed to support and direct future restoration activities. They also recognized the need to undertake activities to address the immediate needs of the creek and its ecosystems. In order to best plan for short- and long-term needs, the Coalition has developed a Watershed Plan, through discussions at a series of meetings. Based on the goals delineated in 1999 and listed above, the San Pedro Creek Watershed Coalition has identified sets of objectives, organized in the following sections:
(a) **Geomorphic Assessment**; (b) **Biological & Ecological Assessment**; (c) **Water Quality Assessment and Mitigation**; (d) **Information Compilation, Analysis and Planning;** (e) **Restoration Program**; and (f) **Education & Outreach**. The specific objectives, listed on the following several pages, have been discussed in planning meetings in 1999, 2000, 2001 and 2002. The Coalition uses these meetings to update its goals and objectives, based on accomplishments and new information.

Table 1A. Geomorphic Assessment

	Funding	Cost	Who	When
Geomorphic analysis of main stem ♦ Field-based geomorphic analysis of main stem ♦ Quantitative and graphic representation of conditions. ♦ Classify stream reaches (Rosgen system)	RWQCB	14,780	SFEI Collins	1999-2001 completed
Develop Hydrologic Data ♦ Compile existing precipitation and hydrologic data – SPV County Park, Army Corps project ♦ Expand precipitation data with recording rain gauges ♦ Expand streamflow data with stage recorder	DFG		SFEI & SPCWC Amato, Davis	1999-2001
Work with City & Army Corps to develop restoration plans ♦ Next phase of flood control project. ♦ Capistrano Bridge Restoration ♦ Adobe Bridge Restoration			SPCWC	2001-ongoing
Longitudinal Profile: Main stem	DFG		SFEI, SPCWC	Fall 2001
Channel Cross Sections ♦ Middle Fork ♦ North Fork ♦ Main Stem sections	DWR		SFEI, SFSU, SPCWC	Spring 2002+
Upland Sediment Yield Analysis ♦ Aerial photographic analysis ♦ Field analysis Quantification of the sources of sediment (landsliding, slopewash, etc.) by tributary	SWRCB 205J		SFEI, SFSU, SPCWC	2002+

Table 1B. Biological & Ecological Assessment

	Funding Source	Cost	Who	When
Map riparian vegetation ▪ map & quantify riparian vegetation along main stem ▪ identify NIS & evaluate infestations ▪ extend into tributaries	RWQCBD FG		Vasey	1999-2002 completed
Map upland vegetation ♦ Create watershed scale map of veg. patterns using digitized satellite imagery, aerial photography & ground truthing.	RWQCB	3200	SFSU	1999-2002
Survey of non-indigenous species in lower reaches of creek & map NIS infestations.	RWQCB	4,000	Vasey	1999-2002
Macro-invertebrate survey. ▪ Map results ▪ Provide final report.	STOPPP	20,000+	SFSU, SPCWC	2002+
Perform fish habitat assessment. ▪ Field work ▪ Interpretation of Collins geomorphic report for mainstem habitat ▪ Map results ▪ Prioritize for restoration/barrier removal	DFG	10,000	Hagar, SFSU students	Fall-2001
Bird Survey	?	?	?	

Table 1C. Water Quality Assessment & Mitigation

	Funding Source	Cost	Who	When
Perform one year water quality assessment in creek and ocean. ♦ Physical (temp., conductivity, pH, etc) ♦ Biological (coliform, E coli, strept. etc)	DFG,	15,000	SFSU SPCWC	1999-2001 completed
Perform bacterial pollution source analysis ♦ Optical brighteners ♦ DNA fingerprinting	STOPPP, RWQCB	5000 + ?	SPCWC	2001-2002
Establish long-term water quality monitoring program ♦ Physical parameters ♦ Biological	?	10,000 per year	SPCWC B Halloran V Matuk	2001 - continuing
Institute sewer lateral ordinance: Inspect and repair at sale	?		SPCWC B Halloran	2001-2002
Evaluate BMP for urban/storm water runoff ♦ Catch basin filtration ♦ Link to sewer			SPCWC B Halloran, Matuk, Chan	2002
Carwash feasibility study for San Pedro Valley ♦ Linda Mar park & ride site for non-profit group funding activities	?	?	SPCWC E. Halloran	2002-2003

Table 1D. Information Compilation, Analysis and Planning

	Funding Source	Cost	Who	When
GIS Data / Map Development	RWQCBD FG in-kind		SFSU Davis	1999-2002, ongoing
Internet Map Serving, Web Development			SFSU others	2002+
Prepare history of land use ♦ interviews w/locals ♦ analysis of historic aerial photos.	RWQCB?		SFSU Wilkinson	1999-2002
Watershed Assessment & Management Planning			SPCWC, City of Pacifica	Planning Meetings: March 1999, April 2000, August 2001, ongoing

Table 1E. Restoration Program

	Funding Source	Cost	Who	When
Form committee, evaluate status of NIS infestations & identify treatment.	?	?	SPCWC	Committee formed 1999; Ongoing
Public input	?	?	SPCWC,	2001-2002
Prioritize Restoration Scenarios ▪ Prepare list of detailed restoration scenarios ▪ Prioritize projects. (also see geomorph, bio assessment)			SPCWC, City of Pacifica	
Daylight culverts where possible. ▪ North Fork/Library ▪ Sanchez fork? ▪ Oddstad School site?	?	?	SPCWC, City of Pacifica	2001-2002
Remove barrier to fish migration at Weiler Ranch road.	RWQCB, NFWF	63,000	SPCWC, County Parks	Nov. 2001 done
Perform NIS removal and revegetation projects. (Arundo, Cape Ivy, pampas grass). a. SPV County Park b. Creekside Townhouses southbank c. Creekside northbank	a. NFWF b. NFWF c.Trammell-Crow	a. 15k b. 15k c. 40k	SPCWC Vasey	2001-2002
Maintenance & Cleanup of Restoration				
Contact & form alliances w/other organizations working on NIS control issues.	?	?	SPCWC	Ongoing

Table 1F. Education and Outreach

	Funding Source	Cost	Who	When
Creek Days (cleanups)			SPCWC Chan	April, July, October
Web site ▪ Provide assessment data in map and tabular form			SPCWC	
Participation in Events ▪ Fog Fest ▪ Earth Day	?	400+	SPCWC Chan	ongoing
Work w/schools, involve students with projects.	?	3,000 – 5,000 per year	SPCWC E Halloran	
Construct scale model of watershed.	RWQCB, NFWF	1,000	SPCWC Chan	2000-2002
Develop program to reach out to existing community groups, involve them w/projects.	? Volunteer	?	SPCWC	Ongoing
Forge alliances & share info. w/other watershed groups.	? Volunteer	?	SPCWC	Ongoing
Brochure production	STOPPP	500+	SPCWC Wilkinson	2002
Publicize activities, meetings & goals via/ Tribune articles, announcements & flyers.		500 +	SPCWC E Halloran Coordinators City of Pacifica	Ongoing
Work with Creekside Residents ♦ update list of creekside residents ♦ provide residents w/regulatory and other information ♦ obtain access for on-going monitoring.	?	2,000 annually	SPCWC City of Pacifica	Ongoing
Establish water quality alert network, "Creek Watchers"	?	5,000. annually	SPCWC Chan	Ongoing
Stormwater education program ♦ develop and gather BMP materials for "hot-spot" businesses ♦ distribute information	?	5,000. start-up, 500/yr	SPCWC STOPPP City	2002
Hold regular SPCWC meetings.	?	5,000 annually	SPCWC E Halloran	Ongoing
Establish Riparian Station.	?	?	SPCWC	?

1.3 Restoration & Educational Work to Date

While major restoration work awaits the completion of this Assessment and Enhancement Plan, some activities do not require the scientific analysis the plan provides: (1) Non-indigenous Invasive Species management, along with replanting with riparian natives; and (2) ongoing creek cleanups. Perhaps the most important work is educating the community, especially creekside residents about how they can help, not harm the creek and its ecosystem.

The coalition has also been involved in restoring native vegetation, community education through and creek clean-ups (Figure 1.), improving fish passages (Figure 2.) and bioengineering workshops (Figure 3.).

Fig. 1. Creek Cleanup at North Fork, 2000 (Photograph by Patricia Delich).

Bridge Project at Weiler Ranch Road

On July 29, 2001, the Parks and Recreation Department of the County of San Mateo (County Parks) and the San Pedro Creek Watershed Coalition (SPCWC) began removal of a 26' concrete culvert from the middle fork of the San Pedro Creek in San Mateo County, California. The culvert and the overburden were removed and construction started with the goal of replacing the culvert crossing with a free-spanning bridge that is 45' in length. The existing 6-foot deep plunge pool on the downstream side of the culvert under the existing bridge was a barrier to fish migration and movement. Additionally, stream banks have been degraded due to eddying behind the culvert and accelerated stream flows exiting the culvert. The upper reaches of the middle fork and its tributaries provide ideal habitat for steelhead spawning and rearing. By replacing the existing earthen trail crossing and culvert in the middle fork of San Pedro Creek with a new, free-spanning, 45-foot long bridge, we will be able to stabilize and repair the Creek banks, recontour the slopes, plant native vegetation to reduce soil erosion, and improve wildlife habitat. Supporters of the project have included: SPCWC, City of Pacifica, San Mateo County Parks and Recreation Department, National Fish and Wildlife Foundation, Urban Creeks Council, Regional Water Quality Control Board, and the San Mateo County Parks Foundation.

Fig. 2. Bridge Project in San Pedro Valley County Park (Photograph by Jerry Davis 2001)

Bioengineering Workshop

The San Pedro Creek Watershed Coalition held a four-day bioengineering workshop in the fall of 1999. Ann L. Riley, of the Waterways Restoration Institute in Berkeley California, conducted the workshop, which was meant to teach city officials and private landowners how to naturally and effectively stabilize eroding banks along San Pedro Creek. The following photograph illustrates a Brush Layering technique that was taught at this workshop. (Chan, 2000).

Fig. 3. Bioengineering workshop at San Pedro Creek, 1999. (Photograph by Christine Chan)

1.4 The Physical Characteristics of the Watershed:

San Pedro Creek is an urban, coastal, perennial stream located in Pacifica, California approximately 15 miles south of San Francisco. It provides critical habitat for a state and federally threatened species, the steelhead trout (*Oncorhynchus mykiss*), and is the only stream with a steelhead population along a 30 mile reach of coast between the Golden Gate Bridge to the North and Half Moon Bay to the south (San Pedro Creek Watershed Coalition 1999).

Existing information about the 8 mi^2 San Pedro Creek Watershed has been gathered from existing data from the USGS and other sources, extended with interpretation of aerial photography, satellite imagery and some field observations, though most of the field analysis is described in the assessment to follow.

Like many Coast Range drainages, the San Pedro Creek Watershed (Figure 4) is drained by a network of perennial and intermittent streams, with many zero-order drainages susceptible to debris flows. In the 1970's, the North Fork was culverted, and many downstream tributaries are also underground. The impact of urban runoff is significant and is addressed later in this report.

The San Pedro Creek watershed is developed on an array of metasedimentary, metavolcanic and intrusive igneous rocks, and Quaternary alluvium and colluvium (Figure 5). Not surprising given its proximity to the San Andreas Fault, uplift and horizontal displacement are significant to its history. The creek is aligned along the Pilarcitos Fault, and Montara Mountain has experienced uplift along a vertical fault on its northern margins.

Soils

The geological framework produces a unique assemblage of soil and hydrological characteristics, though many of these we are only beginning to understand. While most of the soils (Figure 6) are mapped as mollisols (US Department of Agriculture, 1991) there are many local and lithological variations significant to the hydrology and flora. On a coarse scale, the greenstones to the north produce deep clay soils rich in magnesium and iron, the sandstones sandy textured soils, the granitics of Montara Mountain relatively shallow sandy soils, and the alluvium and colluvium soils of their own texture. Lenses of limestone and serpentinite produce local variations where they occur; for instance the well known association of endemic plants and unstable shallow soils on serpentinite.

Locally, sandstone seems to occur in two quite distinct textures. The predominant impure sandstones are rich in smectite clay. Local outcrops of relatively pure sandstones on the middle slopes of Montara Mountain produce very thin sandy soils vegetated by Manzanita chaparral. Due to naturally sparse vegetation, these were impacted preferentially by off-road vehicle use in the 1960's and 1970's, leading to significant sediment yield and debris flow production.

The watershed is approximately one-third built-up, with approximately 13% impervious cover (e.g. pavement and rooftops). Studies of vegetation communities in the surrounding protected areas are reviewed in a later document, with a detailed analysis in Volume II, but the general pattern is illustrated in Figure 6. Coastal scrub and chaparral dominate the hillsides, except on many sunny slopes where scattered grasslands occur. Significant Eucalyptus forest patches occur primarily where planted, but have also expanded from their initial distribution.

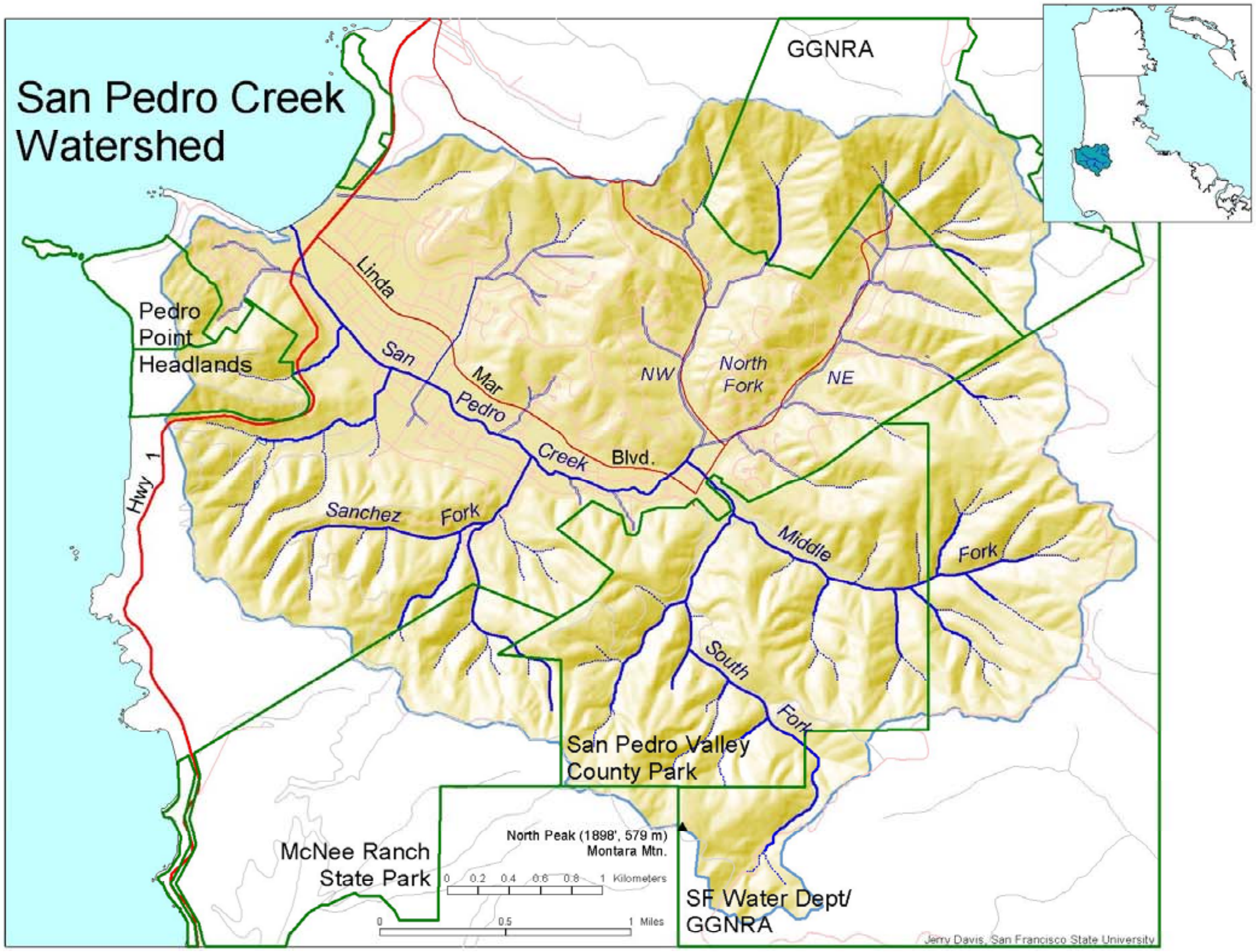


Figure 4. San Pedro Creek Watershed

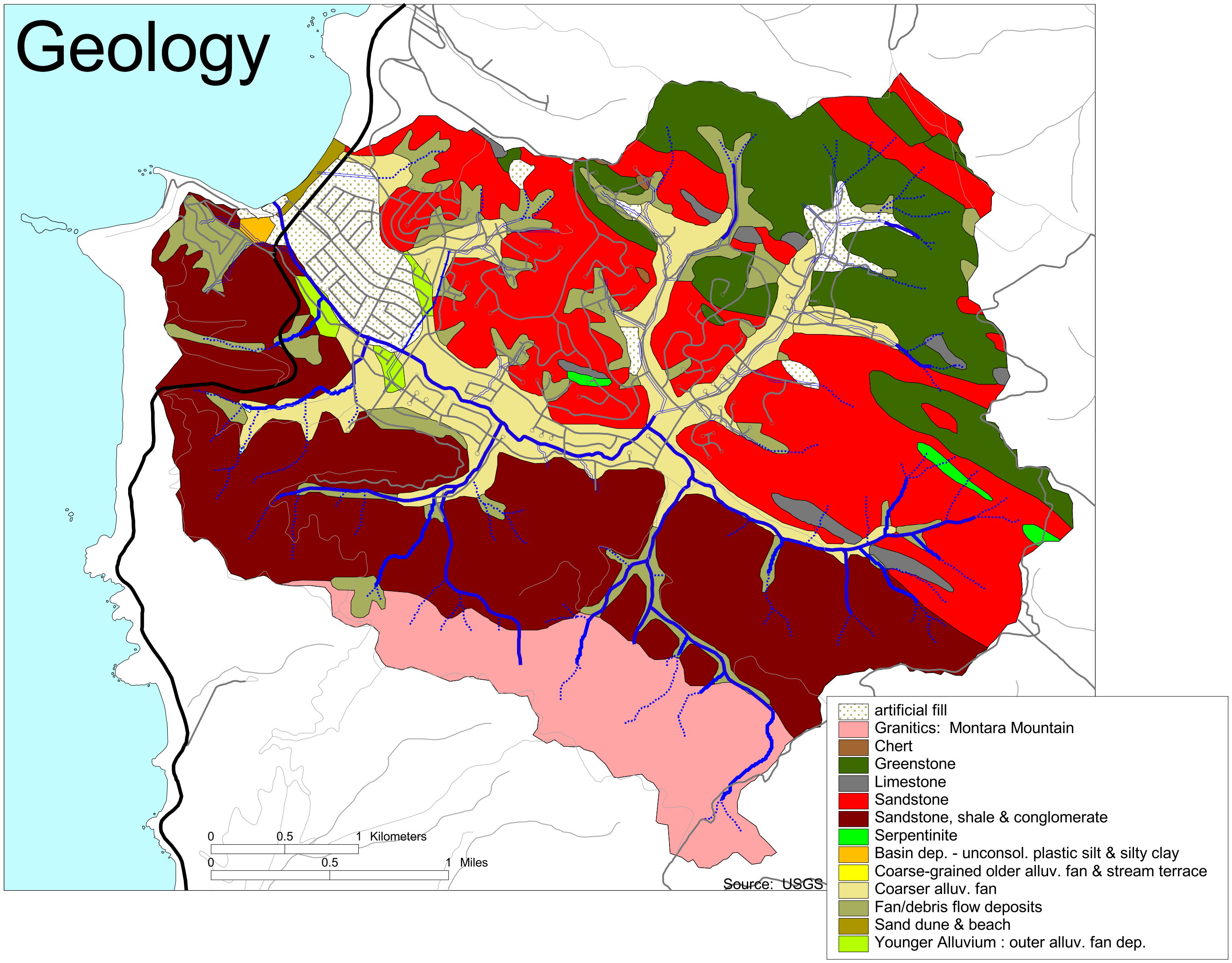


Figure 5. Surface Geology, San Pedro Creek Watershed

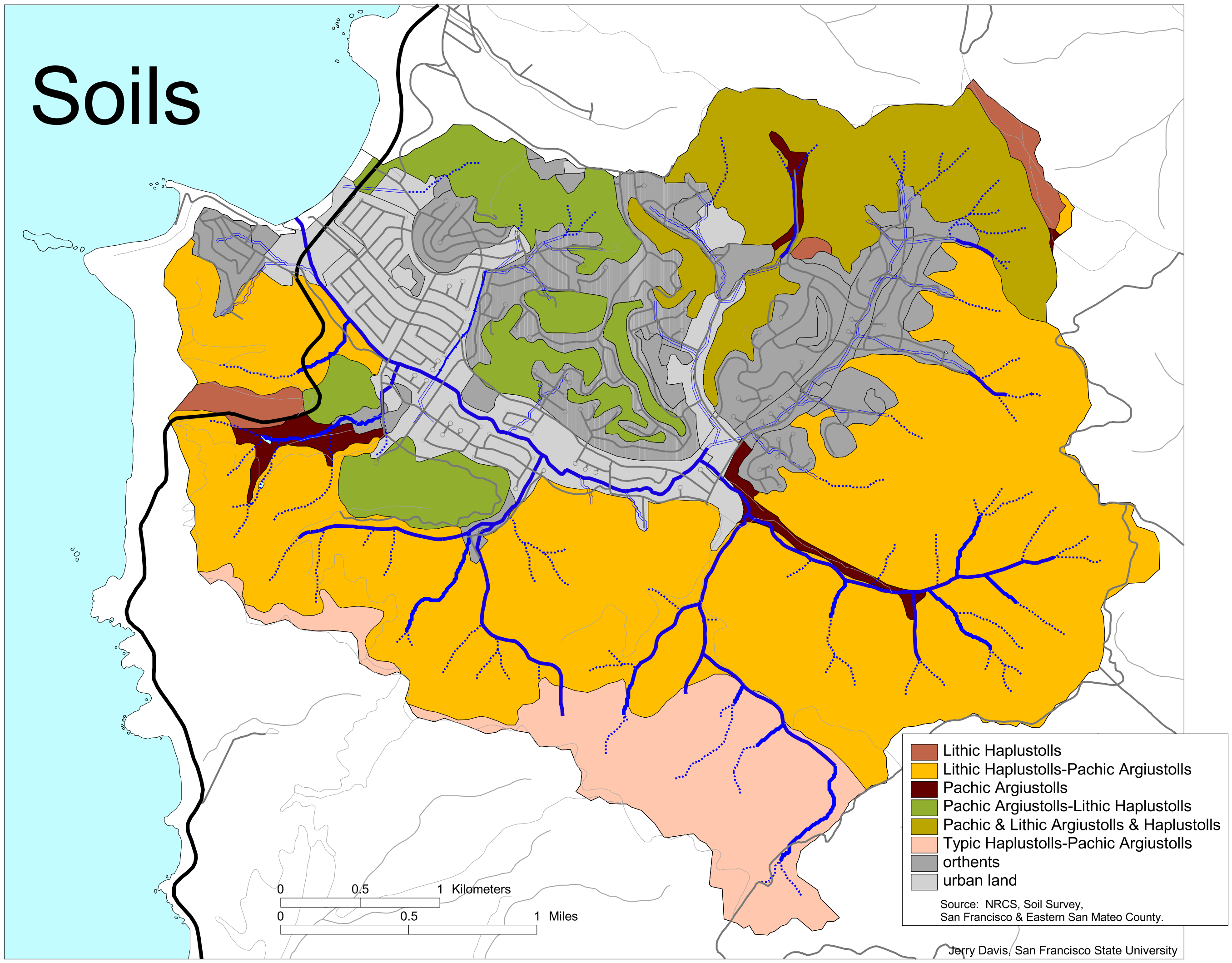


Figure 6. Soil Taxonomy Subgroups, San Pedro Creek Watershed

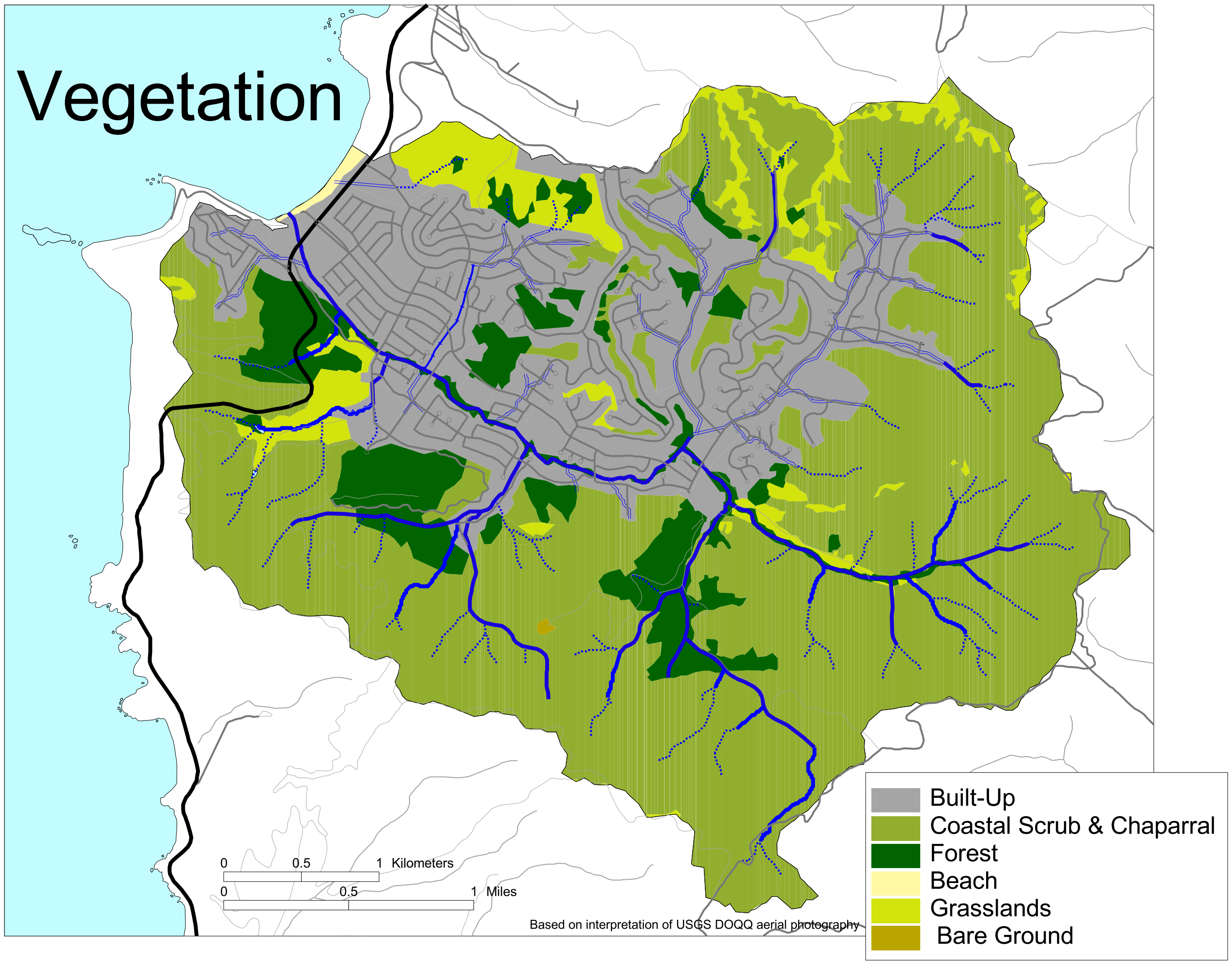


Figure 7. Generalized Vegetation Patterns, San Pedro Creek Watershed

1.5 Project Purpose

The purpose of the San Pedro Creek Watershed Assessment and Enhancement Plan is to provide a better understanding of watershed processes and continue building the community coalition needed to implement additional restoration activities. This information will help to enhance one of the most significant fisheries on the central Coast of California. Specific objectives linked to this project include:

- Developing an assessment of the physical, biological and chemical conditions of the watershed.
- Preparing conceptual plans to manage and repair identified problems generally at specific sites.
- Setting priorities for restoration.
- Providing strategies to implement conceptual repairs and management programs.

The Assessment and Enhancement Plan also aims at anticipating and addressing future deterioration in the watershed as a result of the exacerbation of existing conditions.

2. WATERSHED ASSESSMENT

Section 3 provides a detailed description of San Pedro Creek Watershed. Information about the geomorphology, water quality, land use history, vegetation, and fish habitat is included. Each of these topics is the result of analyses developed by professionals, contractors, students and residents of the watershed. Due to the length of each report, each is included in the assessment plan in a separate volume.

Geomorphological Analyses (See Volume I)

Geomorphology is the science that investigates the landforms of the earth. Included are the forms on the land surface, the mountains, valleys, slopes, riverbeds and dunes, for example, and the submarine forms on the sea floor. Geomorphology describes the existing landforms, investigates the processes that create them, examines the relationships between landform and processes and seeks to explain landform development (Ahnert 1998):

In 2001, Laurel Collins, Paul Amato and Donna Morton developed a Geomorphic Analysis of the San Pedro Creek main stem. Collins, Amato and Morton analyzed the lower 2.6 miles of the creek determining current physical conditions and assessing the impacts of land use activities. Their report (Volume 1) provides process-related findings to support the success and cost-effectiveness of future restoration and management efforts focused on San Pedro Creek. The volume includes information about topography, climate, stream flow analyses, geology, landscape change, as well as an analysis of channel characteristics. Maps and graphs visually display the results of this detailed study.

Vegetation Analyses (See Volume II)

Mike Vasey conducted riparian and upland vegetation surveys of the San Pedro Creek corridor and watershed, assisted by Eugenie Mont Blanc, Mike Faden, Erika Kean and Tom Parker from SFSU. His riparian analysis of the main-stem and major tributaries is organized into eighteen reaches. A total of 205 vegetation samples were taken every 100 feet from the mouth of the creek to the upper reaches of the Middle Fork and South Fork. A total of 142 non-native invasive species (NIS) infestations were also mapped along these reaches. A vegetation map of the entire watershed is being produced to provide insight into large-scale hydrological processes affecting the lower riparian environment. The general vegetation survey enables an analysis of frequency, dominance and the Relative Importance Value (RIV) for native and non-native species in each survey area. This information provides insights into good candidate species for use in revegetation and problematic NIS infestations that need control efforts. Overall findings as well as a detailed description by reach are included in the report. The survey also included the development of a detailed GIS map identifying and locating the results of the survey.

Water Quality Analyses (See Volume III)

Water quality monitoring is defined as the process of sampling, measuring, recording and analyzing various water quality characteristics (Bartram and Helmer 1996). An important objective of water quality monitoring is to provide managers with appropriate information that aids the decision-making process. Water quality studies are important tools that provide valuable and sufficient information to maintain a high level of stream quality or ecological integrity (physical, chemical and biological) (Eyre and Pepperell 1999).

Vivian Matuk, a Master student at San Francisco State University, Doctor Bernard Halloran, a doctor of University of California at San Francisco and the chair of the water quality committee of San Pedro Creek Watershed Coalition, and Doctor Jerry Davis, an Associate Professor of Geography at San Francisco State University examined the water quality of San Pedro Creek. This research sought to study the water quality of the stream considering the following objectives: 1) To establish and compare physical, chemical and biological water quality characteristics in San Pedro Creek Watershed during four sampling periods (winter (January-February), late spring (April-May), summer (July-August) and fall (October-November) (seasonal variability), 2) to compare in-stream physical, chemical and biological characteristics of the watershed to the San Francisco Regional Water Quality Control Board, the Environmental Protection Agency (EPA) or literature standards, and 3) to determine whether cumulative changes occur in water quality along the creek (variability over space). The method used in this study is a routine type of water monitoring involving the periodic collection of samples from a number of fixed locations along the watershed (Bartram and Helmer 1996).

The results of this research provide important information about the water quality dynamics in the creek. This information helps in identifying sources of pollution and controlling their impact on the watershed and its ecological integrity; providing base-line information for decision-making; restoring, protecting and maintaining activities; establishing a permanent water quality testing program to ensure high water quality; and building a sense of the importance of the creek and its role in the watershed. Furthermore, this research could be used as a model for similar watershed programs that seek to develop a monitoring and protecting program in order to preserve urban creeks and their watersheds. Maps, photographs, and graphs summarize the results of this report.

Fish Habitat Analyses (See Volume IV)

This report describes a survey conducted by Hagar Environmental Science to assess the existing habitat conditions for steelhead within the San Pedro Creek watershed, and identify potentially limiting factors, needs for habitat protection, and potential for habitat enhancement. The habitat survey included detailed mapping of representative stream reaches, identification and reconnaissance-level evaluation of potential steelhead migration barriers, and recording visual observations of steelhead present in each survey area.

Titus *et. al.* in a report titled *History and Status of Steelhead in California Coastal Drainages South of San Francisco Bay*, still in preparation, report the following steelhead information from 1941 to 1988 (Marty Gingras, CA Department of Fish and Game, 2000, communicated this information from Titus et al. via email).

> San Pedro Creek is somewhat unique in that it is a highly urbanized stream, which continues to support a naturally reproducing steelhead stock, in part due to the interests and efforts of local residents in the community of Pacifica. From an historical perspective, the California Department of Fish and Game (CDFG) files indicate that adult steelhead were seen ascending the stream to spawn in April 1941. At that time, ranches dominated the drainage area and it is assumed that the creek system was in relatively good condition. There was tidewater at the stream mouth, but no real lagoon. The main stem was about 4 km long and formed by flow from three forks, the "east" fork

being the only one with perennial flow. Water was diverted from the creek system for irrigation.

However, by 1971 the creek habitat was severely degraded due to the effects of garbage dumping, rat poisoning, and wastewater discharge in conjunction with urbanization of the area. Apparently, a fish kill had occurred on 22 December 1970. Local citizens formed a committee to promote the protection and enhancement of San Pedro Creek (J. Ladd, CDFG, unpubl. memo. of 14 January 1971).

Two adult steelhead were seen in the stream during a single spot check on 6 April 1972 (E. Armstrong, CDFG, unpubl. memo. of 7 April 1972). Adults ascended the stream during the winter of 1972-73 as well (D. C. Erman, UC Berkeley, unpubl. letter of 9 February 1973). San Pedro Creek was surveyed by the CDFG in July 1973.

Urban debris was still common in the streambed, and spawning areas were both quantitatively and qualitatively limited. Rearing habitat was adequate, with the presence of pools and abundant riparian cover. Several barriers to upstream migration were identified, especially at culverts, and several diversions were observed, the largest being that for the North Coast County Water District. Storm drains discharged into the creek. Juvenile steelhead were observed in all reaches of the main stem. As determined from electrofishing samples, the trout ranged from 3.8 to 20.3 cm in length and averaged 8.9 cm. Steelhead were observed above all culverts on the main stem, but only below the water district diversion in the south fork of the creek system.

The size-structure of the juvenile steelhead population in San Pedro Creek was investigated on four occasions during the 1970's. On 3 July 1973, steelhead were sampled by electrofishing at four main stem stations (K. R. Anderson, CDFG, unpubl. memo. of 29 August 1973). The fish ranged in size from 3.6 to 16.0 cm FL, and averaged 8.0 cm FL (SD = 1.8 cm, n = 220). Thus, rearing juveniles were age 0+ and 1+, and 0+ trout were proportionately dominant in number. Abundance estimates were also made in late summer 1973, by electrofishing seven stream reaches (15–61 m) and applying the two-pass removal method of population estimation (K. R. Anderson, CDFG, unpubl. memo. of 13 November 1973). Juvenile steelhead densities ranged from about 2.0 to 7.6 trout/m, and averaged (± SD) 5.1 ± 2.3 trout/m. Despite its somewhat degraded condition, the creek system continued to support relatively high densities of juvenile steelhead.

On 10 October 1974, the average size of juvenile steelhead electrofished in four main stem reaches was 10.2 cm FL (range, 5.1–18.8 cm FL; n = 125). The largest trout (21.3 cm FL) was found in the South Fork San Pedro Creek (K. R. Anderson, CDFG, unpubl. memo. of 28 October 1974). On 17 September 1976, the average size of juvenile steelhead electrofished in two main stem reaches was 8.9 cm FL (range, 3.3–17.3 cm FL; n = 26). Overall abundance of juvenile steelhead was apparently lower than in previous surveys (K. R. Anderson et al., CDFG. unpubl. memo. of 24 September 1976). Finally, on 15 November 1979, the mean size of juvenile steelhead electrofished in two main stem reaches was 9.4 cm FL (range, 5.6–16.8 cm FL; n = 43) (I. L. Paulsen and L. Fish, CDFG, unpubl. memo. of 21 November

1979). Estimated densities were 0.2 and 0.9 juvenile steelhead/m, which were much lower than those measured in 1973.

Despite apparent differences in relative year-class strength, these four surveys demonstrated that the juvenile steelhead population in San Pedro Creek consistently comprised two age-classes, 0+ and 1+, and that the 0+ group dominated numerically. The relatively small proportion of 1+ trout present in any given survey indicates that the main smolting age of steelhead in San Pedro Creek is age 1.

During the winter of 1975-76, entry of adults from the ocean and their migration to upstream spawning grounds were apparently restricted due to a lack of precipitation and thus reduced stream flow. Consequently, no adult steelhead or redds were observed in San Pedro Creek on 26 February 1976. Several adult steelhead, two estimated at 2.7 kg each, were observed in the creek on 1–2 March 1976, however. The local warden estimated that 60 adult steelhead had been poached at Adobe Road Bridge during this period (G. Scoppettone, CDFG, unpubl. memo of 25 March 1976 and 19 April 1976).

In March 1978, about 600 steelhead died in San Pedro Creek due to the storm drain discharge of an unknown poison, possibly chlorinated swimming pool water (The Times, San Mateo, 22 June 1978).

By 1985, the headwaters of San Pedro Creek were protected by virtue of their inclusion in San Pedro Valley County Park. In March 1985, 800 Dry Creek steelhead (8.8/kg) were stocked into the stream. When surveyed by the CDFG in May 1985 (J. Ford and L. Bordenave, DFG, unpubl. memo. of 29 July 1985), the creek system was in good condition overall. Steelhead spawning habitat was abundant in the upper main stem, or middle fork, but lacking in the north and south forks. Most spawning occurred within the park boundaries. Spawning reportedly occurred as late as May, and during the 1984–1985 spawning season, there were about 40 pairs of spawning steelhead within a 30 m spawning reach. Obstructions for upstream migrating spawners were identified, and storm drain pollution was still cited as a problem. Indeed, on 10 March 1987, 600–700 steelhead fry, yearlings, smolts, and adults were killed in the north fork and 2 km of the main stem as the result of a toxic storm drain discharge, probably chlorinated swimming pool water.

The lowermost 880 m of San Pedro Creek was surveyed by the CDFG on 28 September 1988 (C. Dayes and D. Becker, CDFG, unpubl. memo. of 21 October 1988). Age 0+ and 1+ steelhead, up to about 20 cm in length, were observed throughout the reach, including the lagoon. Riffles provided over 464 m2 of spawning gravel for steelhead. Rearing habitat was good to excellent, and included abundant streamside riparian vegetation. Notably, the creek had continuous flow to the lagoon and contained two consecutive year-classes of juvenile steelhead, despite two consecutive drought years.

This information, as well as the other reports, will be used by the San Pedro Creek Watershed Coalition in setting priorities for adaptive management, educational activities, or restoration projects by considering the practicality of addressing key limiting factors and weighing the relative benefits to be expected.

Ongoing Studies

The Coalition's team feels that the study of San Pedro Creek and its watershed is an ongoing process, as befits the Adaptive Management approach. The major findings included in the four volumes of this report have produced new questions during this project, and some of these questions have been addressed in the following short reports:

1. Longitudinal Profile and Rosgen Classification of Reaches
2. Storm Response of Water and Turbidity Levels in Two Tributaries of San Pedro Creek
3. Optical Brighteners Sewage-Source Study.

San Pedro Creek Longitudinal Profile and Rosgen Classification of Reaches – Fall 2001

Laurel Collins and Jerry Davis

Surprisingly, no longitudinal profiles have ever been surveyed of the entire main stem of San Pedro Creek. Geomorphologists (Collins and Davis) associated with the San Pedro Creek Coalition recently completed a profile of the main stem from Peralta Bridge into San Pedro Valley County Park. For our profile, we stopped at Peralta Bridge because the Flood Control Project a short ways downstream will dramatically change the profile in that reach, as soon as it opens. The graph "straightens out the curves" of the creek displaying channel length on the horizontal axis and channel elevation on the vertical. In order to see the whole profile, the view shown here has a vertical exaggeration of 43 times.

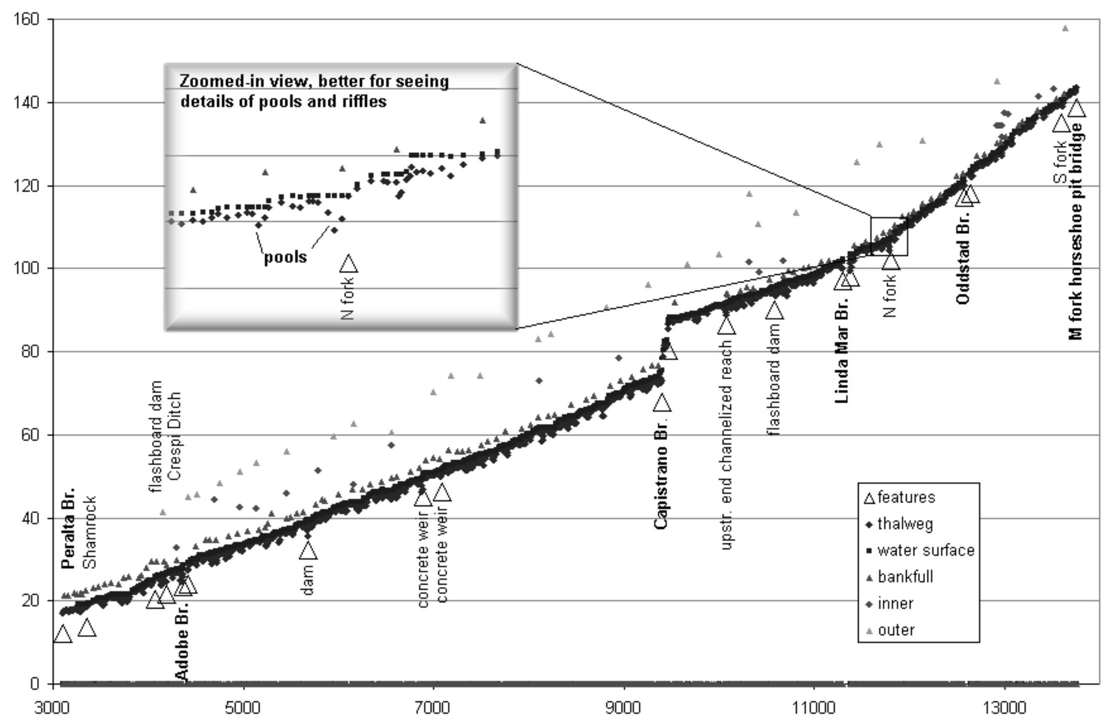


Figure 8. Longitudinal Profile from Peralta Bridge to Horeshoe Pit Bridge.

For the survey, the team used a tripod-mounted optical level, stadia rod and survey tape to capture elevations of (1) the deepest part of the channel – called the *thalweg* (Ger. "valley way"); (2) the water surface at base flow; (3) the bankfull elevation; and (4) various terraces. This technique was very accurate: in a 8200 feet length of the channel – from Peralta to Linda Mar Blvd. bridges – the elevation error was only 0.01 foot. The apparent gradient detected in this profile differs markedly from that derived using contours on the 1993 USGS Montara Mountain 7.5' quad (Figure 9).

Many factors will influence the shape of the profile. As described in Volume 1, a major historical impact to the profile is the channelization of the lower-most reaches, especially below Adobe. Flashy, erosive runoff from impervious cover adds to this impact. What can we see in the profile?

1. The creek's profile has some peculiar patterns that relate to the history of impacts. Clearly the biggest impact can be seen at Capistrano Bridge, where a *knickpoint* was created in the early 1950's by a grade control structure, perhaps at the upper end of a progressive headcut resulting from 19th-20th century channel straightening in the lower-most reaches, when up to a mile of effective channel length was lost as the creek was diverted from Lake Mathilda to drain directly to the ocean. The effect at Capistrano Bridge has been most dramatic during the last 50 years. Since 1960, fifteen feet of vertical erosion downstream of the structure has created a serious barrier to fish migration, plus some serious headaches for downstream residents losing their backyards. A succession of largely ineffective fish ladders have been installed, but this barrier remains and addressing it is a top priority for improving passage to important habitat upstream.
2. Both downstream and upstream of Capistrano, the creek's gradient has eroded to a lower gradient than must have existed before settlement. The average baseflow gradient below the Capistrano fish ladders and above Adobe Bridge is 0.91%, with a similar gradient (0.90%) at the bankfull level. In this reach, the uppermost terrace, which appears to relate to the bankfull level before settlement, has a gradient of 1.07%. The lowered channel gradient is likely the result of erosion from more frequent peak flows from urban runoff (rainfall on paved areas runs off quickly.) The potential for further erosion will depend upon whether this profile is flat enough to be in dynamic equilibrium with the flashy urban runoff it is provided. Unfortunately, the likelihood is that it is not, and even more erosion will occur unless something is done to decrease the flashiness of the runoff.

3. Most of the bridges serve as grade control structures, and this can be seen by looking at the profile at these points. Bridges at Adobe, Capistrano, Linda Mar and Oddstad all force the creek through concrete box culverts, creating a limit to downward erosion at that point in the profile. This is all right for the sections immediately upstream, but it invariably creates a fish migration barrier as a steep step and deep pool develops downstream. This is why people often see fish on the downstream side of Adobe Bridge.
4. Below the North Fork confluence and extending downstream to the next grade control structure at Linda Mar Bridge, the gradient has similarly been flattened as a result of urban runoff, primarily from the North Fork watershed and delivered by its system of culverts draining Park Pacifica. While the upper terrace gradient is 1.85% in this reach, the water surface and bankfull gradients are 1.09% and 1.07% respectively.
5. For the same reason, the main-stem upstream of the North-Fork confluence has been *steepened* to a gradient of 1.8%. This is because the downcutting below the confluence creates a steeper gradient in the main channel draining into it. This steeper gradient will no doubt create a headcut, which will migrate upstream until it reaches the next grade control structure at Oddstad Bridge. This is where we should expect the next major barrier to fish migration, as a deep pool develops downstream of the concrete pad under the bridge.

This profile has now been integrated with Rosgen classifications interpreted by Laurel Collins. The changing classifications along the stream's length can be seen in Figure 10 a-d. The added detail of the profile, especially coupled with Rosgen classification integration indicating stable and unstable sections, will help guide restoration efforts. We are now in the process of identifying and surveying cross sections in areas of special concern, especially below Capistrano Bridge.

Repeating the longitudinal survey in a few years will also help us to understand erosion rates in various reaches. The section from the park down to just below the North-Fork confluence has in fact been surveyed on three successive years recent, and from this temporal view we can see in this some surprising effects. For example, upstream of the Oddstad bridge grade control structure, there has been significant downcutting – approximately 1.5 feet in two years. Why is this happening in a park, with the only significant rapid runoff coming from the few gravel roads and a small parking lot at the visitor center? The answer, being investigated by students at SFSU, appears to be that we're seeing the response of the creek to a major *depositional* event from the 1962 debris flow that wiped out John Gay's trout farm operation. The creek is now rapidly cutting through these quite recent deposits.

We will probably discover other surprises when we repeat the downstream survey. We may be able to detect which sections are possibly stable, and which are heading for failure. We will need the cooperation of all creekside residents. The key to the success of any restoration project is taking the *longitudinal view*: (a) what happens at any point relates to things both upstream and downstream; and (b) what you do to any part affects the creek both upstream and downstream. This profile helps us to see it.

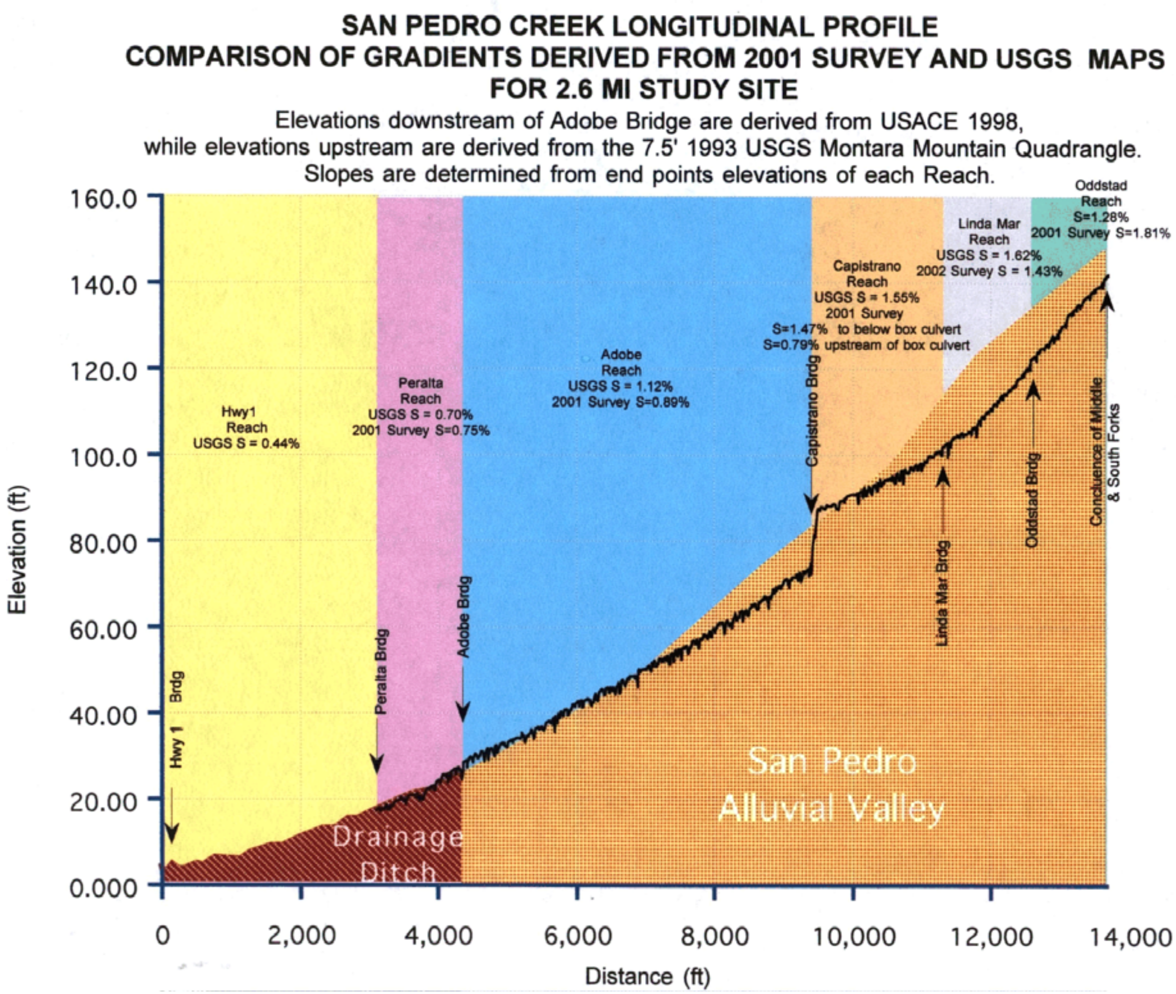


Fig. 9. Comparison of longitudinal profiles from contours and field survey (L. Collins).

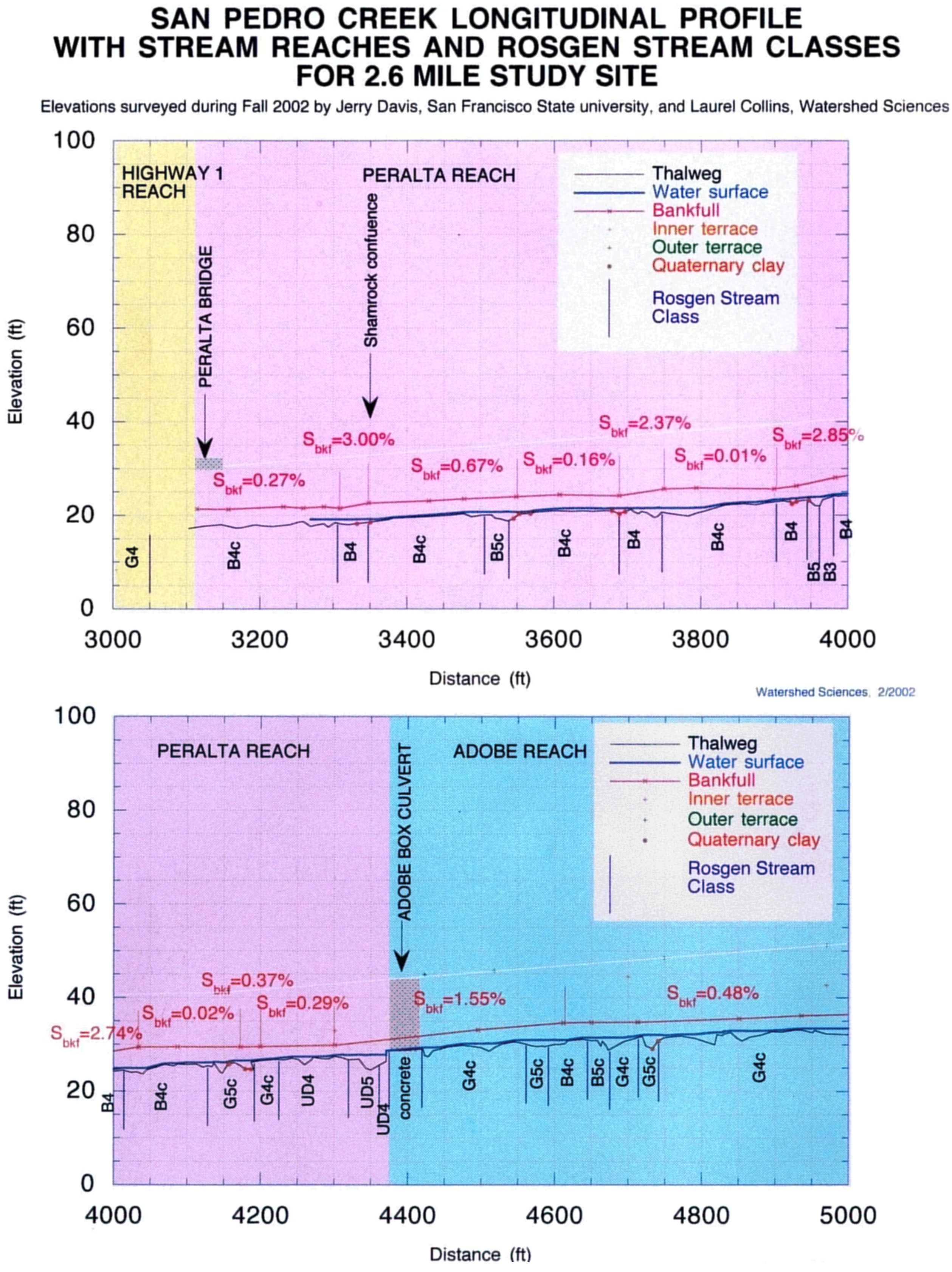


Fig 10. a-b. Profile, gradients and Rosgen class, 3000-5000 ft. from mouth (L. Collins.)

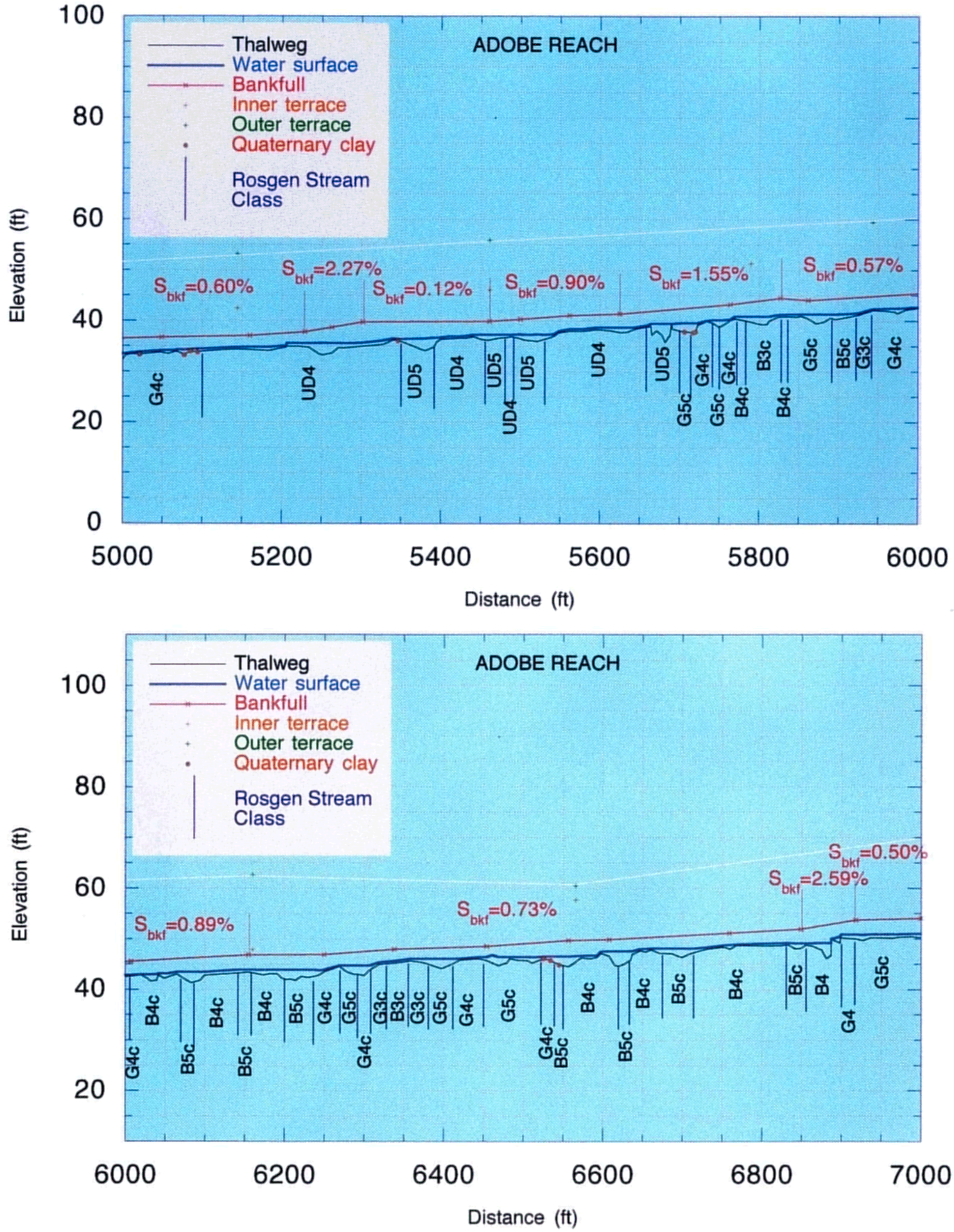
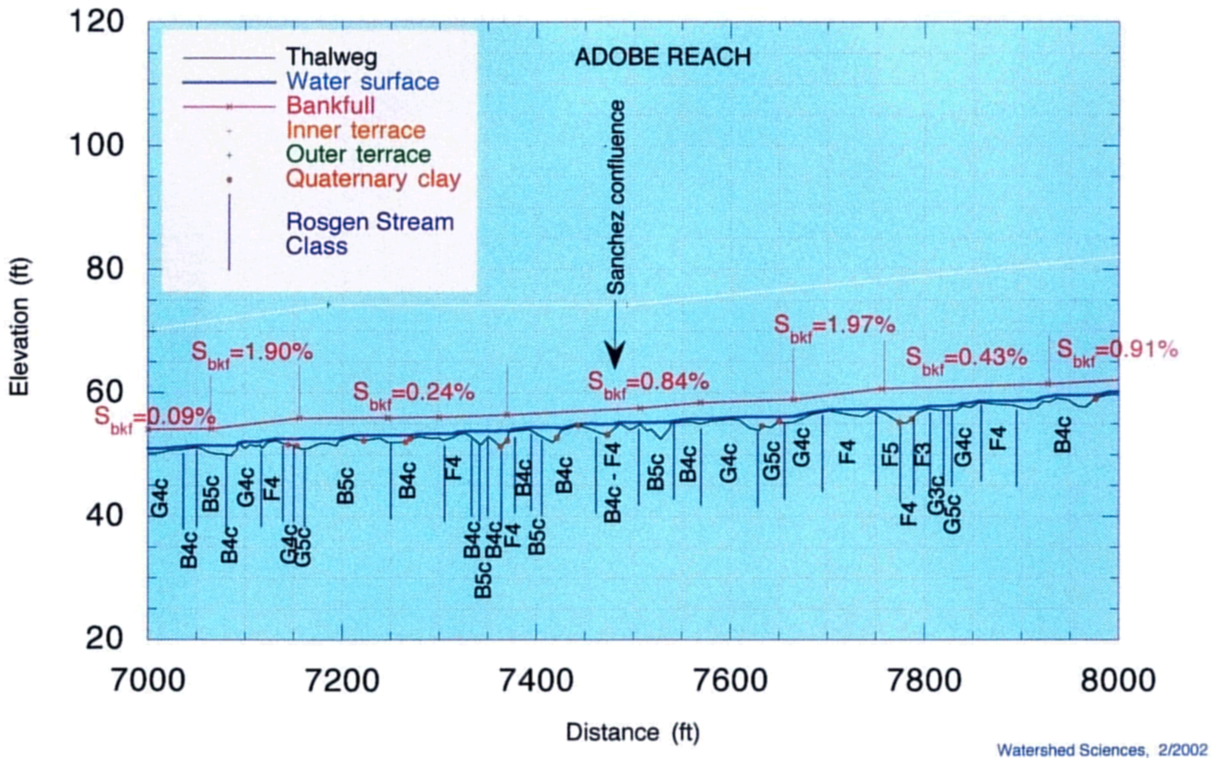


Fig 10. c-d.. Profile, gradients and Rosgen class, 5000-7000 ft. from mouth (L. Collins.)



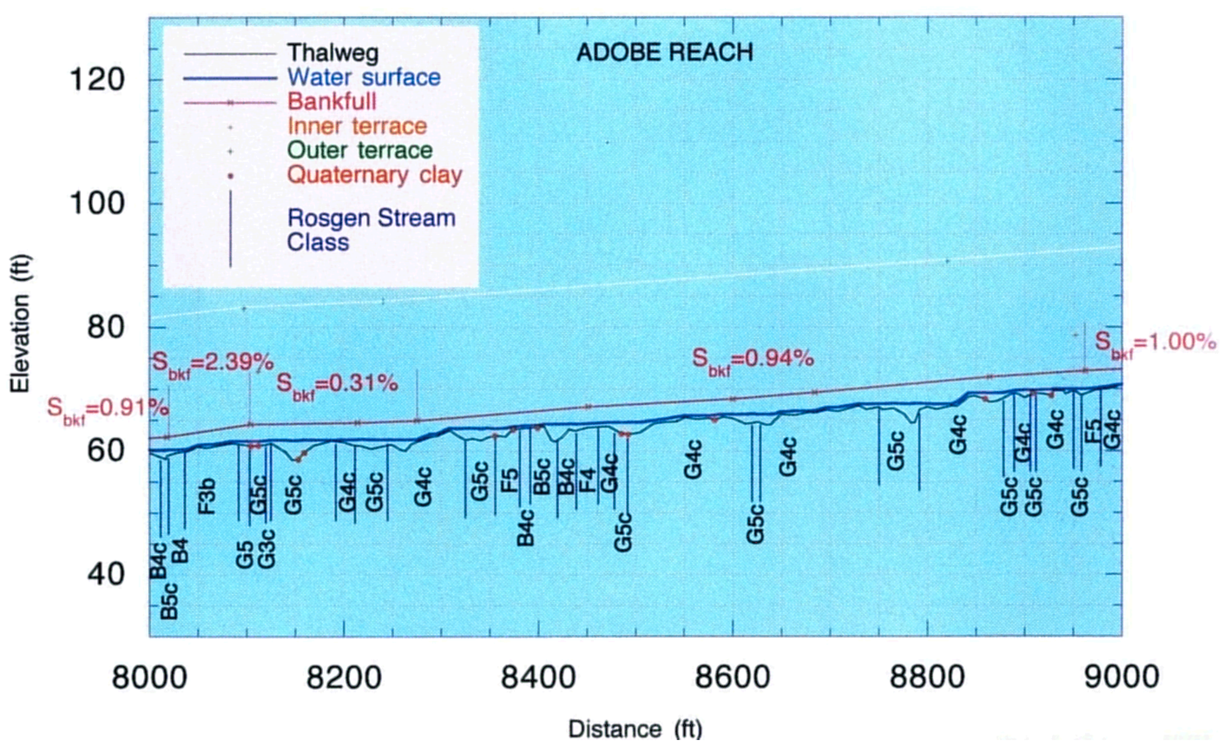


Fig 10. e-f.. Profile, gradients and Rosgen class, 7000-9000 ft. from mouth (L. Collins).

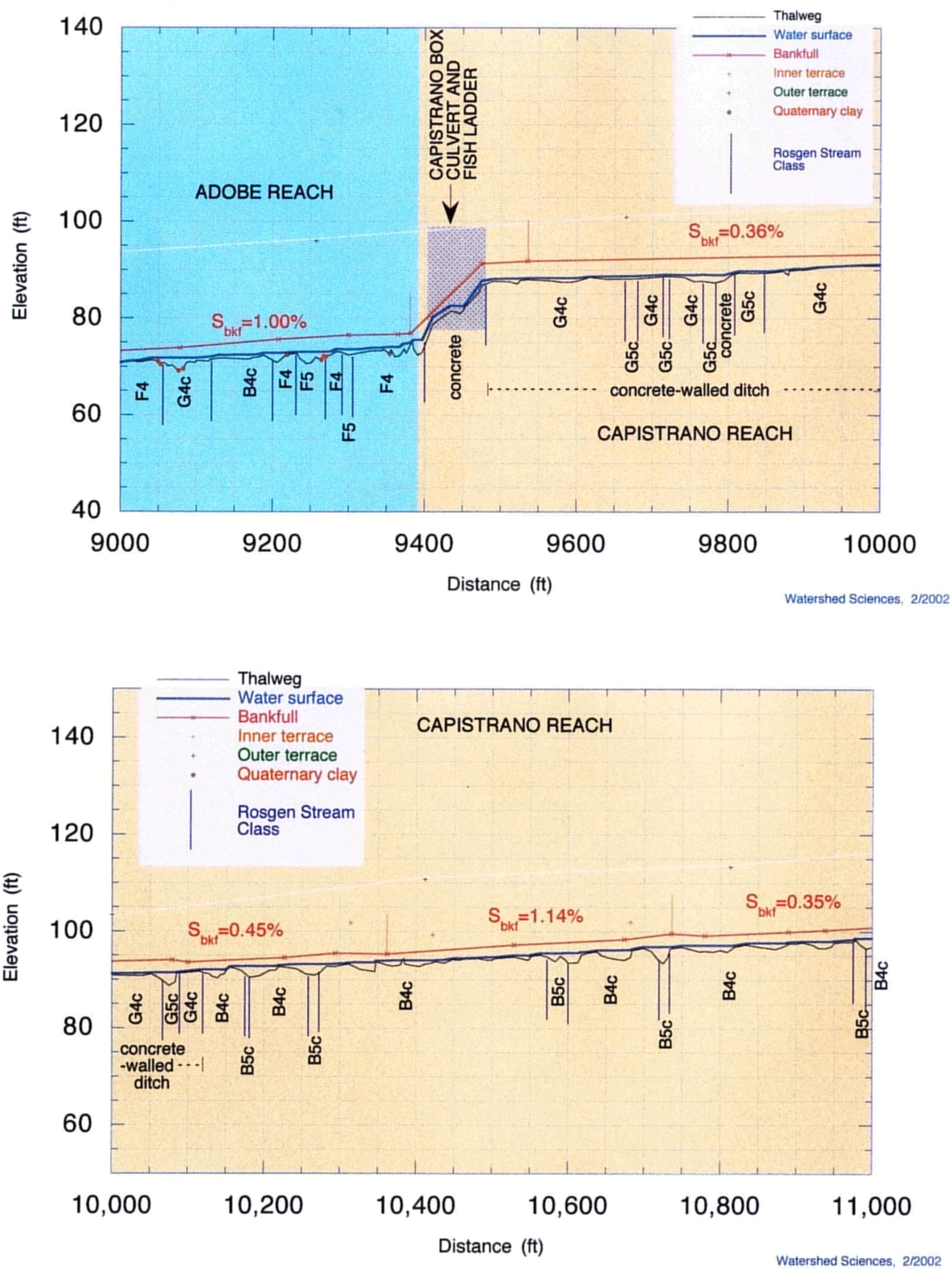


Fig 10. g-h. Profile, gradients and Rosgen class, 9000-11000 ft. from mouth (L. Collins).

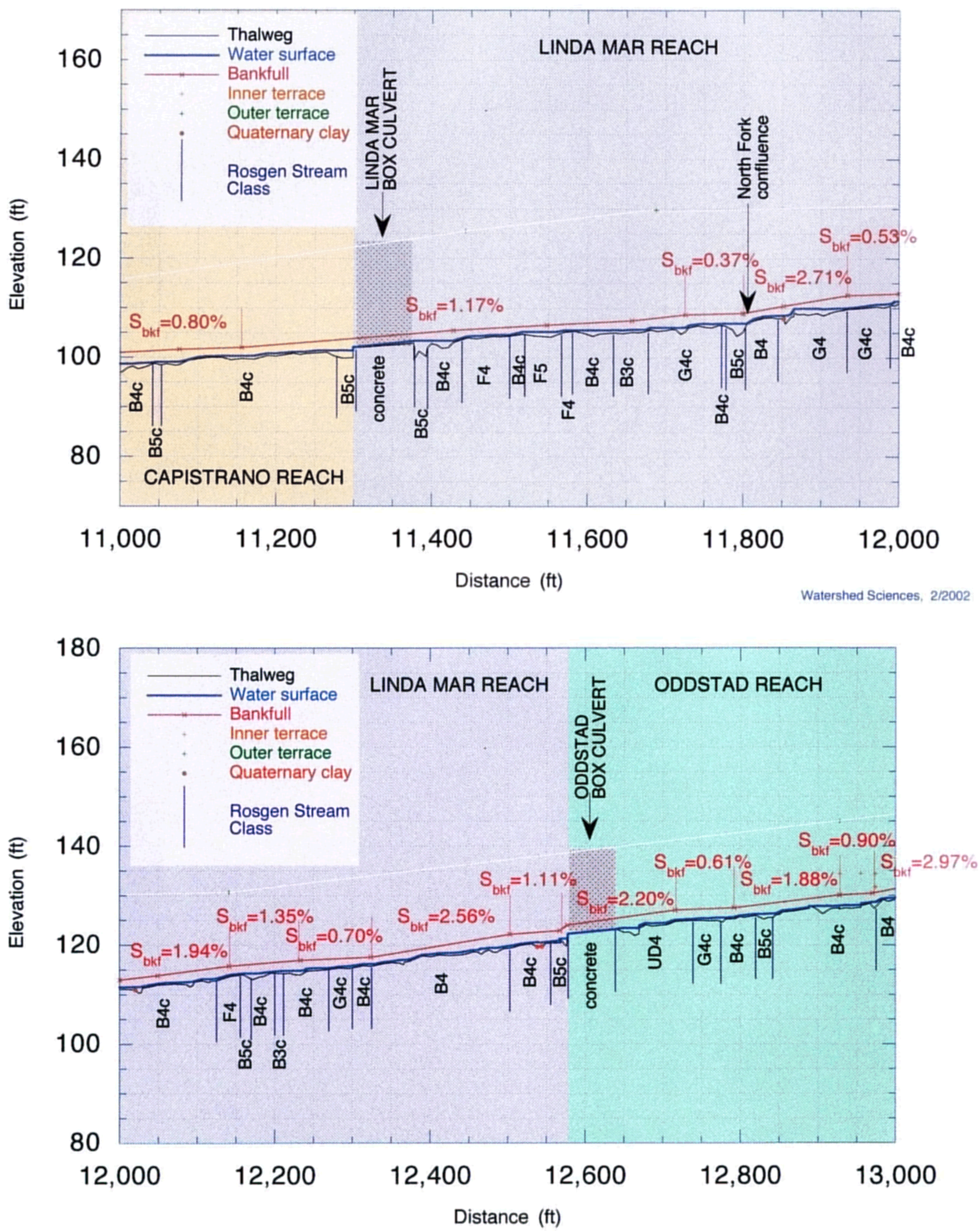


Fig 10. i-j. Profile, gradients and Rosgen class, 11000-12000 ft. from mouth (L. Collins).

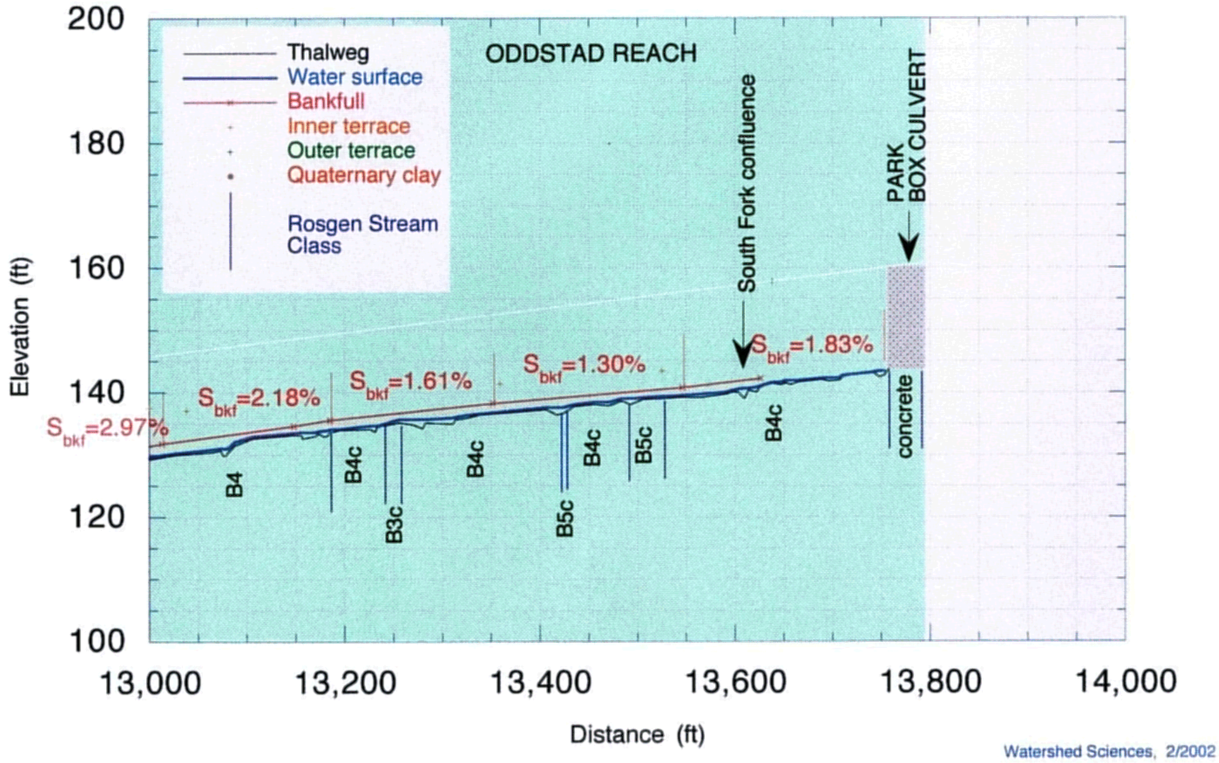


Fig 10. k. Profile, gradients and Rosgen class, 13000-13800 ft. from mouth (L. Collins).

Storm Response of Water and Turbidity Levels in Two Tributaries in San Pedro Creek

Paul Amato, January 2002

During part of the water year of 2000, data was collected in two tributaries of San Pedro Creek, to estimate rainfall in the watershed, and discharge and turbidity values of the two largest, and similar sized sub-watersheds. The point of the study was to try and improve the rainfall estimates in the watershed and to compare discharge and turbidity levels in the developed North Fork tributary with the undeveloped Middle Fork tributary. Two Rainwise© tipping bucket rain gauges were installed, one on Sweeney Ridge to measure rainfall at the top of the North Fork, and the other near Montara Mountain to measure precipitation in the Middle Fork. Rainfall data was collected with a continuous event counter, activated each time 0.01 of an inch of rain fell. This information was then compared to the long-term daily records taken since 1978 at the San Pedro Valley Park near the center of the watershed. Discharge values in each of the study sub-watersheds were derived by measuring water depth near the confluence using Global Water© water pressure level transducers installed near the tributary confluence. The North Fork sensor was installed by securing the sensor near the bottom of the concrete culvert that forms most of the main channel of the North Fork. The Middle Fork sensor was installed in a plastic PVC pipe upstream of any significant development. Values were collected using a continuous recording data logging system. A Swoffer© flow meter was used to measure velocity and determine discharge values for future conversion of water level readings to discharge. Global Water© transmittance turbidity sensors were installed with the water pressure level transducers and data was collected using the same data logging system.

As shown in the graph below, a consistent rainfall pattern can be seen between the Park, the North Fork watershed, and the Middle Fork watershed. This pattern was looked at as a way to determine a long-term rainfall average for the entire watershed. The monthly average rainfall was calculated for each recorded location between February and May. The Park was 5.67 inches, the North Fork was 4.71 inches, and the Middle Fork was 6.51 inches. This pattern may be explained by the watershed topography and by the prevailing wind during storm events. Storms typically move in from the south, where they are slowed by Montara and San

Pedro Mountains, causing increased precipitation. The Park is located on the valley floor at the back of the watershed. Storms may be moving slowly past the Middle Fork then releasing moderate rainfall over the Park as they are backed up at Sweeny Ridge to the North. It may be that the North Fork then experiences a slight rain shadow effect in comparison to the other locations on record. The average of the North Fork and the Middle Fork gauges for the months of February through May equals 5.61 inches, a value very close the average rainfall recorded in the Park during the same period. It may be that the Park is a suitable average for the watershed and that it can serve as an accurate long-term rainfall record location.

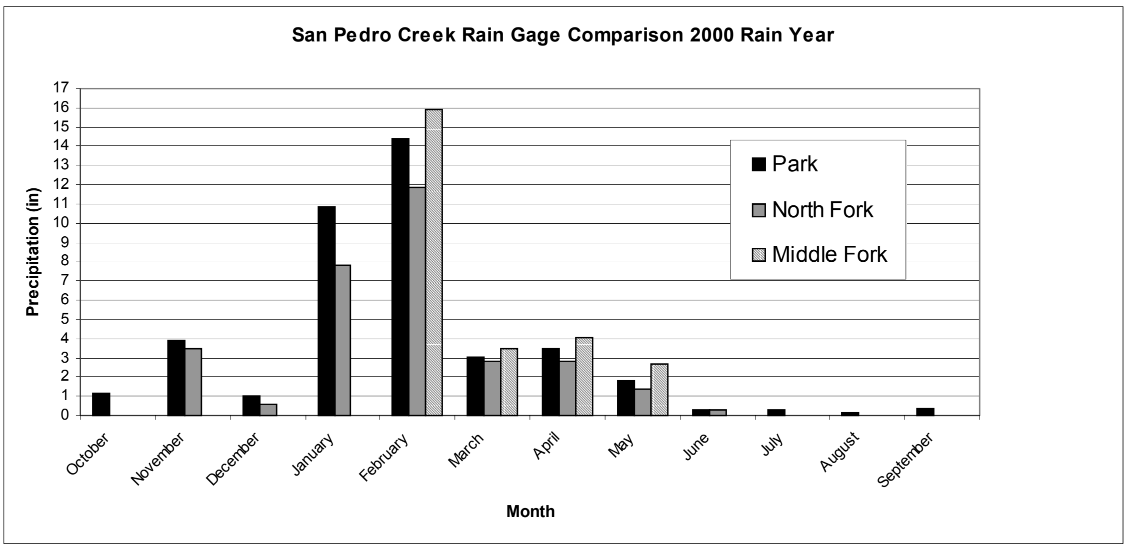


Figure 11. San Pedro Creek Rain Gage Comparison 2000 Rain Year

Preliminary analysis of water level response shows a distinct difference between the unurbanized Middle Fork watershed and the North Fork, which is 19% impervious due to development. Values on the Y-axis of the graphs are simply an electronic signal in milliamps (mA) that increases as the water level depth increases over the sensors. Depth and discharge will later be derived from these values using known cross-sections and measured discharge at the sensors. Data is shown from approximately 11:00 PM on February 12, 2000 when a storm event began, to approximately 6:45 AM on February 15, 2000 when the Middle Fork water level appears to return to pre-storm levels.

The Middle Fork responds gradually (Figure 12), peaking at two different times during the storm. This shape is more typical of an unurbanized watershed that experiences slower runoff response and less runoff contribution to the stream due to adequate surface infiltration. Runoff gradually increases as continued precipitation saturates the ground, limiting infiltration. This is represented by the peaks in the graph. The peaks are then followed by decreases in water level as precipitation decreases causing runoff to diminish. Eventually, the storm stops and the water level returns to pre-storm or near pre-storm levels.

The North Fork is a much flashier system, as shown by the irregular line (Figure 13). This is direct evidence that runoff is reaching the channel of the North Fork much faster and more frequently and that the watershed responds very quickly to changes in rainfall. Unlike the Middle Fork, the North Fork water level is more sensitive to smaller changes in rainfall. This is due to increased impervious area, decreased infiltration, and increased runoff.

Changes in turbidity levels in the Middle Fork (Figure 14) appear to be influenced by the amount of discharge in the channel. Like the water level, turbidity is represented as milliamps (mA) on the Y-axis. This data will later be converted to nephalometric turbidity units (NTUs). For general understanding the following approximations can be made: 4 mA is equal to 0 NTU, 6 mA = 100 NTU, 8 mA = 200 NTU, 10 mA = 300 NTU, 12 mA = 450 NTU. In the Middle Fork, as water levels increase, turbidity levels increase until a point where discharge increases seem to dilute turbidity levels causing a decrease in the concentration of suspended matter in the water column. This inverse relationship is evident upon comparison of the highest point in the water level line and the lowest point in the turbidity line for the Middle Fork. The highest turbidity levels are then sustained for several hours as the water level drops, peaks, and drops back to pre-storm levels.

Like water level, North Fork turbidity levels are flashy, responding quickly to increased precipitation and runoff. The highest turbidity levels appear to correspond with the highest water levels as seen by comparison of the two most significant peaks in water levels with the two most significant peaks in turbidity levels.

The overall turbidity levels are also less in the North Fork than in the Middle Fork. This can be attributed to reduced sediment sources due to increased impervious area and reduced natural channel bed and banks in the North Fork.

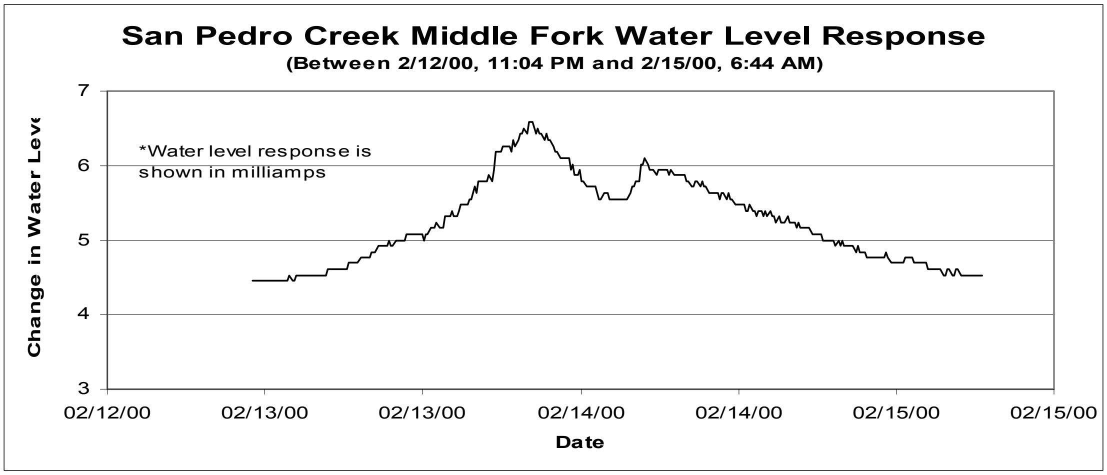


Figure 12. San Pedro Creek Middle Fork Water Level Response

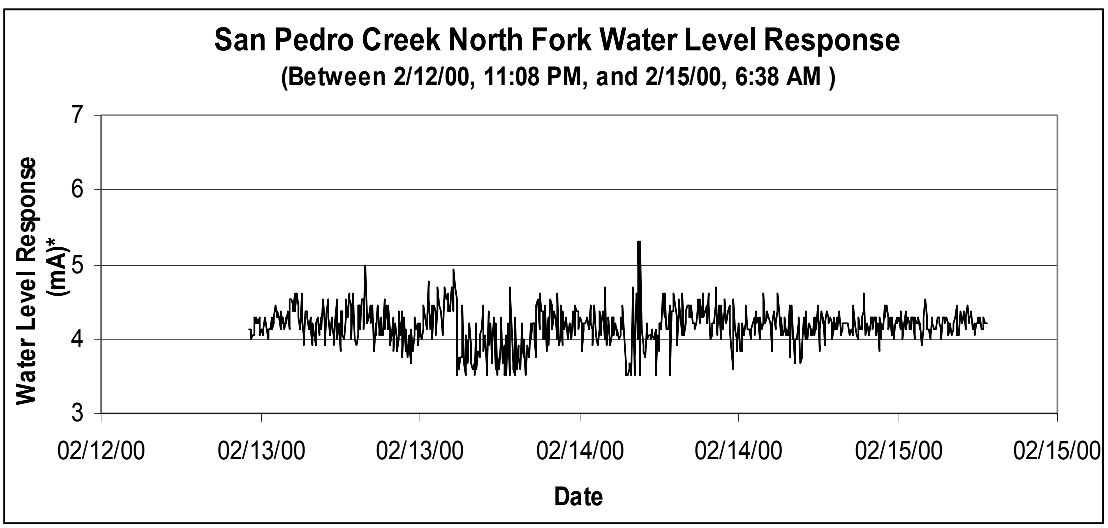


Figure 13. San Pedro Creek North Fork Water Level Response

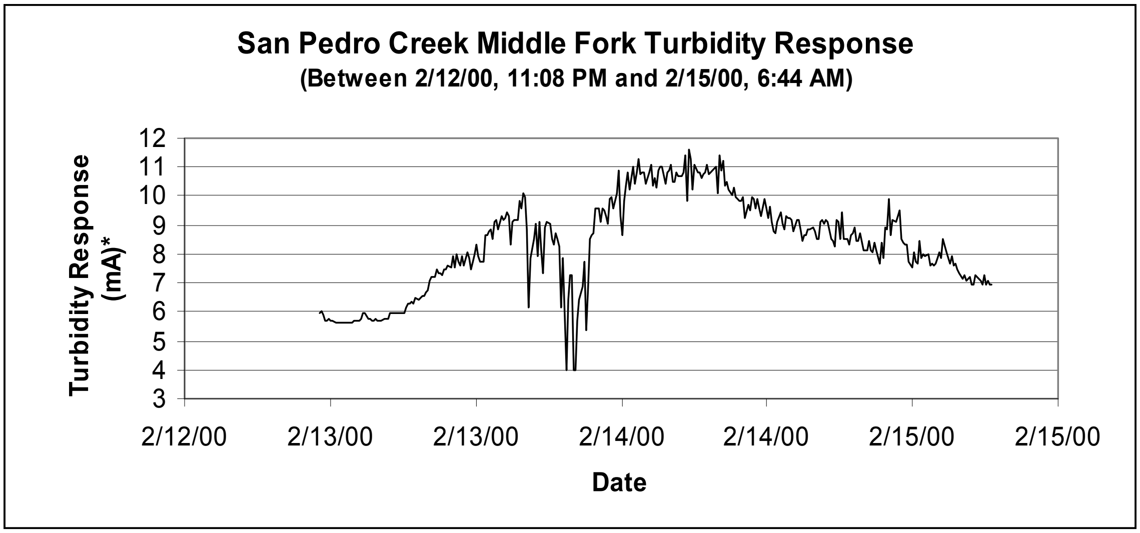


Figure 14. San Pedro Creek Middle Fork Turbidity Response

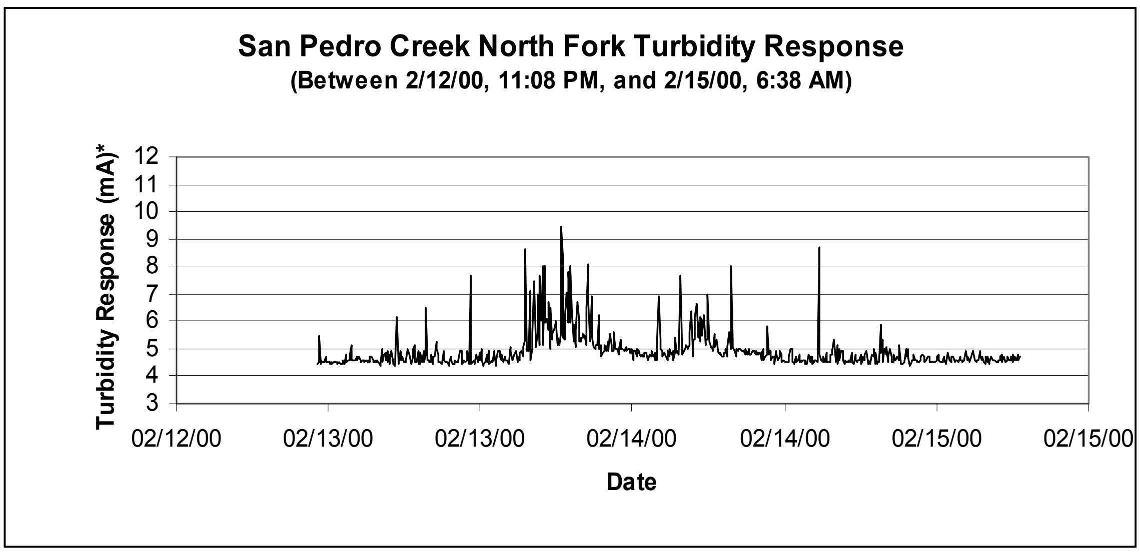


Figure 15. San Pedro Creek North Fork Turbidity Response.

The use of Optical Brighteners to assess sewage contamination in surface waters

Bernard Halloran, Carmen Fewless, Christine Chan, Vivian Matuk, Jerry Davis

As described in Volume III, water quality testing showed extremely high levels of coliform bacteria including E. coli and Streptococcus. Studies indicated high total coliform levels (as much as 40,000 cfu/100 ml) in the creek but the actual source of bacteria is still not known. In the most heavily polluted areas, the North Fork and mouth of the creek, bacteria levels exceeded California State water quality maximums by more than 40 fold.

Because of these studies, we have evidence that San Pedro Creek is polluted, however, as stated, it is difficult to determine exactly where the pollution is coming from. It is possible that the water pollution problem is the result of leaking sewer pipes (human source), pet litter that inadvertently finds its way into the creek, or through naturally occurring processes such as animal feces from deer, raccoon, and other animals living along the creek. To help determine the source of the bacteria, the SPCWC's Water Quality Committee, with the help of Carmen Fewless (a graduate student at Cal. State, Hayward) and Christine Chan (SPCWC Projects Coordinator) has begun testing for *Optical Brighteners* (OBs) at various sites along San Pedro Creek.

Optical Brighteners are fluorescent compounds found in laundry detergents that are used to increase the brightness of cotton clothes (makes our cotton clothes brighter and whiter) and that appear in sewage-contaminated water. The SPCWC is using *optical brighteners* as a means of distinguishing whether sewage is contributing to the bacterial load of the creek. *Optical brightener* compounds are in most laundry detergents but are not found in dish or hand soaps. When home washing machine's, which are connected to our sewer system, empty used soapy water from the washer, the soap also carries with it the remaining *optical brightener* compounds. If the sewer pipes are leaking, the *optical brighteners* escape into the ground water and eventually make their way into the creek. To test for the presence of optical brighteners in San Pedro Creek, we place a small cotton pad (about 2 inch square, OB-free) mounted in wire baskets, in the creek in regions of moderate to high flow for periods of up to 7 days. After 7 days, the cotton pads are removed, dried, and placed under a UV A lamp to induce fluorescence. If during that 7 day period, there are optical brighteners present in the creek water, the optical brighteners compounds stick to the cotton pad just as they do to our cotton laundry and when exposed to ultraviolet radiation (black light) will fluoresce. The SPCWC's *Optical Brightener* testing program will take place over the next 12 months and results should be available during the summer of 2002.

Optical Brighteners Testing Along San Pedro Creek (Phase One): The San Pedro Creek Watershed Coalition has obtained a grant from the Regional Water Quality Control Board to begin testing for Optical Brighteners along four sites along San Pedro Creek. The first site, located on the Middle Fork, is our control site and is situated just outside of San Pedro Valley County Park. At this site, the creek water has moved through San Pedro Valley County Park, but has not yet reached areas of urbanized development. The second testing site is located approximately 400 feet from the North Fork Culvert before the creek mixes with the Middle Fork. The North Fork is most problematic of the sub-watersheds in that its upland drainage areas are steep and drain rapidly into culverts. Coupled with storm-drains from impervious surfaces along developed areas, the North Fork sub-watershed and the area surrounding its outfall is considered one of the most highly contaminated areas in the creek. The third sampling site is located along the Main-stem. The Main-stem is entirely within public lands, with the exception of a small inclusion of private land, which cannot be developed, and thus has fewer problems than the North Fork. This site was chosen because it provides the SPCWC with the ability to test for Optical Brighteners after the confluence of the Middle Fork (Control Site) and the highly contaminated North Fork. The final sampling site is located at the mouth of San Pedro Creek at Pacifica State Beach. This sampling site was chosen to help the San Pedro Creek Watershed Coalition determine if the OB's were actually making there way through the Linda Mar Valley and into the Pacific Ocean.

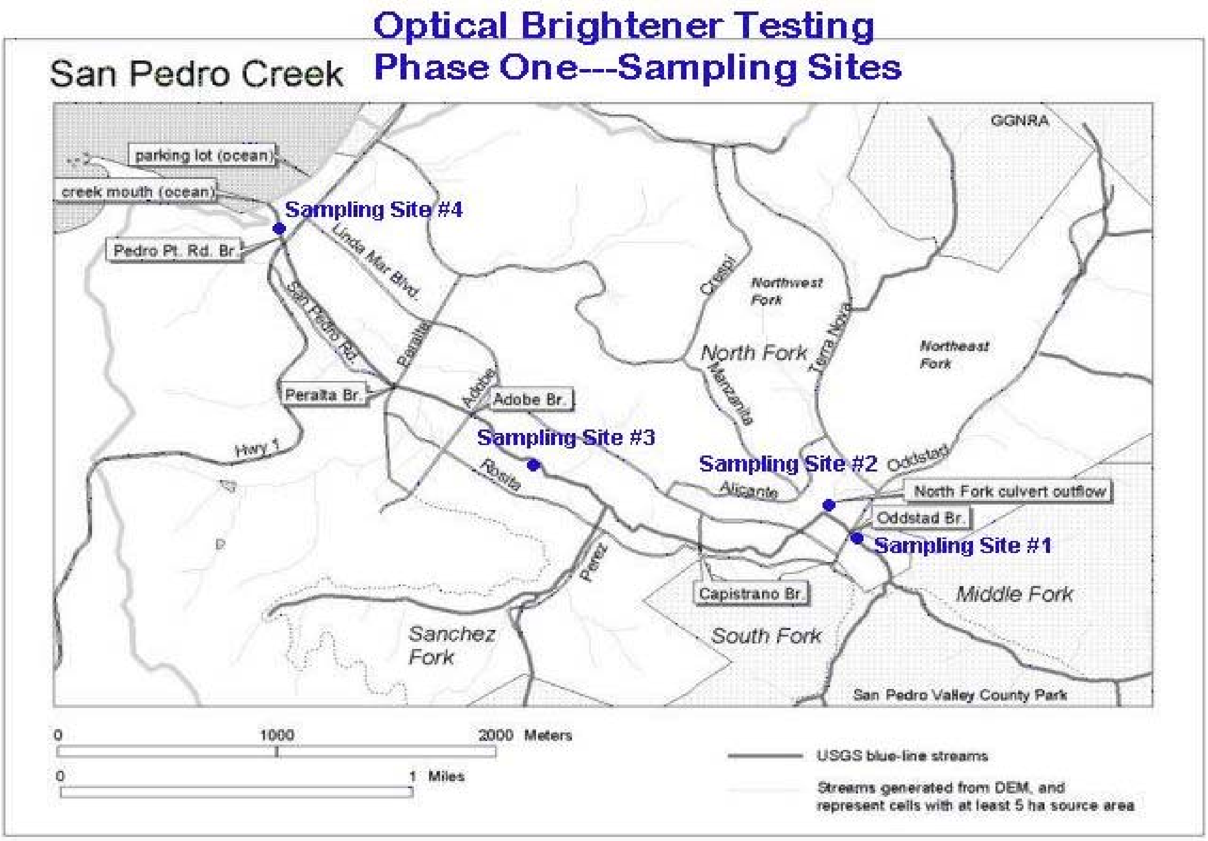


Figure 16. Optical Brighteners Testing Phase I Sampling Sites

<u>Optical Brighteners Testing on the North Fork of San Pedro Creek (Phase Two):</u> The San Pedro Creek Watershed Coalition has obtained a grant from the San Mateo Countywide Storm-water Pollution Prevention Program (STOPPP) to expand its optical brighteners testing program to the North Fork in an effort to find the source of the high bacterial levels in San Pedro Creek. With assistance from Carmen Fewless, Christine Chan, Bernard Halloran and Brain Martinez, Assistant Superintendent of Calera Creek Water Recycling Plant, the San Pedro Creek Watershed Coalition has begun testing a total of 9 sampling sites in the North Fork. Sampling will take place along Terra Nova and Oddstad Boulevards in pre-selected storm sewers and storm drains using city planning maps that identify approximate locations and diameters of each storm and sewer drain. Initial sampling will take place in storm sewers and storm drains located in the lower half of the North Fork along Oddstad and Terra Nova Boulevard's. If Optical Brighteners are detected, the sampling locations will then be moved up Oddstad and Terra Nova Boulevard in order to isolate areas with suspected sewer pipes leaks.

Sample sites are either labeled "O" for Oddstad or "T" for Terra Nova and numbered according to the location and order in which the pads are placed.

While results to date must be considered preliminary, we are clearly identifying optical brighteners in many of the samples, with the greatest signal from the North Fork. While this might not expected considering the proven concentration of bacterial pollution at this site, it is in fact surprising given the relatively young age of sewer connections upstream (primarily 1970's). The detailed results of the second phase of sampling will help us to understand these sources.

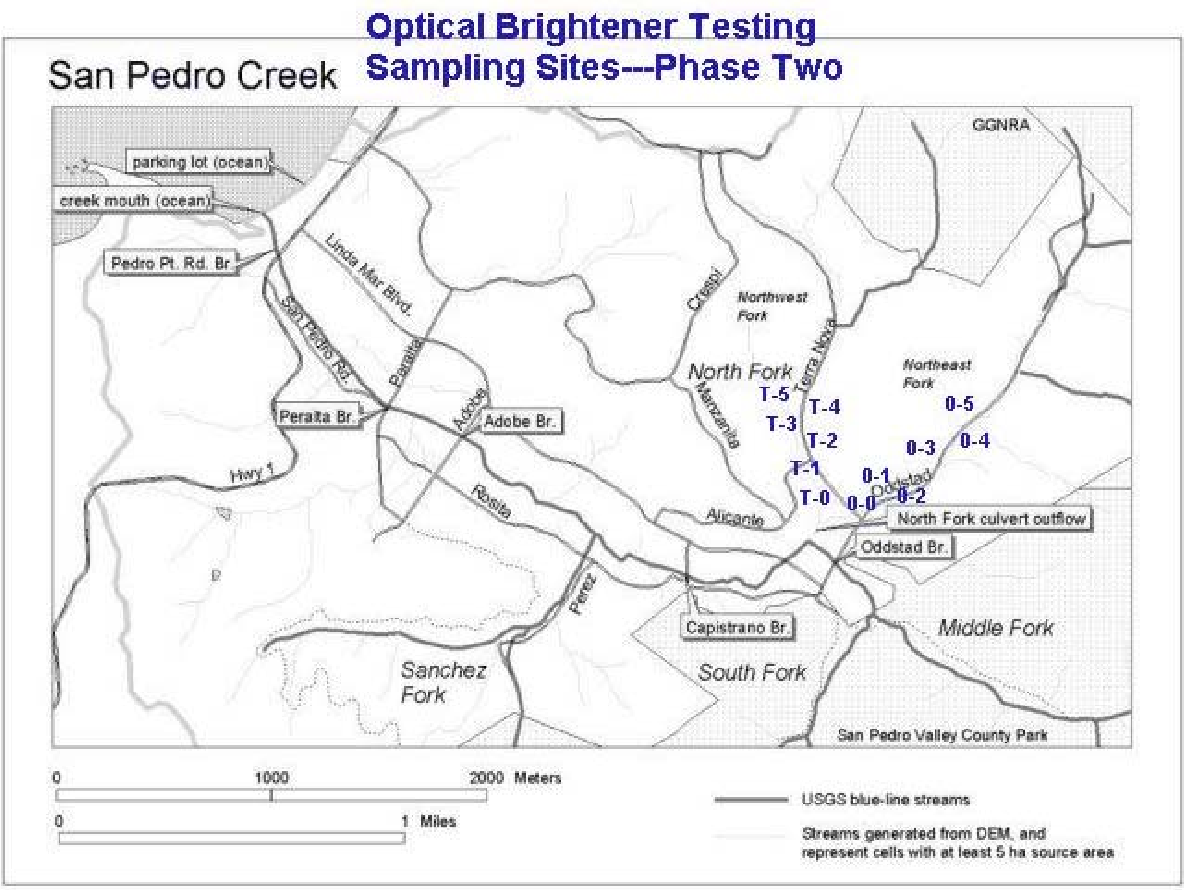


Figure 17. Optical Brighteners Testing Phase II Sampling Sites

3. SYNTHESIS OF WATERSHED ASSESSMENT

The assessments described in this report provide us with a picture of the watershed and its major stream corridors. The biogeomorphic, ecologic and hydrologic systems in this watershed are interrelated, and only through a comprehensive understanding of all can we start to undertake restoration projects.

Stream channel bed and bank material analyses described in the **geomorphic analysis** (Volume 1) and subsequent longitudinal profile demonstrate that the creek is subject to many human impacts. The full suite of bed and bank stabilization methods are illustrated along its length: riprap, gabion, wood and concrete revetments, concrete culvert structures at bridges, and remains of old dams from the farming period. A long history of impacts to this watershed beginning in the late 18th century have left many marks, including significant channelization of the lower reach and tributaries. Bank erosion has been identified as a major source of sediments. Creek observers frequently report turbid conditions at the Linda Mar Bridge (for location, see Fig. 18) even when the middle, south and north fork inputs are relatively clear. The Rosgen classification of stream reaches linked to a detailed longitudinal profile will provide useful and significant tools for stream restoration projects.

In addition to the important information on channel characteristics in Volume I, we have begun evaluating the significance of historical changes in land use, sediment sources and their impacts on channel erosion. From discussions with local residents, aerial photographic and field interpretation of stream terrace ages (from using growth whorl analysis of red alders- *Alnus rubra),* we can see the effects of debris flows with origins in South-Fork areas impacted by dirt biking. Two major debris flow events of widespread significance in the upper watershed occurred in 1962 and 1982. We are still seeing the effects of these events in channel erosion processes in the creek. The anomalously high incision rates noted in a two-year study (Amato 2002 pers.comm) of the upper mainstem (above the north fork confluence) can be understood as a response to relatively recent debris flow deposition events. We believe that a more through sediment sources analyses is needed to better quantify these effects.

Also important to planning a restoration project is a good understanding of the magnitude of hydrological inputs: precipitation and runoff. Our studies indicate watershed precipitation averages 38 inches (965 mm) annually. This is significantly higher than the 33-inch (838 mm) estimate reported in the hydrologic engineering report of the Army Corps' flood control project Environmental Impact Statement (1998?) (Appendix 1). Our estimates are based upon using data from two recording rain gauges (one in the north fork and one in the upper south-middle fork) to support the use of long-term precipitation results from the San Pedro Valley County Park as representative of the basin as a whole. The 38 inches (965 mm) figure is based on 23 years of record (1978-2000) at the park. This figure can be used to predict stable channel configuration using regional curve methods (Dunne and Leopold 1978).

Any in-stream restoration projects will also need to consider the contrasting responses of more and less urbanized subwatersheds, especially the north fork and middle-south fork (see Amato "Storm Response…" section above). Another runoff effect significant to this watershed is the probable maintenance of perennial flow in upper tributaries by fog drip. While we have conducted no fog-drip studies in this watershed, dense fog is a frequent occurrence and a contributor to stream flow elsewhere.

This watershed has experienced a long history of European-origin impacts starting with establishment of an *asistencia* in the late 18th century. Intensive grazing and agriculture produced many effects in the 19th and earlier 20th centuries: gulling on south facing grass covered hillsides; draining and diking of wetlands in the lower valley and the resulting channel erosion effects described in Volume I; and the introduction of non-native species altering the riparian corridor (Volume II). Sub-urban development from the 1950's thru 1970's (described in Volumes I) exacerbated the channel impacts by dramatically expanding areas of impervious covered. Today the watershed is approximately one-third built up, with a 13% overall impervious surface (EOA, 1998). Significant expansion of urbanized areas is not expected due to the Hillside Protection and Growth Control ordinances.

Our **vegetation analysis** (Volume II) has provided maps and analysis of riparian vegetation and the general characteristics of upland vegetation in the watershed. To make sense of the varying changes in riparian conditions, we have organized this information by reach (Figure 18) and can now identify areas that need special attention for canopy gaps and removal of non-native species. For the most part, the creek is blessed with good canopy conditions though certain areas need attention. Through the Coalition's efforts, we have largely removed Arundo donax infestations. Cape and English Ivy remain the most pernicious invasive exotics.

Water quality analyses (Vivian Matuk, Volume III) comparing different sites along the creek during winter, late spring, summer and fall of the year 2000, provided significant information about in-stream physical, chemical and biological characteristics of San Pedro creek watershed. The dry-summer maritime type of climate of San Pedro Creek watershed directly influenced the water quality of the creek. Highest values of alkalinity, hardness, electrical conductivity, pH, total, fecal coliform bacteria, *Escherichia coli* and enterococcus were reported during the April-May and July-August sampling periods. The lowest values of water temperature, and highest values of turbidity and dissolved oxygen were reported during the winter period (January-February and October-November). Rainfall events and changes in the water temperature clearly influenced these patterns. Also, Matuk found that spatial variations were evident when comparing the sampling sites along the creek. Generally, the highest water temperature, pH, alkalinity, hardness, electrical conductivity and bacteriological values were reported at the North Fork. In addition, lower values of turbidity and dissolved oxygen were reported at that sampling site. Similar physical, chemical and biological values were reported at Linda Mar, Peralta and the Outlet sampling sites. The lowest values for parameters such as pH, alkalinity, conductivity, hardness, electrical conductivity, bacteriological analyses and water temperature were reported at Oddstad (the "control" sampling site). In addition, the highest dissolved oxygen and turbidity values were reported at the "control" site. Land-use categories, urbanization, inputs from the sewage and storm systems, and the influence of geology may explain the spatial variations and the water quality characteristics reported in this study.

Overall, Matuk found that San Pedro Creek is a well-oxygenated creek with somewhat alkaline water, at a fairly stable water temperature, with relatively "hard" waters and moderately conductive. Its water quality met most of the San Francisco Regional Water Quality Control Board, EPA and literature standards for a freshwater habitat. On the other hand, the creek samples did ***not*** meet the EPA's bacteriological standards for water contact recreation bodies. Water quality is impaired, possibly due to inputs from the sewage and storm systems, and the creek's bacteriological contamination may pose a risk to public health even though it provides a significant habitat for aquatic species such as the steelhead trout. Matuk recommends developing additional and more intensive water quality-monitoring program to account for annual variability along the creek, especially at the North Fork where variations of parameters such as temperature might be significant factor for fish habitat.

Our **Steelhead Habitat Assessment** (Jeff Hagar, Volume IV) has helped to clarify the character of different major stream reaches and tributaries as habitat for spawning and rearing. The Middle Fork appears to have the greatest potential for spawning, as well as rearing to smolt size, while the main stem is important for rearing despite significant water quality and disturbance issues significant to steelhead – especially turbidity, alkalinity, and temperature. Hagar emphasized that additional temperature monitoring, especially of the North Fork, would help to identify if this parameter may be significant seasonally. Of the tributaries, the South, North and Sanchez forks were emphasized primarily for water quality and quantity concerns: the significance for potential diversions of South Fork flow by the water district, the diverse water quality problems associated with the North Fork, and sediment concerns from the Sanchez Fork. The danger of reduced flows from any South Fork diversions is especially significant if North Fork runoff is removed due to water quality concerns. While the report doesn't emphasize habitat potential for Sanchez, he did note observations of small resident trout, and many of the limiting factors – a major barrier and a steep gradient downstream – can be addressed by relatively inexpensive restoration projects. The primary concerns Hagar recommends addressing, however, are barriers to fish passage, especially at bridge culverts, listed in order of decreasing importance as Capistrano, Linda Mar, Oddstad, and Adobe. The important spawning habitat identified in the Middle Fork is upstream of all of these barriers.

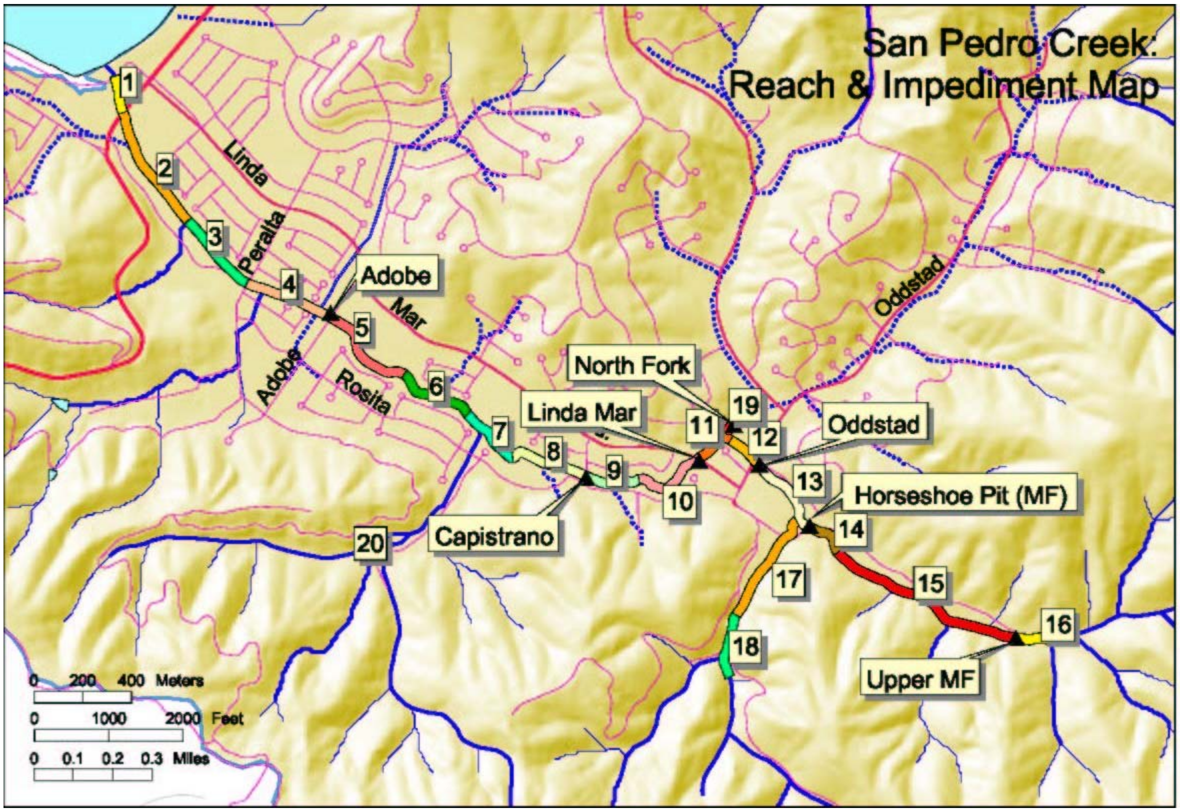


Figure 18. Reach and Impediments, San Pedro Creek Watershed

4. RESTORATION ISSUES AND ALTERNATIVES

Each volume of our assessment above notes specific problems and recommends restoration needs. The basic categories of restoration goals relating most directly to anadromous fish can be summarized as:

1. Removal of impediments to migration
2. Enhancement of habitat for spawning and rearing

There are of course many ways of accomplishing these goals, and many locations along the creek where efforts can have the most impact. In considering the results of the Assessment, the Coalition met to discuss and prioritize projects, organized geographically by stream reaches (see Figure 18). Reaches were defined to subdivide the creek in sections of similar general character and level of impact, though the many detailed changes in character – especially mapped in the **Geomorphic Analysis** (Volume 1) as well as in the vegetation data – are important to consider, especially as specific projects are designed.

Table 2 lists an array of potential restoration projects. Each project is identified by reach location, specific site, its benefits, the problem it addresses, the restoration method proposed, cost estimates where possible, funding sources and required permits. Each project is also assigned a level of urgency: High (H), Medium (M), and Low (L).

The highest priorities are given to addressing serious fish passage impediments, especially at **Capistrano Bridge** where a fish ladder has become seriously compromised by downstream erosion, and the ladder itself continues to contribute to serious bank failures downstream. While likely to be an expensive project, stopping fish migration at this fish ladder closes off the best spawning areas along the creek, as identified by Jeff Hagar. The City of Pacifica and the San Pedro Creek Watershed Coalition (SPCWC) have agreed to work collectively to address issues of severe bank erosion and impediments to fish passage for the section of San Pedro Creek downstream of the Capistrano fish ladder in Pacifica. In Spring 2002, the SPCWC will conduct the necessary field reconnaissance work and survey creek conditions in the project area. Upon completion of the assessment, the SPCWC will graph and analyze the data and then develop a conceptual restoration design to address erosion and fish passage issues. The conceptual design will be developed to work in combination with a series of designs already developed by L.C. Lee and Associates for the segment of creek immediately upstream of Capistrano Bridge. The conceptual restoration design will be presented to the City of Pacifica and L.C. Lee and Associates in the form of cross sections and a planform map using the Rosgen Stream Classification method. The major steps being pursued are:

1. **Reconnaissance Meeting**. Field reconnaissance meeting with Scott Holmes, Maria Aguilar, Jerry Davis, Christine Chan, Laurel Collins and Peggy Fieldler, to discuss project and review field site.
2. **Field Work**: (a) to position longitudinal profile distance stations and locating future cross sections; (b) to survey cross sections downstream of Capistrano box culvert, through pools and riffles at two stable reference sites; (c) survey associated stream profile at the two reference sites and downstream of the box culvert; (d) collect surface and subsurface sediment samples at the two stable riffle sites; and (e) document cross sections with photographs.
3. **Plotting Data**: Reduce, analyze, and graph data. Jerry Davis will reduce and plot profile data. Laurel Collins will reduce and plot cross sections.
4. **Data Analysis**: Sieve and weigh gravel samples and consult with reviewer.
5. **Design Development**: Review proposed plans by LC Lee and Assoc., and make additional recommendations for upstream segment. Develop conceptual design plans.
6. **Design Plan**: Meeting with Scott Holmes, SPCWC, and LC Lee & Assoc. to present findings and further develop conceptual restoration design.

Also important, and much less expensive at least in the short-term would be creating low-flow channels in culverts at other bridges upstream of Capistrano: Linda Mar, Oddstad, and the Horseshoe Pit bridge on the Middle Fork in San Pedro Valley County Park. A more long-term, but more expensive solution at each of these sites would be removal of each box culvert and replacement of each bridge with a wider span. The only cost for such we could estimate is the Horseshoe Pit Bridge in the park, for which we can assume the cost to be similar to a bridge we already replaced higher up in the system.

Other barriers exist in tributary watersheds. For example, most of Sanchez Fork is blocked by a substantial drop from a 6' corrugated culvert under a church parking lot (Figure 19).

Figure 19. Sanchez Fork Barrier (photograph by Jerry Davis, 2002)

Other in-stream projects we assigned high priority to include a site (#10) where a serious toxic (creosote) retaining wall (see photo at 5660' in Volume 1) failure is happening at an old dam site. This site benefits from what would appear to be a relatively amenable situation: while the retaining wall protects homes very close to the creek on the south bank, on the north bank is a large property owned by the Alma Heights School, which is also looking for a creek enhancement project to use as an educational tool for its students. There is clearly room here, assuming we can count on the cooperation of landowners, for a highly beneficial and attractive in-stream project involving removal of the dam remnants and a restoration of meanders and riparian corridor system.

We are recommending a longitudinal profile and cross sections of the **South Fork** to assess the potential for adding approximately 3000' of enhanced habitat, and barrier removal to reaches upstream. Hagar's evaluation noted limitations in habitat on this fork, due to steepness; the excessive gradient of this fork is due to channelization and straightening, with a significant berm on the left bank separating the stream from a gravel road. This situation is creating erosion problems, threatened structures, habitat degradation and a greater potential for flooding downstream. As a result of 2002 meetings with the North Coast County Water District, which owns the South Fork subwatershed and leases most to the County Park, we have furthered the cooperative efforts of our Coalition with one of its important members, and plan to pursue joint projects. For example, we have agreed to pursue an assessment of channel conditions (longitudinal and cross-sectional) and erosion features along this reach. We are hopeful that this will lead to a corridor restoration plan for this reach, which has great potential for enhancing fish habitat. We also hope to work with the NCCWD to study sediment sources, of concern not only to fish but also to water supplies, and to evaluate (July 2002) the costs and benefits of future water diversions. An important factor in this analysis should be the benefits of water flows to fisheries.

While not a restoration project *per se*, we placed a very high priority on pursuing a feasibility study for an array of possible projects to address the North Fork 8' culvert outlet. This outlet was identified throughout the assessment as a major problem: as a source of extremely fast storm flows and the resultant bed and bank erosion problems downstream, and thus a source of significant fines to the water quality, and the well-documented poor water quality emitted at this site. Clearly these two problems must be addressed in some manner, but the situation is complex and problematic. A stormwater flow storage system, a filtration system, and various partial daylighting proposals have been put forth, but each will require considerably more study. Thus we have listed this as a high priority.

Installation of large woody debris (LWD) structures to enhance fish habitat is commonly used in streams with limited supplies. Our assessment, especially Volume 1, recommends instead using a management policy change: not removing LWD as it collects, currently a flood-control program pursued by the City of Pacifica. It is clear from our discussions with City personnel that further study is needed to best effect a LWD program. The likely result of this study will be to identify suitable areas for specific LWD management procedures.

Other restoration projects given high priority include non-native invasive removal and replanting of the riparian corridor. We recommend that these projects include a significant volunteer component, and thoroughly involve creekside residents in installation and maintenance. Many creekside residents are highly interested in "doing the right thing" in their backyard – restoring native plants and at the same time enhancing the landscape for their own enjoyment – they just need a little help and guidance. Educational projects are also important, and probably the best way to improve water quality and limit the spread of invasive exotics. We hope to sponsor workshops and provide educational materials for creekside residents, and help our citizens to understand what it means to live in a watershed.

Table #2 Proposed Projects: Major Fish Impediments, Vegetation Gaps and Erosional Problems, San Pedro Creek, Pacifica

I.D.	Reach	Priority	Sites	Benefits	Problems	Enhancement Method Sought	Initial Estimated Cost	Potential Funders	Permits
Fish Impediments									
1	9*	H	Capistrano Phase 1 (Downstream)	Restored longitudinal connectivity to vitally important steelhead run	Impediment to juvenile and adult steelhead rearing and spawning habitat, eroding stream channel and adjacent banks, canopy gaps, poor fish habitat	Replacement of fish ladder and upstream concrete channel with step pool system, shore bridge footings, stabilize streambanks	$1,500,000	Department of Water Resources, California DFG (Emergency Funds)	USACOE, CDFG, RWQCB, CEQA
2	9*	H	Capistrano Phase 2 (Upstream)	Restored longitudinal connectivity to vitally important steelhead run	Impediment to juvenile and adult steelhead rearing and spawning habitat, eroding stream channel and adjacent banks, canopy gaps, poor fish habitat, sediment erosion	Conduct field reconnaissance work, survey cross-section and longitudinal profile. Develop a conceptual restoration design.	$300,000-$400,000	USACOE, Department of Water Resources	USACOE, CDFG, RWQCB
3	11*	H	Linda Mar Bridge	Improved fish passage	Shallow flows	Install low-flow channel	$5,000	California Coastal Conservancy, DFG	USACOE, CDFG, RWQCB, CEQA
4	5*	L	Adobe Street Bridge	Reduced flooding, improved fish passage, enhanced habitat	Inadequate to pass flood flows of any serious magnitude	Replace bridge, construction of downstream pool/run complex, Restore riparian corridors	$400,000-$450,000	California Coastal Conservancy, DFG	USACOE, CDFG, RWQCB, CEQA
5	13*	H	Oddstad Bridge	Improved fish passage, provides rearing habitat during extreme events on mainstream	Shallow flows and potential for greater impediment from downstream erosion	Low-flow channel	$5,000	California Coastal Conservancy, DFG	USACOE, CDFG, RWQCB, CEQA

I.D.	Reach	Priority	Sites	Benefits	Problems	Enhancement Method Sought	Initial Estimated Cost	Potential Funders	Permits
6	13*	M	Oddstad Bridge	Improved fish passage, provides rearing habitat during extreme events on mainstream	Shallow flows and potential for greater impediment from downstream erosion	Culvert removal and bridge replacement	$1,000,000	California Coastal Conservancy, DFG	USACOE, CDFG, RWQCB, CEQA
7	15*	H	Horseshoe Pit Bridge	Improved fish passage, provides rearing habitat during extreme events on mainstream	Shallow flows and potential for greater impediment from downstream erosion	Low-flow channel (short-term)	$5,000	California Coastal Conservancy, DFG	USACOE, CDFG, RWQCB, CEQA
8	15*	L	Horseshoe Pit Bridge	Improved fish passage, provides rearing habitat during extreme events on mainstream	Shallow flows and potential for greater impediment from downstream erosion	Culvert removal and bridge replacement	$75,000	California Coastal Conservancy, DFG	USACOE, CDFG, RWQCB, CEQA
Instream Projects									
9	11	H	North Fork	Reduced downstream erosion and concomitant fine sediment problems, improved water quality, etc.	Peak flow issues, water quality	Feasibility study to consider storage/ peak-flow reduction project alternatives	$25,000	California Coastal Conservancy, DFG	USACOE, CDFG, RWQCB, CEQA
10	5	H	Alma Heights School creekside property	Lengthening of channel, improved riparian habitat, flood water storage	Erosion on (opposite) south bank at old dam site and toxic material used in revetment	Restore meanders and riparian corridor, revetment removal	$200,000+	California Coastal Conservancy, DFG	USACOE, CDFG, RWQCB, CEQA
11	7	M	Sanchez Center Property	Lengthening of channel, improved riparian habitat, flood water storage	Erosion and failing revetments on (opposite) south bank	Restore meanders and riparian corridor, revetment removal	$200,000+	California Coastal Conservancy, DFG	USACOE, CDFG, RWQCB, CEQA

I.D.	Reach	Priority	Sites	Benefits	Problems	Enhancement Method Sought	Initial Estimated Cost	Potential Funders	Permits
12	3	L	Downstream of Peralta Bridge Project	Lengthening of channel, improved riparian habitat, flood water storage	Flooding, degraded habitat	Restore meanders and widen riparian corridor above Linda Mar Convalescent Home, revetment removal	$250,000	California Coastal Conservancy, DFG	USACOE, CDFG, RWQCB, CEQA
13	17	H	South Fork	Enhance habitat and allow for fish passage to areas of potential habitat	Ditched stream with associated poor habitat; contribution to downstream flooding and sediment supply; fish passage barrier at old dam structure	Removal of berm & dam structures; restoration of meanders and riparian corridor	$150,000	California Coastal Conservancy, DFG	USACOE, CDFG, RWQCB, CEQA
14	1	H	Creek Mouth	Enhance steelhead habitat	Inadequate staging area for anadromous fish	Constructing tidally influenced wetland	$250,000	DFG, State WRCB, CA Coastal Conservancy	USACOE, CDFG, RWQCB, CEQA
15	ALL	H	LWD Feasibility Study	Enhance fish habitat with LWD	Degraded habitat, especially pools and resting areas	Study methods of LWD management and potential installation	$25,000	CDFG	Existing City permits
Non-Native Invasive Species									
16	7/8	M	N. Bank downstream of Capistrano Avenue to the lower end of the Sanchez Art Center Property	Restored riparian habitat, increased area and duration of shading, lowering of water temperatures, protection of exposed banks against erosion, improved water quality	Degraded habitat due to invasion of non-native vegetation	Eradication of exotics, followed by high density replanting of native riparian species	$30,000-$35,000	NFWF, RWQCB	NA
17	4	M	Peralta to Adobe reach	Improve canopy cover	Canopy gaps	Eradication of exotics, followed by high density replanting of native riparian species	$20,000-$25,000	NFWF, RWQCB	NA

I.D.	Reach	Priority	Sites	Benefits	Problems	Enhancement Method Sought	Initial Estimated Cost	Potential Funders	Permits
18	ALL	H	Entire creek	Provide most cost-effective approach to control of problematic exotics	Continuing invasion	Establish a comprehensive NIS maintenance program	$250,000+ (five years)	NFWF, RWQCB	NA
18	13-18	M	County Park area	Improving habitat for native species and decreasing the threats of invasive propagation downstream	Invasive species and disturbance of natural riparian canopy cover	Ivy eradication, using an intensive volunteer eradication program	$5,000 + volunteers	NFWF, RWQCB	NA
19	6	M	Alma Heights to Sanchez Nursery	Improve canopy cover/shade	Major canopy gap	Revegetation with natives	$20,000+	NFWF, RWQCB	NA
Water Quality									
20	ALL	M	Upper watershed	Enhance water quality of significance to salmonids	Non-point source sediment pollution from debris flows and slope wash	Sediment source analysis	$120,000	California Water Resources Control Board (205J)	None
21	ALL	H	Entire watershed	Improve water quality, prevention of major fish kills	Acute toxic spills, loss of young fish & eggs	Educational program	$50,000	Coastal Commission, STOPPP, DFG	None
Land Acquisition									
22	19	H	North Fork Terra Nova branch	Storing flood flows, mitigating water quality issues, steelhead and other habitat improvement	Severe bank erosion downstream and associated sediment pollution and fish barriers; bacterial water quality degradation	Land purchase, daylight creek, riparian corridor restoration	City-owned	Coastal Conservancy, Pacifica Land Trust (PLT)	USACOE, CDFG, RWQCB, CEQA
23	12	H	Upstream of NF Confluence	Steelhead and other habitat improvement, potential site for Riparian Station	Bank erosion on both banks, significant potential for future fish barrier at Oddstad Bridge	Land purchase, riparian corridor restoration	$561,000	Coastal Conservancy, PLT	USACOE, CDFG, RWQCB, CEQA
24	NA	H	Oddstad School site	Storing flood flows, restoring Red-legged Frog habitat	Urban runoff flashy flows, landfill runoff	Land purchase, riparian corridor restoration	School-district-owned	Coastal Conservancy, PLT	“

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7. INDEX TO ASSESSMENT VOLUMES

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