BIG SUR RIVER STEELHEAD ENHANCEMENT PLAN

Prepared for:
Department of Parks and Recreation
Monterey District
2211 Garden Road
Monterey, CA 93940

Prepared by:
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Contact: Josh Harwayne

Consultants:
Kittleson Environmental Consulting
Fall Creek Engineering, Inc.

March 2003

Denise Duffy & Associates, Inc.
PLANNING AND ENVIRONMENTAL CONSULTING

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I. PURPOSE AND NEED

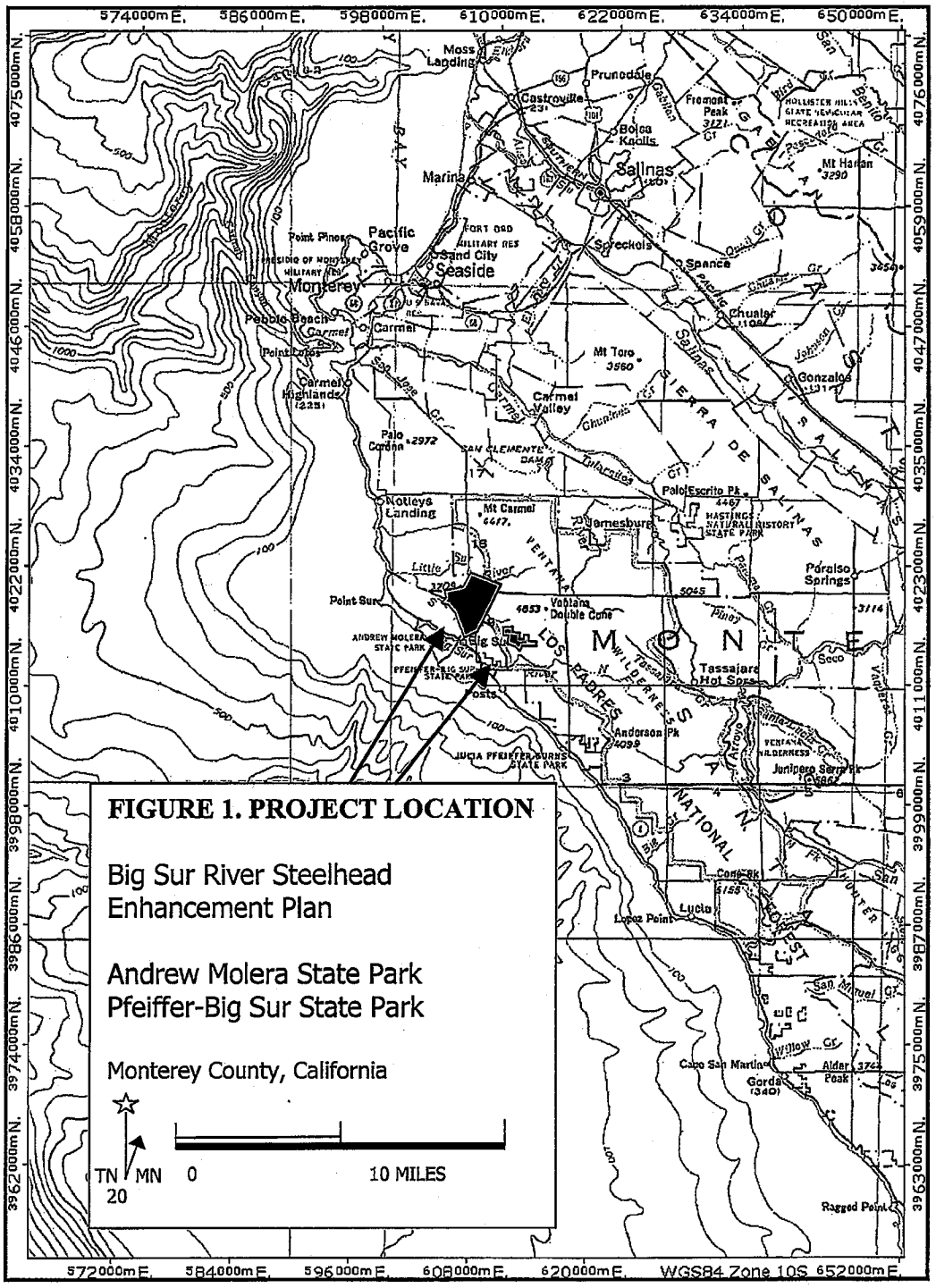
California Department of Parks and Recreation (DPR) authorized development of the Big Sur River Enhancement Plan for Steelhead Habitat (Enhancement Plan) in the two State Park properties within the Big Sur River watershed: Andrew Molera State Park (AM) and Pfeiffer-Big Sur State Park (PBS), **Figure 1**. The primary purpose of the Enhancement Plan is to characterize the status of the existing steelhead resource within the project area and provide recommendations for habitat enhancement and resource management measures that benefit the species. The Enhancement Plan is limited in geographic scope to the State Park properties, and proposed projects and management measures reflect that limit.

Populations of native anadromous salmonids all along the Pacific Coast of the continental U.S. have declined sharply within the last 150 years. Steelhead trout (*Onchorhynchus mykiss*) in the Central and south coast of California have been especially hard hit within the last 50 years, primarily because of the reductions in the amount and quality of freshwater habitat (Titus et. al. 1994). Within the State Park project area, specifically the mainstem Big Sur River and lower Post Creek, steelhead are widely distributed throughout all available habitats.

Anadromous steelhead live in the ocean and return annually to spawn and rear in coastal rivers, streams and lagoons. Resident rainbow trout live their entire lifecycle in freshwater streams and waterbodies. Both are present within the Big Sur River system, although steelhead migration is limited by a complex of boulder rockfalls and log barriers in the Big Sur River Gorge at the Pfeifer Big Sur State Park boundary with the Los Padres National Forest. Passage improvements using explosives and manual logjam removal crews have been attempted several times over the past 5 decades. These efforts have resulted in some short-term successes, though limited by wildland fires, landslides and episodic sediment delivery from throughout the upper watershed.

Below the steelhead passage barrier at the Big Sur River Gorge, California State Parks manages approximately 6.5 miles of the approximately 8.5 miles of stream habitat known to support steelhead. Post Creek in PBS and Juan Higuera Creek are the only two tributaries to the Big Sur known to support steelhead. Juan Higuera Creek flows into the Big Sur between the Parks and is outside of the Project area. State Parks lands therefore represent approximately 75% of available steelhead habitat for the entire watershed. Targeted conservation efforts closely linked to adaptive management of the State Park resources is therefore critical to the long-term viability of the Big Sur steelhead population.

The longest stretch of State Park-managed stream is at Andrew Molera State Park, from the mouth of the river to upstream river mile 3.6, **Figure 2.** Upstream of Andrew Molera State Park and the community of Big Sur, State Parks manages Pfeifer-Big Sur State Park with approximately 2.8 miles of steelhead stream, primarily in the mainsteam Big Sur River and 0.3 miles of lower Post Creek, **Figure 3**.


574000mE.
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4022000mN.
4010000mN.
3998000mN.
3986000mN.
3974000mN.
3962000mN.
4076000mN.
4059000mN.
4047000mN.
4035000mN.
4023000mN.
4011000mN.
3999000mN.
3987000mN.
3975000mN.
3963000mN.
572000mE.
584000mE.
596000mE.
608000mE.
620000mE.
WGS84 Zone 10S
652000mE.
Moss Landing
Prunedale
Castroville
Fremont Peak
Bolsa Knolls
Salinas
Mt Harlan
Marina
Spreckels
Spence
Pacific Grove
Sand City
Seaside
Monterey
Point Pinos
Pebble Beach
Carmel
Point Lobos
Carmel Highlands
Mt Toro
Carmel Valley
Chualar
Gonzales
Palo Corona
Notleys Landing
Mt Carmel
Palo Escrito Pk
Jamesburg
Paraiso Springs
Point Sur
Little Sur River
Ventana Double Cone
Big Sur
Tassajara Hot Spgs
Seco
Andersons Pk
Junipero Serra Pk
Lopez Point
Lucia
Cone Pk
Cape San Martin
Gorda
Alder Peak
Ragged Point
MONTEREY
SALINAS
SIERRA DE SALINAS
LOS PADRES
NATIONAL FOREST
VENTANA
MONTEREY BAY
FIGURE 1. PROJECT LOCATION
Big Sur River Steelhead Enhancement Plan
Andrew Molera State Park
Pfeiffer-Big Sur State Park
Monterey County, California
TN
MN
20
0
10 MILES

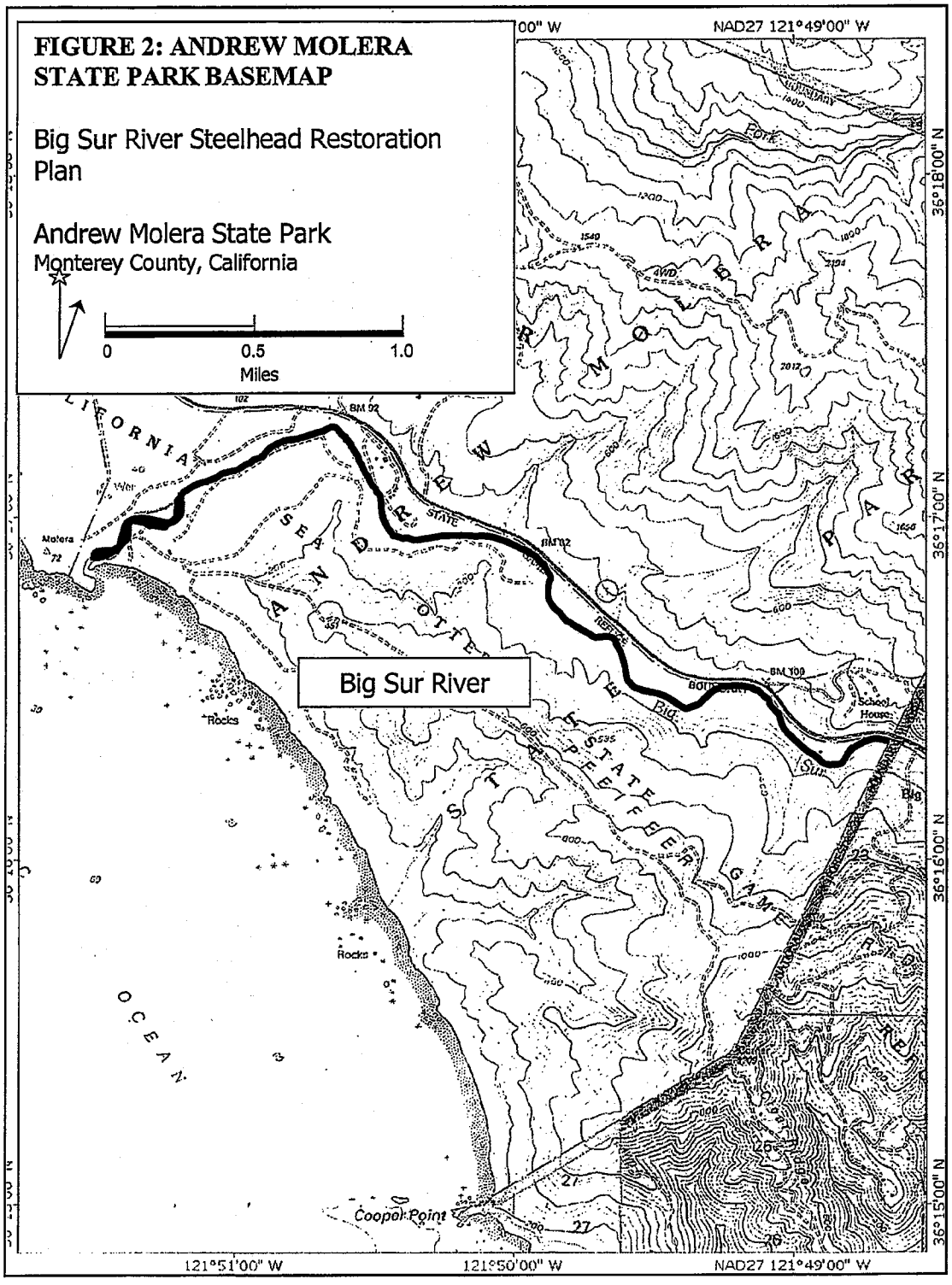
FIGURE 2: ANDREW MOLERA STATE PARK BASEMAP
Big Sur River Steelhead Restoration Plan
Andrew Molera State Park
Monterey County, California
0
0.5
1.0
Miles
Big Sur River
NAD27 121°49'00" W
121°51'00" W
121°50'00" W
36°18'00" N
36°17'00" N
36°16'00" N
36°15'00" N
OCEAN
Coopoi Point

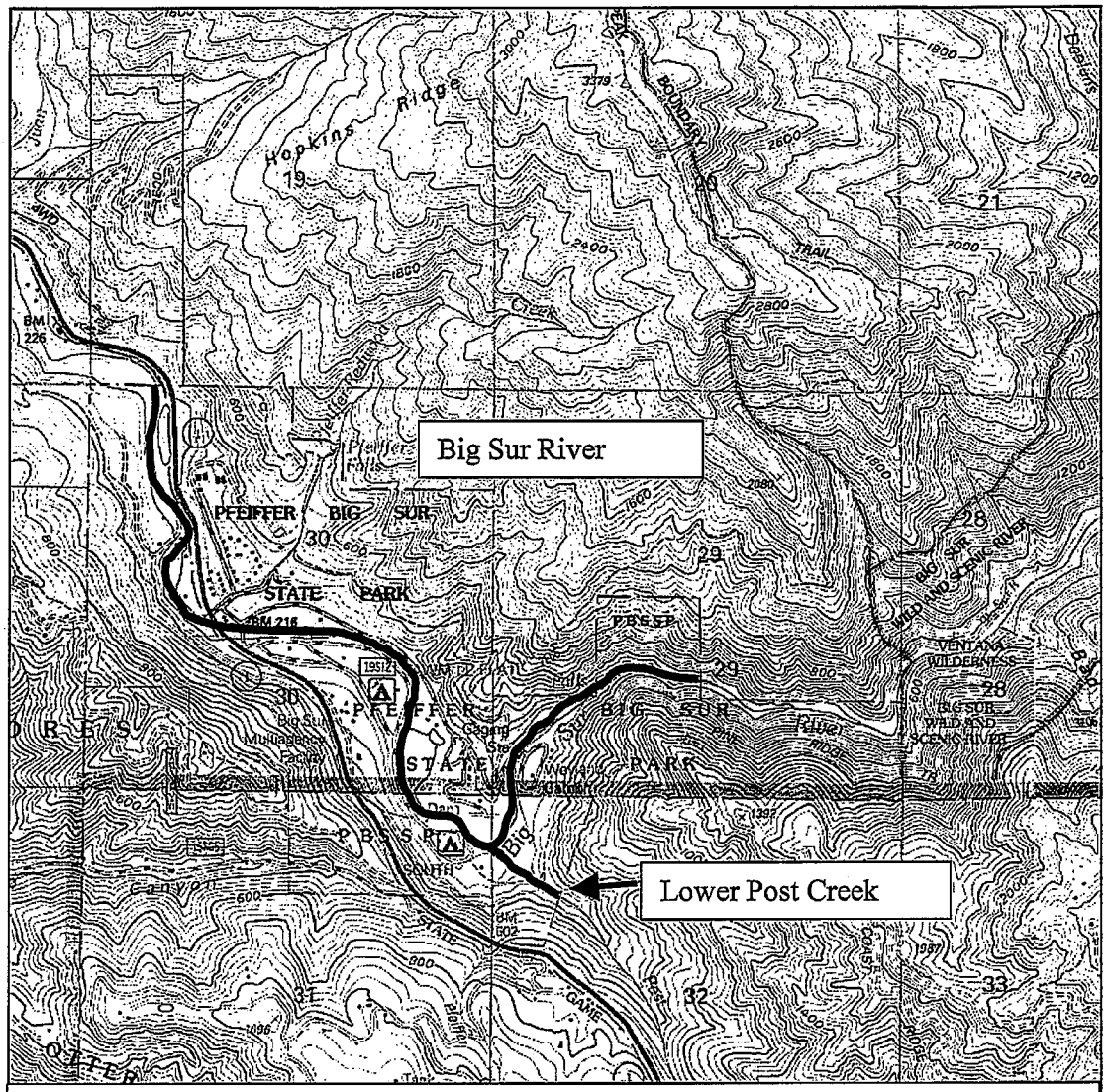

FIGURE 3: PFEIFER-BIG SUR STATE PARK PROJECT BASEMAP

Big Sur River Steelhead Restoration Plan

Pfeiffer-Big Sur State Park
Monterey County, California

II. EXISTING CONDITIONS

A. Regional Setting

The Big Sur River Watershed is located within the Coast Ranges natural region or geomorphic province (Oakeshott 1971). This region extends from Oregon south along the Pacific coast to the Santa Ynez Mountains in Southern California. The Coast Ranges are a complex of geologically active mountain ranges and valleys with peaks and ridges averaging between 2,000 and 4,000 feet in elevation, with the highest peaks over 6,000 feet (Martin 1990).

The Big Sur watershed is located within the Santa Lucia Range of the Coast Ranges. Encompassing approximately 59 square miles (37,504 acres) of rugged mountain terrain, the Big Sur watershed has a steep gradient, falling some 1,200 vertical feet from its intermittent headwater streams below the crest of the Santa Lucias Mountains to the nearby Pacific Ocean. The highest elevations in the watershed are along this crest at Ventana Cone (4,727 feet), Ventana Double Cone (4,853), Black Cone (4,535), South Ventana Cone, (4965 feet). Closer to the coast, Post Summit (3,455 feet), Manuel Peak (3,379 feet), and Pico Blanco (3,708 feet) serve as a watershed boundary, separating the Little Sur River watershed to the north.

The Big Sur mainstem and its major tributaries above the project area are entrenched in deep sinuous canyons in the Los Padres National Forest and Ventana Wilderness. Within the National Forest and Ventana Wilderness, 19.5 miles of the Big Sur River upstream of Pfeiffer-Big Sur State Park is designated a Wild and Scenic River under the Federal Wild and Scenic Rivers Act. The upper watershed is largely considered to be pristine and supports a diverse assemblage of native aquatic and terrestrial species. On the boundary between the National Forest and Pfeiffer Big Sur State Park the river passes through a feature known as the Big Sur River Gorge. Downstream, through Pfeiffer Big Sur State Park to the town of Big Sur, the river flows through a narrow, redwood dominated alluvial valley that is bounded by steep canyon walls.

Development and visible habitat degradation along the mainstem of the river is limited to this relatively flat, alluvial reach. Riparian encroachment, inner gorge roads, water extraction, and wastewater generation are concentrated in the Pfeifer Big Sur Park Campground reach and through the Highway 1/Big Sur corridor. Below the developed area of Big Sur, the lower 3.6 miles of river flow through a gradually widening alluvial valley set in a low coastal terrace. The meandering alluvial reach terminates at the Big Sur lagoon at Molera Point.

Several tributaries to the Big Sur flow through the project area. Only Post Creek is known to support steelhead. Redwood Creek flows through a culvert under the developed area of Big Sur State Park and is considered impassible to fish. Other tributaries in the project area are ephemeral or have flows insufficient to support salmonids.

Precipitation

The Big Sur River watershed is located in a Mediterranean climate with cool, wet winters and hot, dry summers. Annual precipitation is highly variable throughout the watershed due to elevation differences, but averages 39.7 inches at the U.S. National Weather Service rain gage at PBS (elev. 240'), which has operated since 1913. The highest elevations in upper watershed average 55 inches of rain per year. Snowmelt and fog drip are not considered substantial

contributors of runoff. Rainfall normally occurs from November through May and significant runoff events generally occur from December to April.

Hydrology

The USGS has operated a stream gage continuously at Pfeiffer-Big Sur State Park since 1950 (**Figures 4 and 5**).[1] The gage is located below the Gorge at the upstream vehicle bridge crossing. The 46.5 square mile watershed area contributing runoff to the gage location is undeveloped, with no reservoirs or stream diversions. Surface and groundwater extractions are concentrated within the lower 12.5 square miles on tributaries and along the alluvial plain of the Big Sur River's mainstem.

The maximum peak flow recorded on the Big Sur River was 10,700 cubic feet per second (cfs) on January 5, 1978. The lowest flow on record was 2.6 cfs. on August 23, 1978, just five months earlier than the record flood. Mean annual flow is 102 cfs. The highest mean daily flows (300-350 cfs) are most likely to occur in January and February as a result of winter rains.

Overall, December through April represent the peak spawning period (**Table 1**). Because the Big Sur River lagoon remains open the majority of the time, early and late storms may attract adult fish into the system as early as October and as late as May/June. Outmigration occurs at any flows sufficient to pass fish through the Lower Big Sur's critically shallow gravel and cobble riffles. Summer low flows, or rearing flows, are typically 15 to 20 cfs.

The peak discharge of 6,690 cfs in 1995 was the second highest peak of record for the gage, or a *20-year* recurrence interval storm. Since then all but 2 years have had above-bankfull flood events, which has resulted in notable channel changes. These geomorphically significant events have caused severe lateral erosion, channel braiding and deposition of coarse backwater-induced cobble bars in the broad alluvial floodplains and lagoon in Andrew Molera State Park.

USGS flow statistics cited below represent full natural flows, without upstream diversions or extractions.

[1] 11143000 BIG SUR RIVER NEAR BIG SUR, CA. LOCATION - Lat 36°14'45", long 121°46'20", in SW 1/4 SW 1/4 sec.29, T.19 S., R.2 E., Monterey County, Hydrologic Unit 18060006, on right bank at downstream side of bridge, 0.4 mi upstream from Post Creek, and 2.6 mi southeast of town of Big Sur.

Table 1.
MONTHLY MEAN FLOWS (CFS)
FOR WATER YEARS 1950 - 2001,
BY WATER YEAR (*WY*)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	17.8	44.2	101	244	290	227	144	67.6	37.2	24.0	17.6	15.5
MAX	86.8	302	449	1047	1,329	964	843	333	119	71.4	43.0	39.4
(WY)	1963	1951	1956	1997	1998	1983	1958	1983	1998	1998	1998	1983
MIN	5.08	4.97	7.52	8.27	11.4	16.8	9.15	8.70	6.17	4.94	3.80	4.52
(WY)	1991	1991	1991	1991	1977	1977	1977	1977	1977	1977	1977	1961

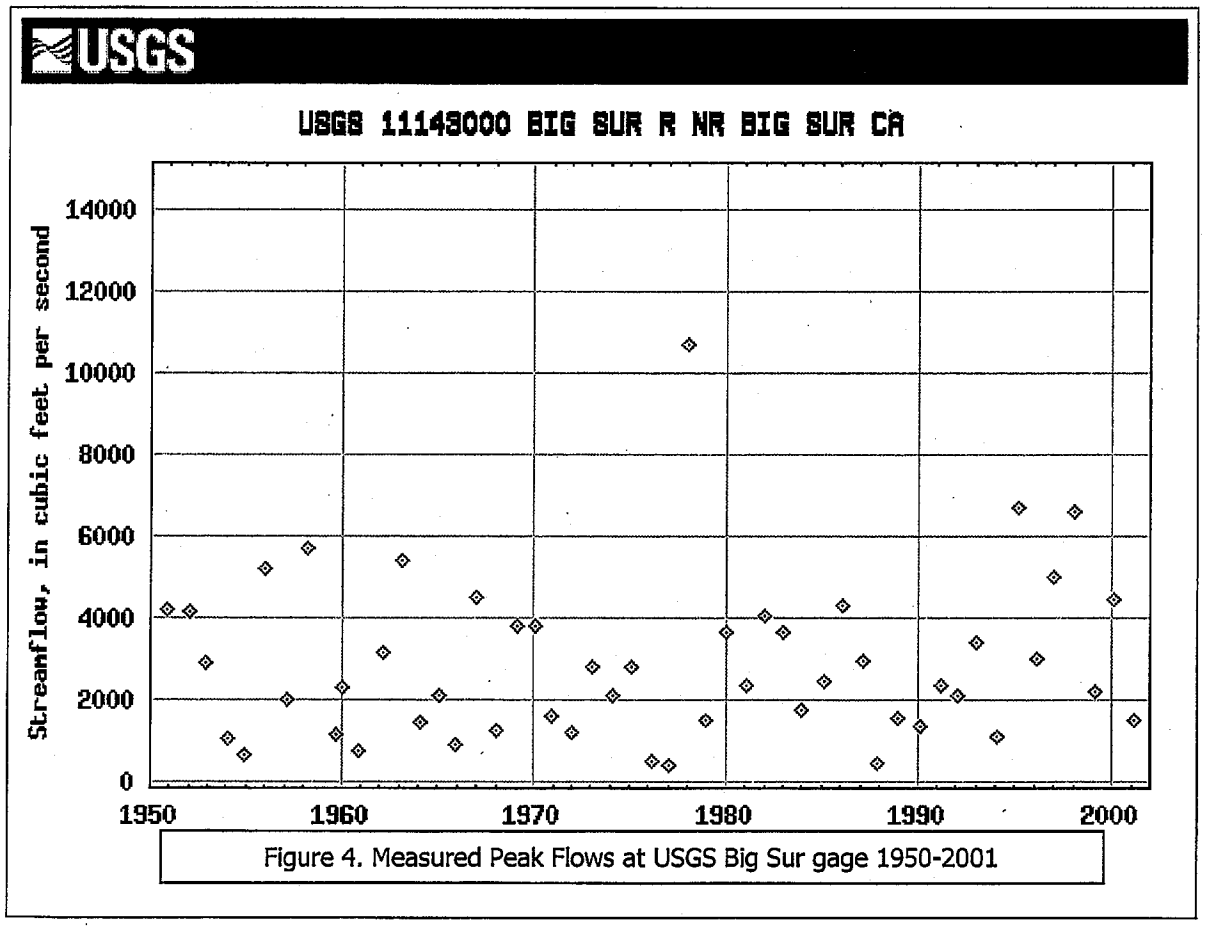

Figure 4. Measured Peak Flows at USGS Big Sur gage 1950-2001

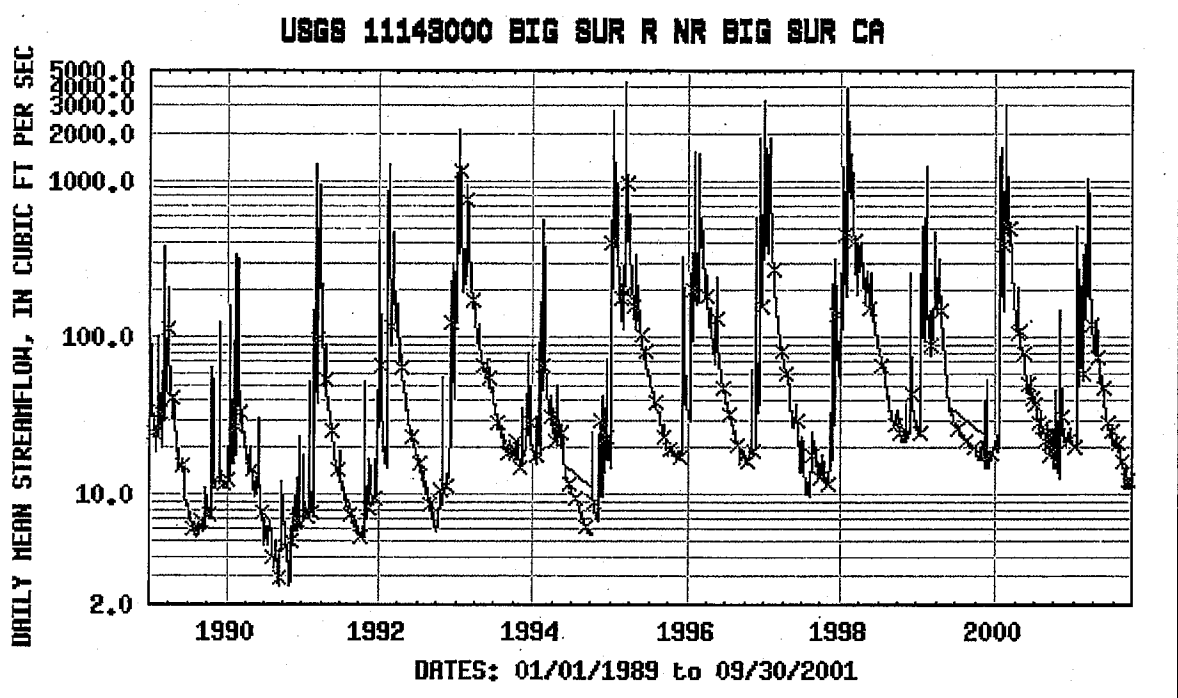

Figure 5. Measured Daily Mean Flows at USGS Big Sur gage 1989-2002

Water Sources and Wastewater Management

Water supplies for the two subject properties are located within the parks' boundaries and rely on local alluvial groundwater recharge for sources. No surface water diversions currently operate in the subject properties. State Parks operates two shallow alluvial wells in PBS, which supply an average of 62.07 acre-feet of water annually. In AM near the ranch houses, State Parks operates one shallow alluvial well that supplies an average of 5.34 acre-feet of water annually.

The total average annual well yield for DPR use is 67.41 acre-feet, or 0.0393% of the 171,590 acre-feet total average annual runoff in the Big Sur River. It was noted in the El Sur Ranch Hydrologic Investigation that net diversions by all water users throughout the Big Sur system amount to 0.1-0.3% of the total average annual runoff at the USGS gage (JSA 1999).

The effects of groundwater use by the El Sur Ranch on streamflow and lagoon conditions in Andrew Molera State Park are currently being evaluated by the California State Water

Resources Control Board in response to the Application for Appropriative Water Rights by James Hill of the El Sur Ranch. An Environmental Impact Report on this appropriation of water is being developed by consultants and should clarify the local water budget and the safe yield of the shallow groundwater basin, particularly as it relates to take of steelhead through dewatering in periods of low flow, severe drought or heavy pumping.

Wastewater treatment facilities at the two subject properties return all water, minus evaporation and evapotranspiration, to local groundwater through leachfields. A package wastewater treatment plant has operated in lower PBS since 1998, processing an average of 90,000 gallons per day. Inflow to this plant includes all visitor use, administrative and staff housing facilities within PBS, as well as USFS facilities along Highway 1 to the south. No adverse water quality impacts from the PBS wastewater plant and leachfield were noted to investigators by RWQCB staff. At AM wastewater is discharged to groundwater via septic leachfields at the Ranch complex, main parking lot and the walk-in campground. No data were encountered or obtained during this investigation indicating that park wastewater facilities contribute to adverse water quality conditions since recent upgrades were completed. (M. Adams RWQCB3, Personal communication, 2003).

III. STEELHEAD LIFE HISTORY

Understanding steelhead's life history is crucial for development of practical restoration planning, because the species is vulnerable to different types of impacts at different times of the year and points in their lifecycle. Steelhead trout (*Oncorynchus mykiss*) belong to the Salmonidae family, which includes salmon, whitefish and char. Steelhead trout are anadromous, meaning that they migrate from the ocean into fresh water to spawn and juvenile fish rear partially in freshwater. Rainbow trout are also the same species (*Oncorynchus mykiss*), yet spend their life exclusively in freshwater.

Along California's Central Coast, adult steelhead typically migrate upstream from the ocean December through March (April), with the majority of the migration in December through February, corresponding to the period of heaviest precipitation in most years. During spawning (mating), females dig a nest, called a redd, with their body in ½" to 4" gravels and cobbles. Typically, steelhead spawn at the downstream end of pools (tail), where substrates tend to be stable and the stream channel morphology forces water through the substrate. This flow oxygenates the eggs and carries away waste products.

After spawning, eggs are covered with additional gravels. Intense winter storms can damage redds by depositing fine sediment over the redd or by mass bedload movement that destroys or scours the redd. Fine sediments of sand and silt can smother redds by reducing the amount of oxygen available to the eggs.

Steelhead eggs hatch in 35-50 days, depending on stream temperatures. Newly hatched steelhead, called alevins, have an attached yolk sac that sustains them. Alevin remain in the gravel until their yolk sac is absorbed, usually about another 3 weeks (Barnhart 1986). Trampling or disturbance of redds by park visitors, equestrian users and vehicles can damage eggs and alevins, at this most critical life stage.

When the young emerge from the gravel, now called fry, they stay in quiet shallow habitat, often stream edges with overhanging cover. As they grow, they move into deeper and faster water in riffles, runs and pools. Cover is extremely important in determining distribution and abundance,

with more cover leading to more fish (Bjornn and Reiser 1991, J.Smith, pers. comm 2001). Optimal cover conditions typically occur where there is riparian integrity, large woody debris instream, and minimal bed-impairing sedimentation caused by streambank trampling and local erosion.

Steelhead and resident rainbow trout develop a series of bars on their sides (parr marks) when they are a few centimeters long and are at that point referred to as parr. Non-anadromous fish can retain parr marks throughout their life. In anadromous populations (steelhead), parr transform into smolts and then migrate to the ocean. Distinguishing between resident rainbow trout and wild juvenile steelhead in the parr phase is extremely difficult and requires tissue sampling and laboratory analysis.

Along the central coast, most juveniles spend 1-2 years in freshwater before migrating out to the ocean. Freshwater residency depends on an individual's growth rate. In the fall, a fish will either remain in freshwater to grow or outmigrate to the ocean. The larger a juvenile is when it outmigrates, the higher its chance of survival and the more likely to return as an adult to contribute to its population's success. Juvenile steelhead outmigrate during April – May, or as late as June. During outmigration, adults and smolts must have adequate streamflow and cover habitat. Late season storms have the potential to wash out juveniles in the lower reaches and lagoons before they are ready to adapt to the saline marine environment.

Steelhead live one to three years in the ocean before coming back to freshwater to spawn. Adults return to their natal stream through sense of smell (Moyle 1976). Fluctuating ocean conditions (e.g. El Nino) can greatly influence ocean survivability of steelhead (status of steelhead report). Spawning adults may return annually for one to three years.

Habitat Requirements

Juvenile habitat requirements vary throughout the year. In the spring and summer, good rearing habitat contains feeding areas where drifting insects provide a good food source. In addition, good rearing habitat provides shade and cover to protect from predators such as herons. Cover habitat includes submerged woody material, overhanging vegetation, or surface turbulence. In the winter, submerged woody material, boulders, and deep pools provide juvenile steelhead with refuge high winter flows. As juveniles migrate downstream, they require cover habitat.

Lagoons provide important rearing habitat for juvenile steelhead when hydrologic conditions are favorable. Optimal steelhead rearing conditions occur when lagoons are converted to fresh water (by stream outflow), or strongly wind-driven to prevent salinity and temperature stratification (Smith 1994). During optimal conditions, lagoons can also support rapid growth among young of the year and yearling steelhead (Smith 1990). Quality of lagoons as rearing habitat may fluctuate widely with year-to-year variations in summer inflows. Some lagoons also provide important feeding habitat for outmigrating smolts, resulting in a large spring growth increment (Smith 1994).

Adult steelhead require specific conditions including: unobstructed/adequate passage, sufficient flows and cover habitat for in and out migration, as well as cover habitat adjacent to spawning areas to provide predator protection. Overhanging vegetation in the stream zone also provides shade and moderates water temperatures, which are important survival factors in all life stages of salmonids (Reiser and Bjornn 1979).

Feeding and temperature

As ectotherms, a fish's metabolism increases with higher stream temperatures. Consequently, feeding requirements and potential growth rate also increase. In warmer stream systems with abundant food, steelhead can grow quickly and can outmigrate as one+ year olds. Studies conducted by the California Department of Fish and Game (CDFG) in the early 1990's found that Big Sur steelhead typically migrate after only one year of rearing, supporting the inference that neither water temperature nor food supply limit steelhead productivity at current success rates.

IV. PROGRAM GOALS AND JUSTIFICATION

1. Program Goals

- Goal 1: Identify practical resource management measures to protect aquatic resources and steelhead habitat
- Goal 2: Identify restoration projects to enhance steelhead habitat
- Goal 3: Create Priority Action and Implementation Plan, with suggested Adaptive Management Approaches. *The implementation plan for steelhead habitat improvement recommendations should support and/or be consistent with the individual park property master plans and other proposed capital improvement programs.*

2. Program Justification

The range of anadromous steelhead in California extends from the border with Oregon south to Malibu Creek (Titus et al. in press). The anadromous runs of steelhead that spawn in streams along the southern coast of California (Pajaro River south) have declined to less than 1% of their estimated pre-1940 abundance (**Table 2**). Recent genetic studies have shown that southern steelhead represent a unique population subunit and evolutionarily significant unit (ESU) within this species (Nielsen et al. 1994). According to the National Marine Fisheries Service (NMFS) status review for steelhead, the southern steelhead's genetic diversity is unprecedented throughout the rest of the species range (NMFS 1995).

The ability of the southern steelhead to exist and to sustain such unique genetic diversity is probably contingent on special adaptations to the extreme environmental conditions found in this area (Nielsen et al. 1994a). Juvenile steelhead throughout California must deal with inhospitable warm water temperatures and dry stream reaches due to frequent drought conditions and development of water supplies (Nielsen et al. 1994d). The periodic closure of river mouths by sand bars in California coastal streams often prevents migration to and from the ocean environment (Goodwin et al. 1993), forcing steelhead to adopt extremely flexible life history schedules for smoltification and spawning.

Due to Big Sur's high annual runoff and limited water resource development, the Big Sur lagoon remains open to the ocean nearly all year every year, unlike coastal streams, which have significant water extraction operations to the north and south. Annual access to anadromous steelhead spawning habitat is therefore possible even in hydrologic years with very low flow. As

a result, the Big Sur run is particularly valuable when compared to nearby Carmel, Arroyo Seco, Salinas, Pajaro, and San Lorenzo Rivers, which typically have dry reaches and closed lagoons during summer and fall.

TABLE 2

Summary of recent and historical abundance estimates for the South-Central California Coast evolutionarily significant unit.

River basin	Abundance	Years	Reference
Pajaro River	1,500 1,000 2,000 <100	1964 1965 1966 1991	McEwan and Jackson 1996 McEwan and Jackson 1996 McEwan and Jackson 1996 Nehlsen et al. 1991, Reavis 1991
Salinas River	<100	1991	Nehlsen et al. 1991
Carmel River	20,000 3,177 2,000 <4,000 few 100s few 100s	1928 1964 – 1975 1988 1988 1991 1993	CACSS 1988 Snider 1983 CACSS 1988 Meyer Resources 1988 Nehlsen et al. 1991 Titus et al. in press
Little Sur River	<100	1991	Reavis 1991
Big Sur River	300 <100 few 100s 500-1000	1965 1991 1991 2003	R. Wood, CDFG 1965 Nehlsen et al. 1991 Reavis 1991 Dettman 2003

Within the Big Sur River system, steelhead passage is generally considered to be limited to the seven miles below the Gorge. California Department of Parks and Recreation manages approximately 75% of the available steelhead resource within the Big Sur River system.

3. Special Status of the Species

Steelhead are listed as threatened under the Federal Endangered Species Act (ESA). Big Sur River steelhead are part of the SOUTH-CENTRAL CALIFORNIA COAST ESU (Evolutionary Significant Unit, a genetically similar population group). Steelhead were originally listed as a threatened species on August 18, 1997. The ESU includes all naturally spawned populations of steelhead (and their progeny) in streams from the Pajaro River (inclusive) to, but not including the Santa Maria River, California.

The ESA makes it illegal for any person subject to the jurisdiction of the United States to take any species of fish or wildlife that is listed as endangered (ESA section 9[a][1]) without specific authorization. The term "take" is defined in the ESA as "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct" (ESA section 3[19]). It is also illegal under ESA section 9 to possess, sell, deliver, carry, transport, or ship any species that has been taken illegally (ESA section 9[a][1]). Violating the take prohibitions may result in civil or criminal penalties.

The term "harass" is defined as an intentional or negligent act that creates the likelihood of injuring wildlife by interfering with it to such an extent as to significantly disrupt normal behavior patterns such as breeding, feeding, or sheltering (50 CFR 17.3). The term "harm" refers to an act that actually kills or injures a protected species (50 CFR 222.102 (64FR 60727)). Harm can arise from significant habitat modification or degradation where it actually kills or injures protected species by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering.

The 4(d) Rules

Under section 4(d) of the ESA, the Secretary of Commerce is required to adopt such regulations as he deems necessary and advisable for the conservation of species listed as threatened. Effective September 8, 2000, NMFS issued a final ESA 4(d) rule adopting regulations necessary and advisable to conserve fourteen listed threatened salmonid ESUs. *50 CFR Part 223 Endangered and Threatened Species; Salmon and Steelhead; Final Rules* states:

Although the primary purpose of state, local and other programs is generally to further some activity other than conserving salmon, such as maintaining roads, controlling development, ensuring clean water or harvesting trees, some entities have adjusted one or more of those programs to protect and conserve listed salmonids. NMFS believes that with appropriate safeguards, many such activities can be specifically tailored to minimize impacts on listed salmonids to an extent that makes additional Federal protections unnecessary for conservation of the listed ESU.[2]

And continues:

NMFS has identified 13 programs and criteria for future programs for which it is not necessary and advisable to impose ESA section 9(a)(1) prohibitions because they contribute to conserving the ESU. Under specified conditions and in appropriate geographic areas, these programs and criteria include: (1) activities conducted in accord with ESA incidental take authorization; (2) ongoing scientific research activities, for a period of 6 months from the publication of this final rule; (3) emergency actions related to injured, stranded, or dead salmonids; (4) fishery management activities; (5) hatchery and genetic management programs; (6) activities in compliance with joint tribal/state plans developed within United States (U.S.) v. Washington or U.S. v. Oregon; (7) scientific research activities permitted or conducted by the states; (8) state, local, and private habitat restoration activities; (9) properly screened water diversion devices; (10) routine road maintenance activities; (11) certain park pest management activities; (12) certain municipal, residential, commercial, and industrial (MRCI) development and redevelopment activities; and (13) forest management activities on state and private lands within the State of Washington.[3]

The California Department of Fish and Game is mandated by the Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988 to significantly increase the natural production of steelhead in the state. The goal set for the CDFG was to double the 1988 level of natural population, estimated at about 150,000, by the year 2000 (Section 6900-6902 of the Fish and Game Code of California 1991).

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[2] 73479 Federal Register / Vol. 64, No. 250 / Thursday, December 30, 1999 / Proposed Rules

[3] 50 CFR Part 223 Endangered and Threatened Species; Salmon and Steelhead; Final Rules

Development of the Big Sur River Steelhead Enhancement Plan and implementation of its proposed management measures and capital projects formalizes an adaptive conservation strategy for the Federally Threatened species. The Goals of the Enhancement Plan are in accord with the intent of the recently adopted 4(d) Rules and the California Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988. Implementation and monitoring measures proposed in the Enhancement Plan are consistent with 4(d) Rule programs 4, 7, and 8 described above.

V. DESIRED FUTURE CONDITIONS

To comply with the federal and state mandates for steelhead protection and enhancement, the implementation of the Big Sur Steelhead Restoration Plan should result in:

- Improved knowledge of the natural history of the Big Sur steelhead population and aquatic habitats that support them within State Park properties
- Improved spawning habitat and success
- Improved rearing habitat conditions and enhancement of degraded riparian habitats
- An increased number of returning adult steelhead
- Maintenance of a balance between visitor recreation needs and resource protection. Visitor activities to be managed include:
    - Recreational fishing during winter season
    - Swimming and wading during spring and summer season
    - Streambed manipulations by park visitors
    - Equestrian and vehicle crossings at potential spawning areas
    - Safe visitor access to and through riparian zones

VI. KEYSTONE ISSUES

Reconnaissance-level field assessments for this investigation, review of previous research and interviews with area resource managers show that the majority of the project area steelhead habitats are of high quality, with only limited areas of notably degraded habitat within the project area river channel and adjacent riparian zone. High quality steelhead habitat exists throughout the steelhead accessible reaches except (1) where riparian zones are *encroached or crossed by roads and trails* and (2) where visitor access and use occurs *within the river and riparian corridor.* With the impacted areas, steelhead habitat shows signs of degradation, primarily denuded riparian zones, bank erosion, and visitor-placed rock dams and channel modifications.

Two key factors can be considered limiting to the steelhead population of this system. The first key limiting factor is obstructed passage through the Gorge to the upper watershed. Under most flow conditions and in most years, steelhead spawn and rear exclusively in the lower 8.5 mile segment of the river. The upper 35 miles of suitable salmonid habitat are not considered naturally accessible to anadromous steelhead, despite past attempts at passage improvements, the most recent in 1981-1984. Below the Gorge, no absolute barriers to steelhead migration were identified within the mainstem project areas, although several partial barriers were identified on lower Post Creek, within Pfeifer-Big Sur State Park (PBS).

The second key limiting factor is the volume and intensity of visitor use within the project area. For the past 20 years, with only one exception, annual visitor attendance in PBS has exceeded 350,000, and is often much higher.[4] Visitor use estimates are harder to develop at Andrew Molera (AM), where the river corridor is parallel to Highway 1 and numerous access points are used.

Warm weather swimming and wading in bedrock pool and riffle habitats are primary attractions at both PBS and AM. Where visitor use is concentrated, the visible impacts to salmonid habitat occur through trail erosion, trampling of riparian and instream habitat, and construction of rock dams and channel modifications. These instream activities may result in the *degradation of spawning areas* in late winter through spring and *obstruction of juvenile passage* throughout low flow periods. Effects of streambed modifications on aquatic invertebrates, which make up the drift-feeding steelhead's diet, are unknown. In addition, heavy use in the campground and picnic area riparian zones have resulted in notable loss of riparian understory, denuded banks and localized erosion.

Other factors that typically limit steelhead populations in coastal drainages, like dams, surface water diversions, and urbanization, are less significant in the State Park reaches of Big Sur due to the project area's location at the lowermost reaches of a largely protected watershed. Upstream, the relatively pristine condition of the upper watershed in the Los Padres National Forest and Ventana Wilderness results in a free flowing, trout-bearing stream without water diversions, significant water quality concerns or notable land use impacts.

Titus noted that the Big and Little Sur Rivers along with other small steep Big Sur area streams, provide significant steelhead habitat, especially this far south. Most are strongly perennial, with lagoon habitats that remain open for most, if not all of the year. While individual runs are small, cumulatively they are important to the viability of the species as a whole. (R. Titus, CDFG, pers. comm. 2002)

Within the Coast Ranges in general and the Big Sur region in particular, episodes of wildland fires, landslides, and extreme high flows serve as geomorphically significant events. These events, like the Marble Cone Fire and its aftermath from 1978 through 1983 and the recent high flow winters of 1997 and 1998, can result in abrupt changes in channel alignment, overbank flow, severe bank erosion, and substantial localized riparian corridor disruption. Episodes of extreme flow and sediment delivery are therefore considered expected background conditions for all suggested restoration efforts.

VII. SUMMARY OF FINDINGS AND RECOMMENDATIONS

Management of park visitors within the sensitive river and riparian habitats at PBS and AM represents the greatest immediate opportunity for steelhead enhancement in the project area. Keeping people, horses and vehicles out of spawning habitats in late winter, spring and early summer can be accomplished through signage and education. Monitoring and annual interpretation of the steelhead lifecycle can help refine management strategies to increase success. An annual redd survey and spawning reach closure program for AM and PBS are proposed and detailed in the Enhancement Plan. Equally important is enforcement of State Fish and Game Code prohibitions on streambed alterations and out-of-season and campground reach recreational angling by park visitors. These initial efforts require no regulatory permits

[4] T. Moss, DPR, pers. comm. 2002

and can be done largely with existing staff. However, a formal prohibition of streambed alterations, at specific locations identified in spawning surveys or as a blanket rule within the project area, will require: (1) additional management resources, (2) legal clarification, and (3) coordination among DPR personnel, CDFG field personnel, campground hosts, and visitors, particularly long-term returning campers.

Removal and restoration of two streamside campsites on Post Creek are proposed in the Steelhead Restoration Plan. Both are within Coast Redwood Habitat and are subject to inundation in large winter storms and debris flows from Post Creek. Removal of eight riverside campsites along the mainstem Big Sur is also suggested, consistent with the *General Plan for Pfeiffer-Big Sur State Park.*[5]

Exclusionary fencing and riparian habitat restoration is proposed within the picnic area and at several riverside campsites to promote riparian habitat integrity and natural recruitment of native species and trapping of large woody debris. In addition to controlling visitor use within sensitive habitats, these appear to be the most practical, immediately feasible management measures with potentially measurable benefits.

Several capital projects already under consideration by DPR at AM and PBS will also benefit steelhead habitat and are considered high priority projects in the Restoration Plan. These include new pedestrian (and light utility vehicle) bridges at the AM main parking lot and within the campground reach of PBS, as well as two road crossing improvements at Post Creek. A multi-purpose, all season bridge at AM will improve access to both sides of the river for all users, including pedestrian and equestrian. This will then allow for spawning season closures at six instream trail crossings, four of which have spawning-sized gravel and favorable spawning hydraulic conditions.

Two structural, bioengineered streambank revetment projects are proposed adjacent to existing roadways to reduce future bank migration and erosion while adding habitat complexity and riparian integrity. The larger of the two is located adjacent to CALTRANS property at the Highway 1 pullout north of the Main Pfeiffer gate. The smaller proposed revetment requires a minor re-alignment of the ranch access road in AM.

In addition, minor trail re-alignments and riparian revegetation efforts are proposed at both State Park Properties where trails have recently been undermined by lateral erosion and/or riparian zone habitat integrity is notably compromised.

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[5] *In the fall of 1999, the General Plan for Pfeiffer-Big Sur State Park was adopted. One of the main directives in the Plan is to restore the essence of the park's original primal redwood forest in the Main Camp area. The Plan enumerates a series of guidelines to accomplish this, one of which requires elimination of all camping and its associated infrastructure (i.e., restrooms, tables, parking spaces, etc.) in that area. However, the Plan also requires that within five years of the elimination of the campsites in Main Camp, "substitute overnight accommodations be provided such that the number of overnight accommodations would be neither increased nor decreased in Pfeiffer".*

VIII. EXISTING DATA AND MANAGEMENT ACTIVITIES

Few published studies of the Big Sur River steelhead population exist, although there is a long history of steelhead angling and resource management activities. R.G. Titus summarized the existing studies for CDFG and DPR in 1994.[6] The earliest records of steelhead in the Big Sur River are documented releases of hatchery-raised steelhead. Hatchery distribution records in the Biennial Reports of the California Fish and Game Commission reveal that during 1912, 1913, and 1914 nearly 150,000 steelhead from Sisson Hatchery (Mt. Shasta) were planted the Big Sur, Little Sur and Carmel River. In 1914, 15,000 steelhead were noted as specifically delivered to Big Sur. In 1915, 32,500 steelhead were introduced to the Big Sur River from the Brookdale Hatchery in Santa Cruz County. Egg stock for the Brookdale steelhead is likely to have come from the San Lorenzo River and Scott Creek egg-taking stations in Santa Cruz County. Other records indicate extensive stocking of Monterey County streams from the Brookdale Hatchery on the San Lorenzo River and Big Creek Hatchery in Scott Creek during 1919, 1935, 1936, 1937, 1938, 1939, 1940 and 1941. In 1939 and 1941, resident rainbow trout were also planted in addition to steelhead. From 1942-1944, records note continued Brookdale Hatchery steelhead planting efforts, but distribution is generalized according to county.

The earliest site specific documentation found in the literature review dates from 1940, when CDFG Biologist Leo Shapovalov observed six adult steelhead below the falls at the Gorge. In 1946, CDFG observed migrating steelhead and recently emerged fry below the falls. An undated USFWS stream survey report indicated that CDFG introduced rainbow trout from the Brookdale hatchery in Santa Cruz to Barlow Flat above the Gorge in 1948, but none were introduced in the upper watershed since that time. In 1953, the CDFG formally began stocking fishable rainbow trout annually during May-September to support a lower river fishery. Most hatchery introduction occurred in the PBS reach. Prior to 1975, hatchery introductions included some brown and brook trout, although exact numbers are not known. Resident rainbow trout have not been introduced in the Big Sur River since 1975, following adoption of the steelhead rainbow trout policy, which prohibits introduction of resident fish in steelhead drainages.

The first steelhead migration studies were undertaken in 1959 when Fisher captured 338 juvenile steelhead in a downstream migration trap in the lower Big Sur River, during 4/30-6/2/59. The number of downstream migrants captured per day was greatest during the first three days of trapping then declined sharply and fluctuated at a much lower level. In the 1959 study 87% of the movement occurred during the night or early morning. Most downstream migrants were believed to be one year olds. Streamflow was uncharacteristically low for May and the data may not be representative for normal or wet years.

CDFG correspondence during 1961-1962 indicates both juvenile and adult steelhead were caught by anglers and their presence was observed up to the falls. In 1965, the CDFG estimated the annual Big Sur River steelhead spawning run at about 300 fish, based on the observations of local field personnel (CDFG 1965).

Attempts at modifying the natural barriers in Gorge were conducted in 1947, 1951, and 1957 and were at best, temporarily successful. A CDFG memorandum indicates that calls for additional modification, and possibly the addition of a fish ladder, were made in 1969. No action was taken due to limited previous successes (R. Wood, CDFG 1965).

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[6] R.G. Titus, unpublished memorandum Ken Gray, CDPR, Aug. 3, 1994 and R. G. Titus and D.C. Erman, History and Status of Steelhead in California Coastal Drainages South of San Francisco Bay, 1994

In 1974, State Parks requested that CDFG conduct an investigation of barrier modification. In the early 1980's CDFG and USFS coordinated on geologic evaluations and biologic surveys of the passage barrier and upper watershed salmonid streams to assess the quantity and quality of habitat that could be made accessible to steelhead for spawning and rearing. In December 1980, the California Conservation Corps and CDFG conducted logjam removal in the Gorge. Between 7/14/81 and 8/4/1981, approximately 35 miles of potential steelhead habitat were identified. Between the fall of 1981 and fall of 1984 several passage modifications were carried out on the barriers. Explosives and hand crews were utilized.

Six adult steelhead were observed in upstream areas in 1985, and anglers documented occasional observations in subsequent years and some sightings as recently as the late 1990's. (K. Anderson, CDFG, pers. comm. to R. G. Titus, 1992, and R.G. Titus, J. Nelson and P. Anderson, CDFG, pers. comm. 2002). Despite all attempts at modification and some documented adult passage, the passage barriers within the Gorge reach remain a significant obstacle.

In November of 1988, abundance estimates of juvenile steelhead were made by the CDFG in two sections of the project area, one in Pfeifer-Big Sur State Park, below the Post Creek confluence and the other in Andrew Molera State Park, upstream the main parking lot and ranch area. The calculated abundance for the PBS site was 109 trout/30m at an average size of 84 mm FL (range, 55-247 mm, FL). The Molera site yielded 128 trout/30 m, at an average of 82 mm FL (range, 55-140 mm, FL). An additional electrofishing sample was collected in Andrew Molera in July 1990. This sample averaged 86 mm (D.C. Rischbieter, CDFG, unpub. data). Portions of the mainstem were habitat typed in October 1989 (W.M. Snider, CDFG, unpubl. data).

In the early 1992, 1993 and 1994, R. G. Titus (CDFG) lead a study of juvenile steelhead habitat use in the lower Big Sur River and Post Creek. This study consisted of a series of juvenile population surveys (two to three per year) with marking and recapturing each sample season. The study was undertaken to determine changes in size, population density, and color (to indicate the degree of smolting). Marking and recapturing also allowed for characterization of juvenile migration between habitat units.

Titus noted that steelhead rainbow trout occurred in all study reaches, including the lagoon and river outlet. The study found that most juveniles leave the stream after only one year of rearing, and that there is a relatively small portion of the mainstem population that appear to be resident rainbow trout. The mainstem population structure was dominated by young of the year steelhead, with a small proportion of age 1+, 2+, and possibly older steelhead trout sampled.

Interestingly, most recaptured fish were found in or immediately adjacent to their original mark and release unit. Significant movements upstream or downstream were not noted in the juvenile fish recaptured in summer and early fall sampling. Fish that were recaptured in consecutive years also demonstrated high degree of site fidelity.

Juvenile steelhead were also sampled in the lagoon and river outlet in fall of 1993, by a single unsuccessful seining effort, limited electrofishing, and angling. The fish sampled in the lagoon were classified as silvery parr or smolts, fish on their way out to sea.

The 1993, 1994 and early 1995 sampling efforts included installation of three pipe traps to capture and characterize downstream migrants. One below the Post Creek confluence, one

near the upper AM Boundary, and one near the Walk-in campsite at AM. Each trap consisted of a V-shaped weir of hardware cloth panels and 2-15 cm pipes that drained into a live box that was regularly checked for fish. Both juveniles and adult outmigrants were captured, indicating that the pipe traps did not impede upstream migration.

During June 23-34, 1994, one unit each in the gorge, campground and Molera reach sampled by backpack electroshocker to collect tissue for mitochondrial DNA analysis at Hopkins Marine Station under the direction of Dr. Jennifer Nielsen. In the Gorge reach, seven of the 19 age 1+ (37%) were recaptures, while only one of eight (13%) were recaptures in the Campground reach. No fish sampled in Andrew Molera in this effort were recaptures.

In the fall of 1994, 1,000 fish were marked with PIT (Passive Integrated Transponder) tags. High flows in 1995 destroyed the pipe traps and a lack of funding prevented follow-up work on the PIT tagged juveniles.

Two attempts to collect field data on adult steelhead were made during the 1996-1997 field season. The first attempt involved a migrant trapping effort for both upstream and downstream migrants. The second involved collecting scales and other information from the anglers in the Big Sur River (Collin 1998). High flows early in the year resulting in late placement of the traps and low flows later in that year necessitated movement of the trap from just upstream of the Highway 1 Bridge in PBS to the parking lot area in AM.

In the 1996/1997, effort 28 adult fish were trapped and analyzed. Of the migrating adults captured that year, 57% were on their first spawning run and 43% had spawned previously. For previous spawners, the 58% had spawned once before and 42% had spawned two times previously (Collin 1998).

The one small steelhead tributary in the project area, Post Creek, has been alternately described by investigators as "an inconsequential stream that is reported to go dry or nearly dry each summer" (Shapavolov 1940a) and as an important spawning and rearing area for steelhead (CDFG 1980). Adult steelhead were observed spawning in the lower reach of Post Creek, within the campground in the wet winter of 1992-93. Juvenile steelhead were sampled in the lower reach of Post Creek in July 1993 by electroshocking, which found 57 fish/100m. Numerous passage barriers resulting from the 1986 landslides above the State Park boundary were noted at that time, and remain today. Young of the year steelhead were observed throughout the lower 600 feet of Post Creek in June and August, 2002.

Titus found that overall the Big Sur River continued to support a healthy steelhead population, one that Nehlson, et. al (1991) classified as a stock of special concern. (R.G. Titus, unpubl. manuscript of 1994 CDFG and pers. comm. 2002). Most mainstem trout both above and below the Gorge are infested with "Black spot disease" or encysted metacercaria of the monogenic trematode, *Neascus* (R.G. Titus, unpubl. data of 1992-94, CDFG).

Recreational Fishing and Angler Surveys

The Big Sur River is fished for both its winter steelhead run below Highway 1 and its abundant resident rainbow trout in the upper watershed above the Gorge. The California Constitution, Article 1, Section 25, clarifies the public fishing right.

"The people shall have the right to fish upon and from the public lands of the State and in the waters thereof and no land owned by the State shall ever be sold or transferred without reserving in the people the absolute right to fish there upon."[7]

This constitutional right to fish the Big Sur River requires that the public trust fishery resources are in sufficient abundance to be harvested and enjoyed. To accommodate both the State Constitution and the Federal Endangered Species Act with regard to steelhead, the California Department of Fish and Game and the National Marine Fisheries Service operate under an agreement known as a Fisheries Management and Evaluation Plan (FMEP). State Parks coordinates with CDFG and NMFS with regard to the existing FMEP for coastal steelhead.

The final 4(d) Rules for certain[8] listings of salmon and steelhead under the ESA may limit the application of take prohibitions of listed species in fisheries if a Fisheries Management and Evaluation Plan (FMEP) is developed and approved by NMFS. If the FMEP is implemented accordingly, take of listed species in the fisheries addressed in the FMEP will be covered under the ESA. The primary goal of the FMEP is to devise biologically based fishery management strategies that ensure the conservation and recovery of listed Evolutionarily Significant Units (ESUs).

Steelhead fishing in the Big Sur within the project area is limited catch and release with barbless hooks, below the Highway 1 Bridge. The steelhead season runs from November 16 through February 28, with angling allowed on Saturday, Sunday, Wednesday, legal holidays and opening and closing days. No recreational fishing is permitted at any time between the Highway 1 bridge and the upper Gorge pool on the boundary with the National Forest. Resident trout fishing above the Gorge is allowed from the fourth Saturday in May through October 31. Resident trout angling is also catch and release with barbless hooks.

Since 1996, California Department of Fish and Game has maintained 6 Angler Survey Boxes along the lower Big Sur River to characterize fish caught and the quality of the angling experience. Surveys are filled out voluntarily, **Table 3**.

Results of the CDFG angler surveys represent the best recent data on the Big Sur River steelhead run, although because it is voluntary, it does not represent the full extent of fishing pressure or the number of anglers. It does indicate that the majority of steelhead rainbow trout caught in the project area were juveniles, just 8 inches in length or less.

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[7] The California Constitution, Article 1, Section 25

[8] Applies only to the following Evolutionarily Significant Units (ESUs): Oregon Coast coho, Puget Sound, Lower Columbia, and Upper Willamette chinook, Hood Canal and Columbia River chum, and Ozette Lake sockeye, Lower Columbia River, Middle Columbia River, Snake River Basin, Upper Willamette River, Central California, South/Central California Coast, and Central Valley steelhead.

TABLE 3
CDFG Winter Angler Survey Results

	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001
Surveys	190	74	33	40	52
Hours fished	751	192.5	100.5	109	172
Steelhead trout caught	959	434	97	206	197
Length of fish caught and percent of total catch	<6" (37.4%) 6-8" (39.0%) 9-11" (10.9%) 12-14" (4.5%) 15-17" (2.2%) 18-20" (2.4%) >20" (3.5%)	<6" (35.7%) 6-8" (48.2%) 9-11" (6.9%) 12-14" (5.8%) 15-17" (0.9%) 18-20" (1.2%) >20" (1.4%)	<6" (20.6%) 6-8" (53.6%) 9-11" (12.4%) 12-14" (8.2%) 15-17" (2.1%) 18-20" (1.0%) >20" (2.1%)	<6" (10.7%) 6-8" (40.8%) 9-11" (28.2%) 12-14" (7.3%) 15-17" (3.9 %) 18-20" (2.4%) >20" (6.8%)	<6" (27.9%) 6-8" (45.7%) 9-11" (16.2%) 12-14" (2.5%) 15-17" (3.6 %) 18-20" (1.5%) >20" (2.5%)
Catch rate	1.28 (fish/hr.)	2.25 (fish/hr.)	0.96(fish/hr.)	1.89 (fish/hr.)	1.14 (fish/hr.)
Catch per month	Nov.= 481 Dec.= 320 Jan.= 81 Feb.=77	Nov.=350 Dec.= 67 Jan.=12 Feb.=5	Nov.=8 Dec.=63 Jan.=11 Feb.=15	Nov.=52 Dec.= 53 Jan.= 89 Feb.=11	Nov.=109 Dec.= 62 Jan.= 14 Feb.=12

IX. ENHANCEMENT PLAN METHODS AND OBSERVATIONS

Field activities undertaken in the development of the Big Sur River Steelhead Restoration Plan were limited to: two days of initial field reconnaissance and meetings between State Park Ecologist staff and the consultant team; three days of Level I habitat typing (described in field notes); and two days of informal snorkel surveys of representative habitat types and visitor use areas. Personal and phone interviews with CDFG and NMFS fisheries biologists and resource staff familiar with the project area were conducted throughout the study period, from late July through October 2002.

The field activities focused on reconnaissance-level assessments to identify relevant habitat conditions like riparian degradation, point and non-point erosion and water pollution sources, instream sedimentation, high quality spawning gravels, channel manipulations, and potential passage barriers.

Planning Reach Designations

For the purposes of this Enhancement Plan, the Big Sur River on State Park properties has been divided into 7 planning reaches. These descriptive reaches are outlined below and illustrated in **Figures 6 and 7**.

Andrew Molera State Park

- Reach 1 - Lagoon
- Reach 2 - Mid Molera Reach-Riparian/Meadow Terrain
- Reach 3 - Upper Molera Reach-Riparian/Redwood

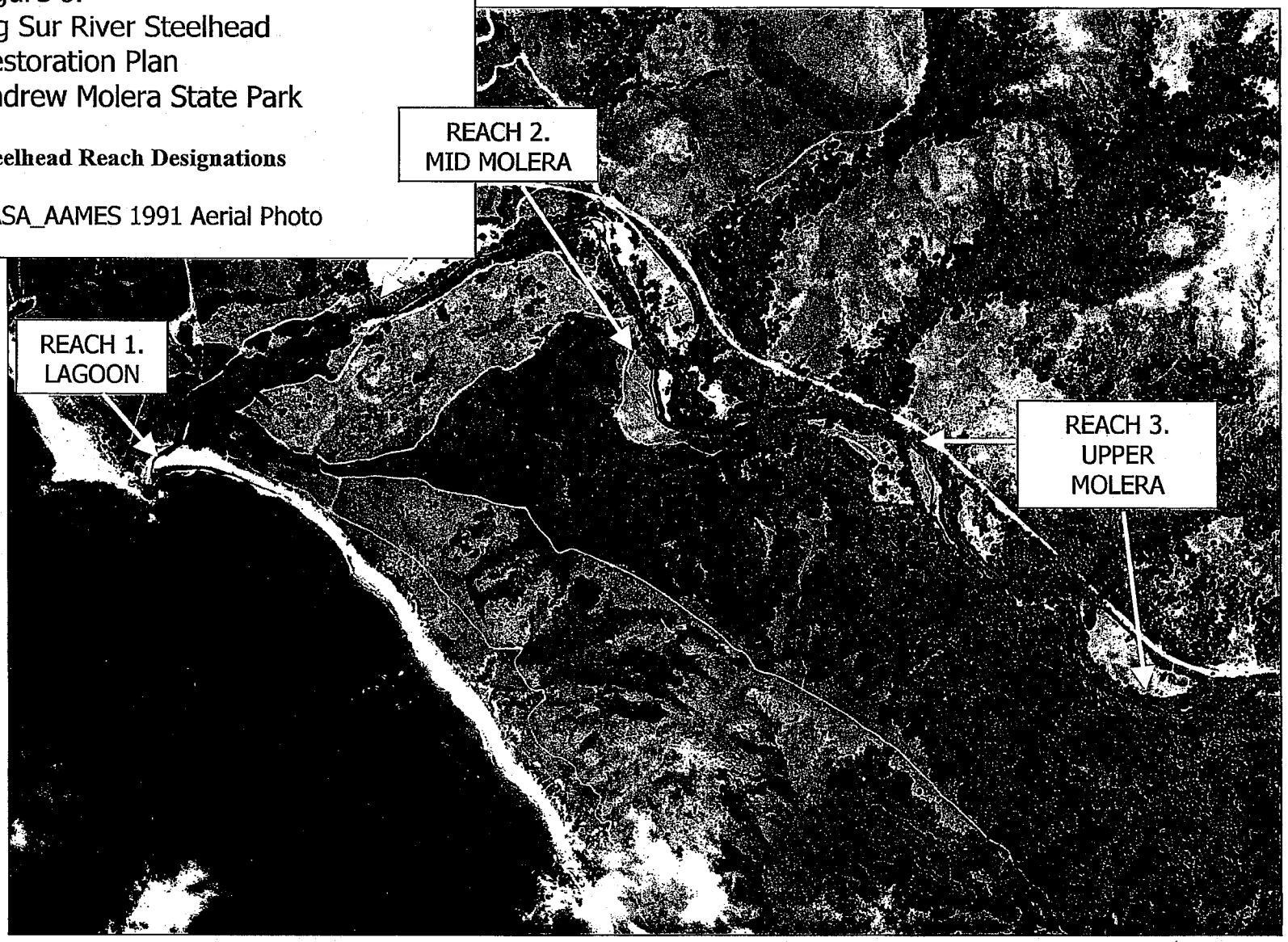
Pfeifer-Big Sur State Park

- Reach 4 - Lower PBS Reach- Park boundary to Hwy 1
- Reach 5 - Campground Reach
- Reach 6 - Gorge Reach to upper barrier falls
- Reach 7 - Lower Post Creek to 1986 landslide toe

Figure 6.
Big Sur River Steelhead
Restoration Plan
Andrew Molera State Park

Steelhead Reach Designations

NASA_AAMES 1991 Aerial Photo



ESR – 30

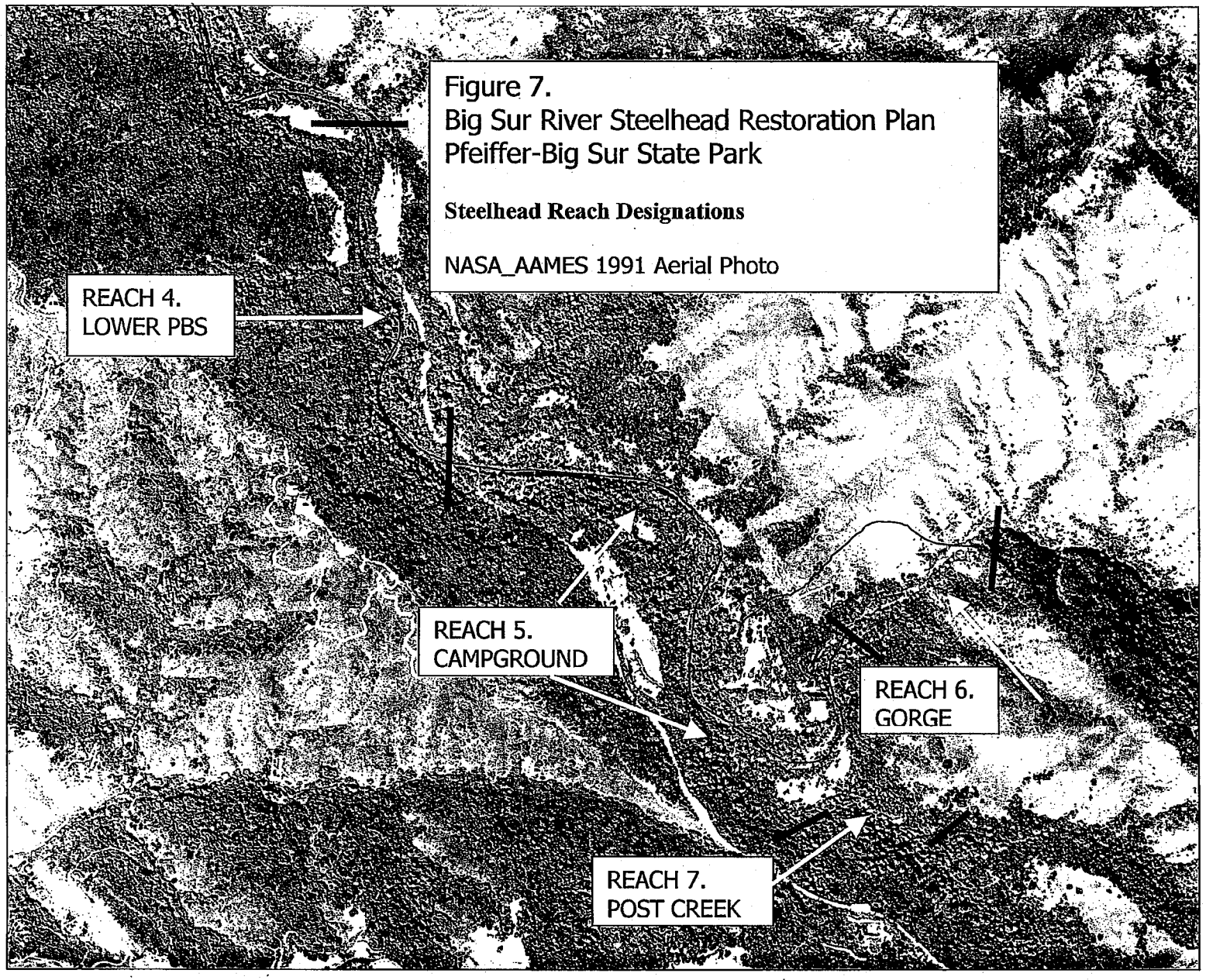


Figure 7.
Big Sur River Steelhead Restoration Plan
Pfeiffer-Big Sur State Park
Steelhead Reach Designations
NASA_AAMES 1991 Aerial Photo
REACH 4.
LOWER PBS
REACH 5.
CAMPGROUND
REACH 6.
GORGE
REACH 7.
POST CREEK

ESR – 30

Reconnaissance Stream Surveys

Unpublished habitat type data (W.M. Snider, CDFG 1989; IN Titus 1994b) were reviewed prior to the field exercises. The Gorge reach consists of mostly a series of step runs and pools. The rest of the project area is dominated by riffles and runs proportionally, both in frequency (66-77%) and by stream length (76-79%). Lateral scour pools (13-15% in frequency, 6-11% by stream length) and main channel pools (4-11% in frequency, 2-10% by stream length) were the next most common habitats collectively.

To assess overall habitat conditions within the project area, hip-chain assessments of stream and riparian habitat quality were conducted by investigators during 8/5/2002-8/9/2002, with a particular focus on areas of visible disturbance or habitat degradation.

The entire project area was surveyed over the period of three days. A total of 3.623 miles (19,130 linear ft.) were surveyed from mouth to boundary in Andrew Molera State Park, and 2.514 miles (13,276 linear ft.) of the mainstem Big Sur River and 0.379 miles (2,000 linear ft.) of lower Post Creek were surveyed. Adapted Level II Habitat types (riffle, run, pool, cascade) and notable habitat features (bedrock pools, erosion sites, critical riffles, passage obstructions, large woody debris, etc.) were measured for length and depth, noted in a field book, and mapped on USGS 7.5 topo maps and aerial photos. Observations most pertinent to impacts to steelhead habitat have been transposed onto **Figures 8 and 9.**

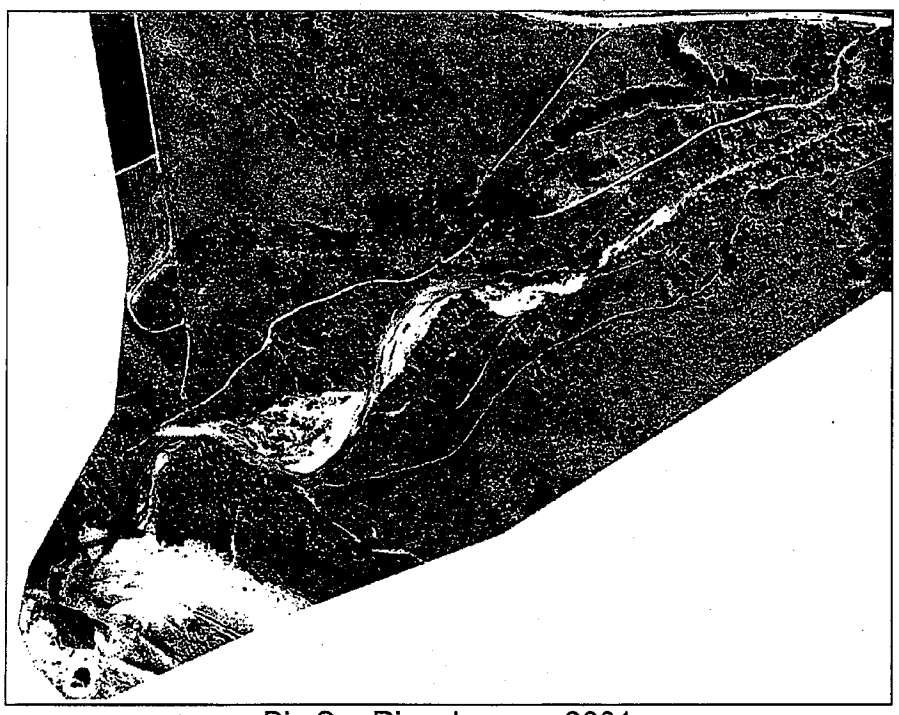
The Big Sur River streambed is characterized by predominately cobble and gravel substrates, with concentrations of fine sands generally limited to the beach and backwater deposits of the lagoon, near trail crossings and erosion sites, as well as downstream of tributary confluences. The substrate becomes more coarse, particles becoming larger in size, as one moves upstream from the beach to the bedrock and boulder-dominated Gorge. Spawning sized gravels were abundant in locations at pool tail-riffle head areas in Andrew Molera State Park and were more sporadically observed elsewhere in the project area, based on localized hydraulic factors such as instream large woody debris, split channels and areas of recent channel change. The presence of juvenile steelhead in all reaches suggests opportunistic spawning occurs wherever adequate substrate exists from year to year.

The entire project length supports a robust riparian system, degraded only in areas of perpetual use or episodic disturbance. Based on reconnaissance-level hipchain surveys of disturbed riparian areas within Andrew Molera State Park, 10.91% of the total AM river length was classified as a disturbed riparian area, defined as an area of active erosion, discontinuous riparian corridor, or visitor-trampled riparian vegetation. If streambank areas disturbed by high flows in 1997-98 in the lagoon and lower river are excluded from this calculation, 4.38% of the total AM stream length may be considered directly affected by visitor access and use.

Within Pfeifer Big Sur State Park 19.24% of the total stream length surveyed exibited signs of active bank erosion attributable to road encroachment, visitor activities, riverside campsites and trampling impacts within the riparian zone. Within Post Creek, the smallest fishbearing reach in the project area an estimated 51.18% of the total stream length exhibited signs of riparian degradation due to campground-related bank erosion, vegetation trampling and undersized road crossings. In general, the entire reach of lower Post Creek exhibits recent terrace deposits and logjams characteristic of debris flows that result from an upstream inner gorge landslide 2000 feet from Post Creek's confluence with the Big Sur River.

Figure 8. Recent Lagoon Changes

Big Sur River Lagoon 1991



Big Sur River Lagoon 2001

Reach 1 (Lagoon/ RM 0.0-0.178) and Reach 2 (Mid Molera/RM 0.179-1.70) [Appendix 1-Photo A] are the most strongly alluvial in character, with the broad floodplains of Creamery Meadow, the Walk-in Camp, main parking lot area and the Creamery Meadow Annex particularly subject to abrupt channel changes, lateral stream migration and channel braiding. Existing beach access trails on both banks of the lagoon and lower Reach 2 have been subject to flooding and substantial damage since 1997, **Figure 8**. Bank erosion alongside the existing right bank ranch road is also a discrete area of concern, due in part to the potential loss of access to the historic ranch buildings and the equestrian concessionaire.

Low gradient riffle-run complexes, separated by long slow runs are the characteristic channel forms in Reach 2. Instream recreation and channel manipulations by visitors are concentrated at easy access points, particularly at downstream end of the walk-in campsite area and at the main parking lot/90 degree bend in the river. Also worthy of note is that DPR's 1990 boulder and log bank protection/fish enhancement project at the 90 degree bend in the river has been washed away by several years of above bankfull flows. While the slope continues to erode above the ordinary high water mark, boulders, alders and willows at bankfull and below provide cover and scour. Given the past history of limited success, subsequent trail re-routing of the Bobcat Trail, and the extreme scour conditions that characterized this hard turn in the river, future restoration at this site was not seen as a high priority, and was not considered in the Enhancement Plan Recommendations. Re-routing of the exposed upslope campground water line should, however, be done as a basic maintenance activity.

Numerous bedrock scour pools, higher gradient cobble-boulder riffles, and redwood riparian habitat distinguish Reach 3 (Upper Molera/RM 1.71-3.623) [Appendix 1-Photo B] from Reach 2. Channel gradients and channel form in Reach 3 are controlled by underlying bedrock geology, riparian integrity, large woody debris and transitory fluvial features like vegetated cobble bars.

Seven large bedrock pools in Reach 3 are used as swimming holes by park visitors. Three of these bedrock pools have horse trail crossings at pool tail-riffle head areas. These particular types of areas are favored by spawning steelhead due to consistently favorable hydraulic and substrate conditions. Use of these crossings by visitors during spawning and alevin development is likely to cause redd destruction and decreased spawning success, **Figure 9**.

Channel characteristics above the town of Big Sur in Reach 4 (Lower Big Sur, or "Lower PBS") [Appendix 1-Photo C] strongly resemble those of Reach 3. The alluvial bottomland is, however, narrower and more confined in Reach 4. Reach 4 is also more deeply shaded by redwood habitat and Pfeiffer Ridge than the downstream Molera reaches. Intense instream use is generally limited to the Group Camp ford area and the failing Highway 1 pullout area. Linear distances measured along the mainstem above the town of Big Sur were started at an arbitrary zero and recorded as "PBS River Miles." Reach 4, therefore, extends from the PBS boundary to the Highway 1 Bridge (PBSRM 0.0 – 0.725).

Reach 5 (Campground/PBSRM 0.726-2.031) [Appendix 1-Photo D] the Highway 1 Bridge to the USGS gage below the Gorge. This reach exhibits the greatest evidence of adverse habitat impacts, particularly riparian degradation and streambed modifications by visitors. A dominant feature is the Main Camp bedrock pool, just upstream of the Day use Picnic Area. Several riverside campsites are located within degraded riparian zones and have adversely impacted riparian integrity through vegetation trampling and localized erosion.

Vestiges of historic uses, large scale channel manipulations, and obsolete diversion works are also visible throughout Reaches 4 and 5, and on older area maps. The most interesting of

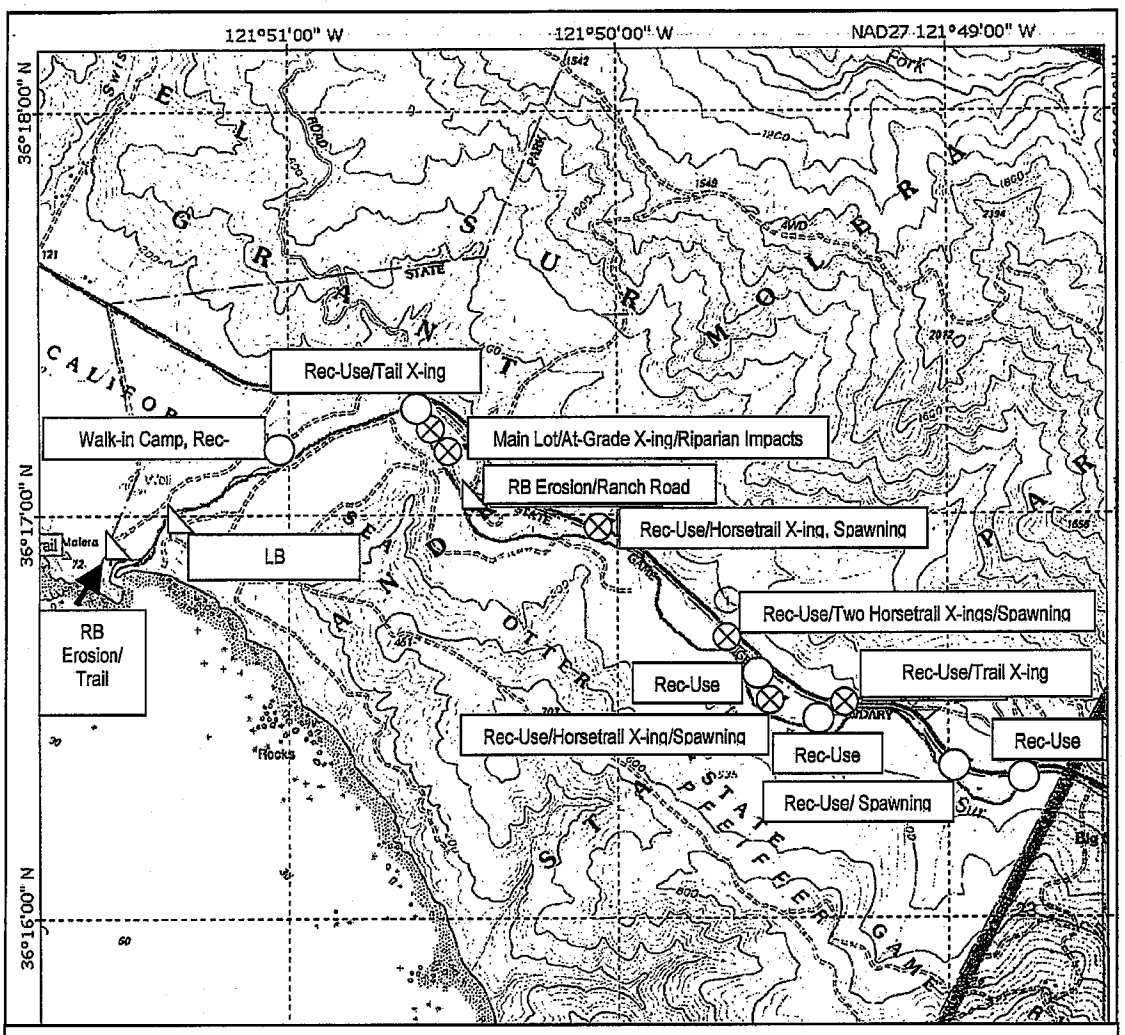


FIGURE 9: FIELD OBSERVATION MAP
Reconnaissance-Level Hipchain Survey
8/5/02 and 8/8/02

Big Sur River Steelhead Restoration Plan
Andrew Molera State Park

Monterey County, California

these historic features, and possibly the most influential on channel form, are the eight grade historical grade control structures that underlie the lower 1.5 miles of streambed in Pfeiffer-Big Sur State Park. Four exist in Reach 4 and four are in Reach 5. Placed in the bed in times past to stabilize channels in the vicinities of bridges, diversions and at-grade crossings, these concrete, stone and steel structures continue to minimize channel downcutting throughout the Park and may serve to encourage the wide, flat riffle-run dominated streambed that is so characteristic of these reaches.

Reach 6 (Gorge/PBSRM 2.032-2.514) [Appendix 1-Photo E] is characterized by high gradient boulder riffles and cascades, confined by steep bedrock walls. Recreational use is concentrated throughout accessible areas of the Gorge, although riparian impacts and associated erosion are greater in the lower part of the reach in the vicinity of the campsites. Reach 6 terminates at the upper boulder falls passage barrier, near the boundary between PBS and the Los Padres National Forest.

Reach 7 (Post Creek/PCRM 0.0-0.379) [Appendix 1-Photo F] consists of lower Post Creek, from the confluence with the Big Sur to the toe of the 1986 slide, which serves as an absolute barrier to steelhead migration. Post Creek is channeled into two culverts within PBS, and is subject to debris torrents from the upstream geologic instabilities. **Figure 10.**

Project-wide, two seasonal footbridges across the Big Sur River are constructed in AM and four are constructed in PBS prior to Memorial Day and removed following Labor Day. Concrete fire rings filled with river cobbles serve as footings for wooden planks. One formal at-grade vehicle crossing exists in AM and two are located in PBS.

Low flows and high clarity during the field period allowed for visual estimation of substrate size and relative embeddedness of gravel and cobble particles. It was also possible to observe juvenile steelhead throughout the project area, with the exception of the lagoon where depth and wind chop limited visibility.

Reconnaissance Snorkel Surveys

In the development of the Enhancement Plan, four sections of the Big Sur River were snorkeled for qualitative observations of steelhead trout habitat use. Three sections within Andrew Molera State Park, and the gorge area within Pfeiffer Big Sur were snorkeled. Heavy recreational use and time limitations precluded snorkeling in the crowded campground reach. Most of approximately 30 habitat units were snorkeled in the four sections including pools, runs, and riffle-runs. Many habitat units were snorkeled in both the upstream and downstream direction to check again the number of fish observed. As much of each habitat unit as possible was snorkeled, with shallow depth in riffles being the primary limitation.

Within the Andrew Molera sections, juvenile steelhead were most often observed in (1) riffle-runs, especially where there was abundant woody material or overhanging and submerged vegetation, such as willow and their roots; (2) at the heads of some pools, especially where flows were concentrated and there was cover habitat, such as woody material; and (3) deeper pockets (8-12") of riffles, especially adjacent to boulders. Fast velocity feeding stations appeared important, especially for larger juveniles. Few fish were observed in slow velocity runs and pools, with the exception of a large group of approximately 20 fish observed in a willow root mass in the middle of a long, deep run.

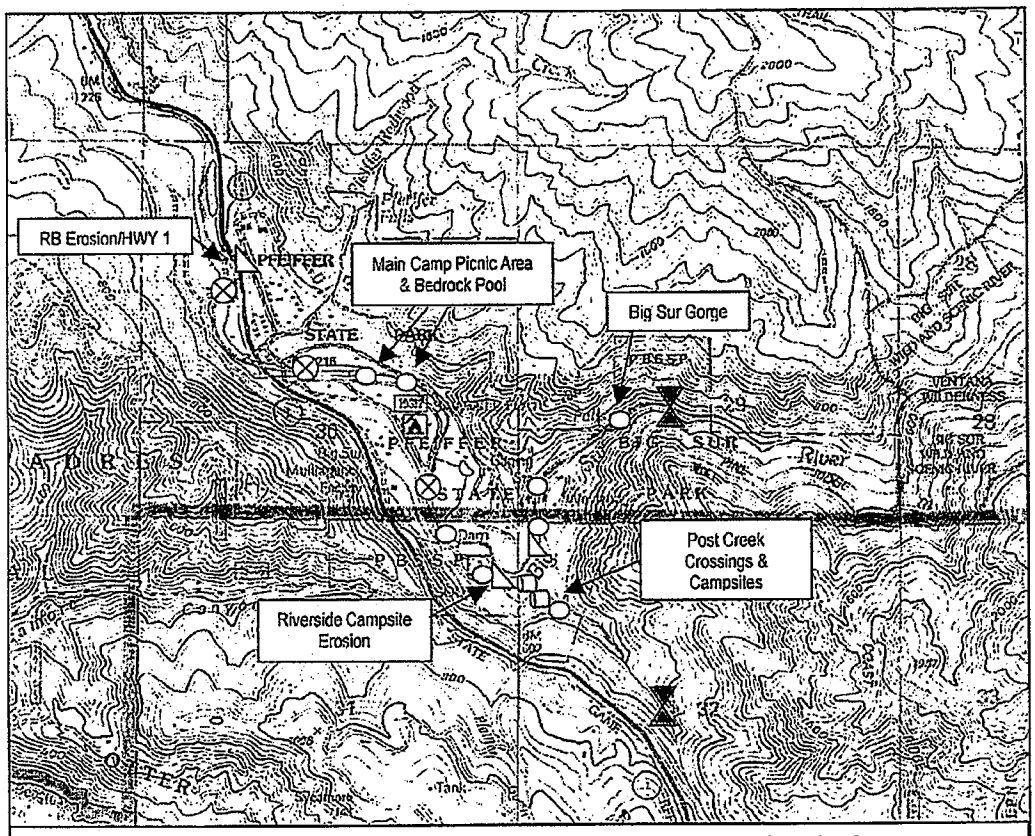


FIGURE 10:
FIELD OBSERVATIONS
Reconnaissance-Level Hipchain Survey
8/6/02 and 8/7/02

Big Sur River Steelhead Restoration Plan
Pfieffer Big Sur State Park

Monterey County, California

0 0.5 1.0
MILES

TN MN

Map Symbols

- Crossing Barriers
- Natural Barriers
- Bank Erosion Sites
- Stream Crossings
- Areas of Concentrated Recreational Use

Habitat use appeared to be somewhat sporadic, since few fish were observed in several units of high quality rearing habitat. In two instances, avian perches were observed adjacent to good quality habitat where no fish were observed, suggesting that predation plays a role in steelhead distribution. In addition, steelhead distribution may reflect the distribution of successful spawning areas.

In the gorge area, juvenile steelhead were abundant in the pool, step-pool habitat found there. Recreational users were observed walking in these habitats. While recreational users disturbed fish, they also seemed to kick up food items. Juveniles were observed biting at detritus dislodged by the recreational users.

These observations provide only a snapshot of abundance and habitat use in the Big Sur River. Smaller juveniles were probably occupying riffle habitats, but were not observable during snorkeling surveys. In years with higher flow, habitat use may be different. In addition, while steelhead were not usually observed in deep, slow pools, these habitats may provide important predator-escape areas and may be used as flow refuge during the winter months.

However, given the observed sporadic distribution of juveniles encountered in our reconnaissance-level observations, we elected not to attempt to quantify fish densities or estimate population size. It should be noted that sampling estimates that calculate number of fish per linear distance may overestimate the number of fish if it does not take into account low abundance habitats such as slow runs. Any future detailed sampling efforts should reflect the variability and distribution of various habitat types present in the project area.

Sculpin were observed in the gorge area, and in one section of Andrew Molera. Many crayfish were also observed, usually in the rocky riffle-runs where steelhead were present. No observations made in the field, nor information provided by CDFG staff, provided linkages between the occurrence of crayfish and the steelhead population (R. Titus, D. McGriff/CDFG-Sacramento, pers. comm.). Crayfish predation of young of the year steelhead has been observed in Corralitos Creek in Santa Cruz County (K. Schroder, pers. obs.). In general, there is a paucity of data on invertebrates in the Big Sur system, like most Central Coast streams, and the role and impacts of introduced scavengers and predators like the signal crayfish in local ecosystems remain open questions.

X. SETTING PRIORITIES : *Restoration or Enhancement?*

Most of the steelhead habitat in the project area is of high quality, with notable disturbances limited to areas of concentrated visitor use or episodic channel changes. Opportunities for significant restoration are limited, simply based on the strongly positive ratio of good versus bad habitat conditions. Opportunities for enhancement of the existing resource are, however, more plentiful.

Within the Enhancement Plan, projects and management measures were prioritized by a screening process based on the criteria described below. To be considered, each project or management measure was evaluated for its ability to:

1. Provide direct steelhead and aquatic habitat benefits
2. Provide erosion control and runoff management
3. Provide riparian corridor protection and revegetation
4. Be consistent with approved Park Master Plan recommendations

5. Be technically feasible
6. Be cost effective

Proposed Management Measures

- **Management Measure 1. Spawning Protection (MM-1)**

Actions: Conduct late winter and spring redd surveys, based on available spawning flows. Institute documented spawning reach signage program for minimum of 60 days after spawning survey(s) in observed spawning areas. Institute trail crossing closures at observed spawning areas. Provide limited access provisions in case of emergency.

Because Big Sur River steelhead habitat in the project area is largely intact, practical management measures should first address limiting access to steelhead habitat at the most critically sensitive stage of their lifecycle, spawning. Juvenile trout are often faced with "making the best of a bad situation" in terms of habitat availability, since their distribution in a stream system appears to be more a function of where they were spawned than one of rearing habitat suitability (Beard and Carline 1991; Titus and Mosegard 1992). Spawning more fish in more places more often will likely increase both distribution and population density. Protection of spawning areas by limiting access and potential physical damage to redds themselves is, therefore, a simple management measure that will enhance the steelhead population.

Scheduling of regular management activities like installation of temporary crossings and use of at-grade vehicle crossings should reflect and respect the results of spawning surveys. Construction of temporary crossings and vehicle crossings in areas with observed spawning should be prohibited for a minimum of sixty days following spawning or redd observations.

- **Management Measure 2. Riparian Integrity Protection (MM-2)**

Actions: Initiate riparian exclusion and vegetation program in Pfeiffer Big Sur Campground and Picnic Areas. Continue Creamery Meadow and Creamery Meadow Annex riparian woodland restoration project in Andrew Molera State Park.

Enhancing steelhead rearing habitat throughout the project area can be accomplished most effectively by promoting riparian habitat integrity wherever use patterns have caused degradation. To maintain or restore watersheds, vegetation remains the most cost effective and beneficial tool for land managers. To restore or maintain riparian habitat integrity, managers must focus on plant succession and on the hydrology needed to support riparian plant communities (Johnson et.al. 1989).). In essence, this requires selection of appropriate riparian species for specific applications, a thorough awareness of soil moisture and hydrologic conditions at each revegetation site throughout the year, and protection of restoration areas through exclusionary fencing and signage. Excluding foot traffic and visitor use in restoration areas enables gradual ecologic succession to occur, thereby allowing natural processes to shape plant habits and habitat continuity. For example, constant trampling of early succession riparian plants and native understory species in areas such as the main picnic area, around the main camp bedrock pool and River sites 148, 149, 151, 152, and 154 denudes riparian habitat, causes excessive erosion and degrades the visitor experience.

Streamside vegetation helps to prevent rapid streambank erosion (Beur et. al. 1984) and provides cover from predation. Instream cover along a streambank increases the physical complexity of a river channel (Shields and Smith 1992). Loss of riparian vegetation can lead to simplified aquatic habitat and reduce the potential for large woody debris recruitment into the stream (Ralph, et.al. 1994, Young et.al. 1994; Fausch et. al. 1995). The importance of large woody debris for salmonid habitat is well documented (Meehan 1991).

Overhanging vegetation in the stream zone moderates water temperatures, which is an important factor in all life stages of salmonids (Reiser and Bjornn 1979). Overhanging streamside vegetation also provides food and habitat for both terrestrial and aquatic invertebrates, which in turn serve as food for bird species and salmonid species (Sekulich and Bjornn 1977). Cover is extremely important in determining distribution and abundance, with more cover leading to more fish (Bjornn and Reiser 1991).

Creamery Meadow, which has been impacted by lateral erosion during and after the 1997-98 high flow seasons, and the lower Big Sur River will benefit from continued riparian reforestation efforts as channel migration continues. The streamside riparian trees currently subject to undercutting serve a primary source of large woody debris and fish cover in this reach. Efforts to broaden the riparian woodland habitat in the lower river through additional riparian planting will likely result in improved bank stability and overall instream habitat quality. A broad riparian zone will continue to serve as a source of large woody material as lateral channel adjustments continue in the future.

In addition, natural recruitment of willow, alders and cottonwoods is occurring on the low, broad gravel bars that characterize the near lagoon habitats since 1997. The ground surface elevation and depth to groundwater in areas of natural riparian species recruitment should be evaluated and considered in all future planting efforts.

- **Management Measure 3. Management of Instream Habitats (MM-3)**

Action: Prohibit construction of in-channel rock dams. Periodically remove rock dams wherever located.

Field surveys and interviews with current and former CDPR resource managers, Fish and Game Biologists, NMFS Biologists and knowledgeable local individuals revealed a pervasive pattern of rock and timber obstructions in both park units, with 18 distinct rock dams observed within PBS during the field component of the study. Invariably these rock dams were constructed to raise water surface elevations in deep-water habitats or to provide concentrated flows, or sluiceways, for recreational rafting.

Rock dams and streambed alterations of this nature have the potential to directly destroy spawning redds or destabilize riffle habitats in spring and early summer (NMFS 2001). This is particularly true in late rain years or drought years, when PBS Park visitors recreate instream in April and May, when school breaks are in effect or warm spring weather arrives early. April and May are also the months when juvenile salmonids typically outmigrate to the ocean in their smolt stage (Brown, et.al. 1994; Weitkamp et. al. 1995; Busby et. al. 1996).

Rock dams and man-made obstructions also may limit juvenile passage, either by completely obstructing passable flows through the gaps between rocks, or by creating high velocity "sluices" that exceed juvenile steelheads swimming speed. Limiting passage may result in increased predation in shallow waters, as juveniles are left exposed without escape options.

Cumulatively, rock dams within the stream corridor were the most visible impact observed during the field period. Prior to this investigation, CDPR staff reported that 37 rock dams were identified in PBS during one period of observation (B. Barton and J. Frey CDPR, pers. comm. 2002).

In July 2001, NMFS released "The Effects of Summer Dams on Salmon and Steelhead in California Coastal Watersheds and Recommendations for Mitigating Their Impacts (NMFS 2001). While small instream rock dams were not directly addressed in this paper, NMFS staff considers the recreational rock dams, such as those found in the project area, to be comparable in impact, if not in scale, to larger summer recreation, diversions and water supply dams (J. Ambrose NMFS, pers. comm. 2002).

In California, summer dams are regulated by CDFG under Fish and Game Code Chapter 1600. Projects addressed under Chapter 1600 are ones, "...that divert or obstruct the natural flow or substantially change the bed, channel, or bank of any river or stream or lake designated by the department, or use any material from the streambed...." Recreational users who construct rock dams and the dams themselves, technically, fall under Chapter 1600 (K. Urquhart CDFG, pers. comm. 2002) and CDFG permits should be required. Removal of these instream structures by hand crews, combined with increased signage and interpretation of the steelhead lifecycle, is strongly suggested.

Enforcement activities, particularly under Section 1600 of the Fish and Game Code, may be undertaken by both CDPR Rangers and CDFG Wardens, although CDFG typically manages streambed alteration permits in California. The designated lead agency responsible for enforcement of Section 1600 within high visitor use areas on State Park lands is not, at this time entirely clear. Nor is it clear what level of this historically-occurring instream activity constitutes "take" of Federally protected steelhead under the Federal Endangered Species Act. (J. Ambrose NMFS, pers. comm. 2002). Minimization of instream disturbance, through education and enforcement, represents a good faith effort on the part of DPR to limit any potential or perceived "take " of steelhead within its properties.

- **Management Measure 4. Retention of Instream Woody Debris (MM-4)**

Instream woody debris serves several functions in salmonid habitats. Wood in stream channels diverts and obstructs streamflow, thereby creating more complex channel characteristics. When large woody debris such as logs, rootwads, and debris dams affect the local hydraulic geometry of rivers and streams, they encourage scour pools, sediment sorting, and flow separation while also serving as cover and escape habitat for fish.

State Parks does not typically remove woody material from its streams, with the exception of lower Post Creek. Retaining instream woody material should be encouraged, except where logs or logjams threaten bridges or public safety. New crossings should be designed to allow for free passage of woody material.

Proposed Capital Projects

Suggested capital projects for each park unit are displayed in Figures 11 and 12.

- **Capital Project 1: Beach Trail re-routes (CP-1)**

Revegetate trail access-related eroded banks with native willow mattress/brush box revetments [CDFG Manual # 230, 274]. Re-route LB and RB beach access trails away from bank failures

(RM 0.9 – RM 0.13). Leave generous riparian woodland buffer (50'-100') if possible to allow for continued lateral erosion and to prevent mass failure of banks under extremely high flows, like those in 1997. Previous foot-trail alignment behind riparian corridor in Creamery Meadow served to concentrate overbank sheet flow and eroded rapidly, thereby allowing damaging floodwater to outflank the streambanks protective riparian vegetation. Significant lateral erosion on the left bank occurred as a result of this high flow event.

- **Capital Project 2: Install SH Lifecycle and Regulation Interpretive Displays (CP-2)**

To directly educate park users, highly visible interpretive displays with critical steelhead life history and regulatory information should be placed at Molera walk-in camp site, Molera main parking lot-river crossing location, Pfeiffer Main camp bedrock pool access trail, Pfeiffer Picnic area, Post Creek crossing(s) and at all seasonal river crossing locations.

- **Capital Project 3: Complete design, permit and construct proposed year-round pedestrian bridge near Andrew Molera State Park parking lot (CP-3)**

CDPR has conducted initial engineering, hydraulic and geotechnical investigations of potential bridge alignments in the the parking lot area of AM (T. Moss CDPR, pers. comm. 2002; Phillip Williams and Associates 1998). A multi-purpose, all season bridge at Andrew Molera State Park will improve access to both sides of the river for all users, pedestrian and equestrian. This will then allow for spawning season closures at six instream trail crossings at Andrew Molera State Park, four of which have spawning-sized gravels and favorable hydraulic conditions for spawning.

- **Capital Project 4: Install exclusionary fencing and institute initial redwood/alder riparian revegetation efforts at Pfeiffer Day Use picnic area (CP-4)**

During field exercises, visitor use of the Pfeiffer Day Use picnic area riparian zone was identified as having severe impacts on riparian habitat, through encroachment and trampling of the right streambank. This denuded site should undergo a program of riparian exclusion fencing (post and wire, split rail, or other CDPR-approved type) and native riparian revegetation. Local woody material and seeds should be collected, grown locally, and installed as funds and labor are available. This project is consistent with proposed PBS General Plan restoration plan, which includes removal of all picnic facilities from this reach.

- **Capital Project 5: Install exclusionary fencing and institute initial redwood/alder riparian revegetation efforts at degraded river sites (CP-5)**

During field exercises, 12 river sites were identified as having moderate impacts on riparian habitat, through encroachment, trampling and erosion. These sites (11,15,17,30,31, 187,189,191,192,199, 200, and 202) should undergo a program of riparian exclusion fencing (post and wire, split rail, or other CDPR-approved type) and native riparian revegetation. Local woody material and seeds should be collected, grown, and installed, as funds and labor are available.

- **Capital Project 6: Remove 8 River Sites (CP-6)**

During field exercises eight river sites were identified for removal due to severe impacts on riparian habitat, through encroachment, trampling and erosion. These sites (13, 35, 37, 148, 149, 151, 152, 154) are all located within riparian habitats and have steep, bare and/or unstable banks that are a source of degrading fine sediments. These sites should undergo a program of riparian exclusion fencing (post and wire, split rail, or other CDPR-approved type) and native riparian revegetation. Specific revegetation techniques vary with each site. The heavily impacted reach near sites 148-154 will benefit from container stock alders, willow staking and

willow wattles at bankfull and above, in addition to top of bank plantings like live oak, native blackberry, and cottonwood. Irrigation will be necessary for top of bank plantings. Local woody material and seeds should be collected, grown, and installed, as funds and labor are available.

- **Capital Project 7: Complete design, permit and construct both previously proposed Post Creek crossings at campground roads with clear-span bridges. (CP-7)**

To improve high-flow debris passage, CDPR has conducted initial engineering and geologic investigations of the two existing crossings on Post Creek (T. Moss CDPR, pers. comm. 2002; K. Vyverberg CDFG, pers. comm. 2002). Improving these crossings with clear span bridges will improve passage to identified spawning and rearing habitat in the lower 2000 feet of Post Creek. Revegetation and installation of riparian exclusion fencing between camp road crossings is suggested to make this small reach an interpretive opportunity.

- **Capital Project 8: Remove 2 streamside redwood campgrounds on Post Creek (Sites 104 & 106). (CP-8)**

The two upstream campsites on Post Creek have been affected by debris flows following the 1986 landslide upstream of the park boundary. Both sites have been overwhelmed by sediment and have unstable streambanks, eroding slopes and no riparian habitat. The goal of this effort is to permanently remove the campsites, to revegetate with native species and install temporary riparian exclusion fencing to limit access to informal trails that connect these sites with the Pine Ridge Trail, upstream. Additional fencing along Pine Ridge Trail may be necessary upslope of the campsites, as well.

- **Capital Project 9:** Construct bioengineered revetment at Hwy 1 road bank failure (PBSRM 0.31-3.45) [Manual # 216, 254, 272] **(CP-9)**

Detailed conceptual plans, prepared by Fall Creek Engineering, Inc., are presented in Appendix 2- Technical Study: Stream Bank Restoration Projects.

- **Capital Project 10:** Construct bioengineered revetment at ranch road bank failure (RM 1.28-1.31) [Manual # 216, 254, 272] **(CP-10)**

Detailed conceptual plans, prepared by Fall Creek Engineering, Inc., are presented in Appendix 2- Technical Study: Stream Bank Restoration Projects.

- **Capital Project 11: Complete design, permit and construct previously proposed year-round pedestrian bridge and/or vehicle bridge in Pfeiffer Main Camp (CP-11)**

To improve traffic circulation and allow for restoration of alluvial redwood habitat, the construction of an additional bridge (or bridges) has been suggested in the Pfeiffer Big Sur Master Plan. Additional crossings that allow park users to access both sides of the river will minimize instream trampling and provide river views for visitors of all capabilities.

All suggested projects and management measures are listed together in the Restoration Treatment Options Summary Table attached below. Suggested capital projects for each park unit are mapped in **Figures 11 and 12.**

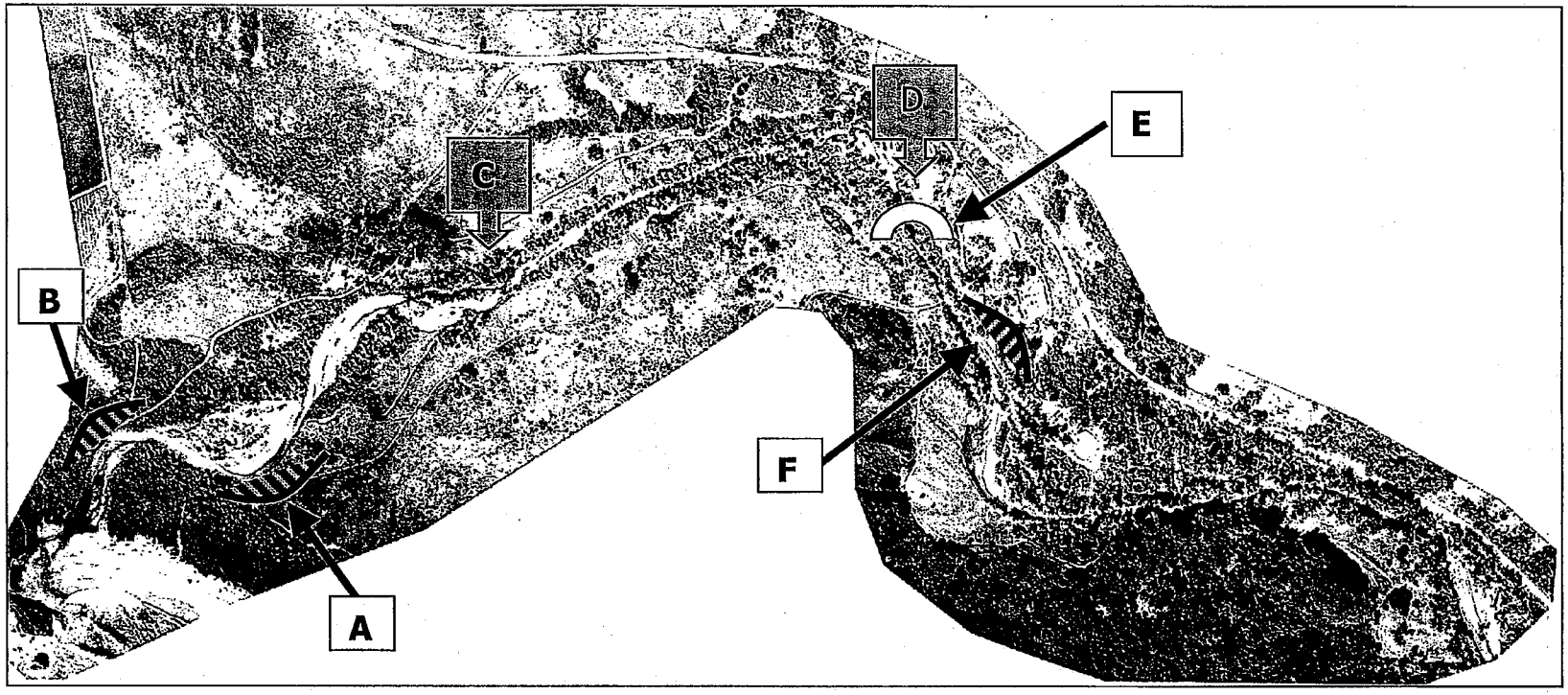


FIGURE 11

Big Sur River Steelhead Restoration Plan
Andrew Molera State Park

Steelhead Restoration Plan

Sites A & B.....Re-route LB and RB beach access trails away from existing bank failures (CP-1). Leave generous riparian woodland buffer (30'-50') if possible. Revegetate eroded banks with native willow mattress/brush box revetments and willow stakes.

Sites C & D.....Install Steelhead Lifecycle and Regulation Interpretive Display at walk-in camp site and at main parking lot-river crossing location. (CP-2)

Site E.....Complete design, permit and construct proposed year-round pedestrian bridge near parking lot to minimize instream trampling and improve access to Creamery Meadow and trail network (CP-3).

Site F.....Realign ranch access road away from top of bank. Construct bioengineered revetment at streamfailure (CP-10).

ESR -- 30

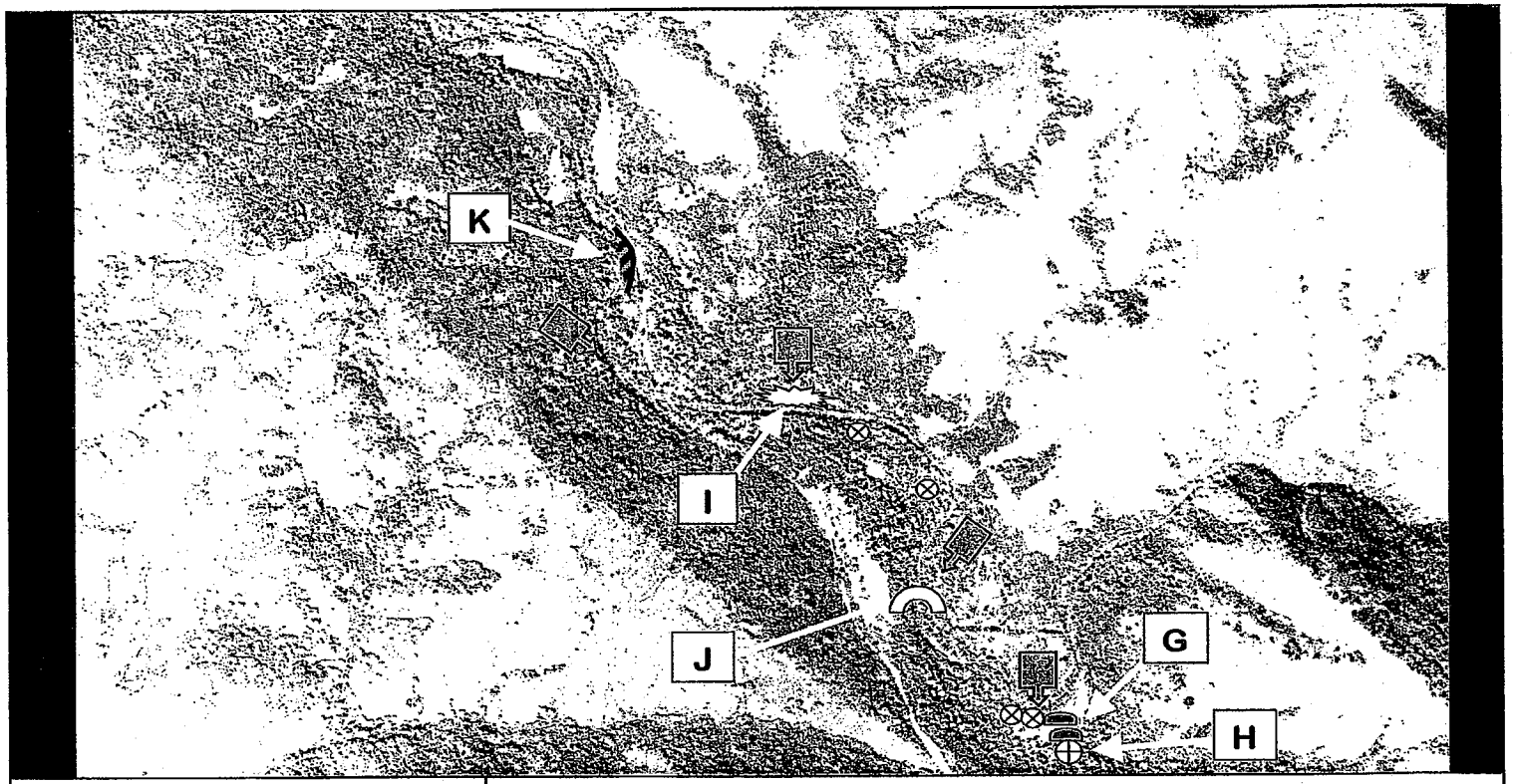


FIGURE 12

Big Sur River Steelhead Restoration Plan
Pfieffer Big Sur State Park

Steelhead Restoration Plan Suggested Capital Projects

Signage..... Install Steelhead Lifecycle and Regulation Interpretive Displays at group camp, campground store area and day-use river crossings. (CP-2)

Site G..... Replace 2 existing Post Creek crossings with clear-span bridges. Revegetate corridor. (CP-7)

Site H..... Remove 2 Post Creek streamside campsites [104, 106]. Revegetate and install temporary riparian exclusion fencing to limit access to informal trails. (CP-8)

Site I..... Install exclusionary fencing and institute initial redwood/alder riparian revegetation efforts at main picnic area-campfire area streamside. (CP-4)

River Sites... Remove 8 River Sites with significant erosion and riparian impacts [13, 35, 37, 148, 149, 151, 152, 154]. Revegetate with willow/alder/redwood. (CP-6)

Site J..... Complete design, permit and construct proposed year-round multi-use bridge to minimize instream trampling (CP-11).

Site K..... Construct bioengineered revetment at Hwy 1 road bank failure (CP-9)

ESR – 30

TABLE 4
Big Sur River Steelhead Enhancement Plan Matrix
Andrew Molera State Park

Project Reach:	Noted Impacts:	Suggested Management Measures:	Suggested Capital Projects:
1. Lagoon	• Groundwater withdrawals • Streambank failures • Episodic channel shifts, loss of riparian cover	• Continue Creamery Meadow riparian woodland restoration project (MM-2) • Minimize groundwater use from alluvial wells to limit groundwater depression and seawater intrusion through lagoon substrates (Refer to *El Sur Ranch Water Rights Application EIR* for technical discussion)	• Revegetate trail access-related eroded banks with native willow mattress/brush box revetments (RM 0.9 & RM 0.10) Re-route LB and RB beach access trails away from bank failures (RM 0.9 - RM 0.13). Leave generous riparian woodland buffer (50'-100') if possible (CP-1)
2. Mid Molera Reach	• Episodic channel shifts, loss of riparian canopy and integrity • Trail access and erosion • Rock dams and instream recreational use • At-grade crossings • Streambank failures	• Conduct late spring redd survey (MM-1) • Institute documented spawning reach signage program for minimum of 60 days after spawning survey(s) (MM-1) • Institute trail crossing closures at spawning areas(MM-1) • Continue Creamery Meadow and Creamery Meadow Annex riparian woodland restoration project (MM-2) • Periodically remove rock dams (MM-3)	• Install SH Lifecycle Interpretive Displays at walk-in camp site and at main parking lot-river crossing location(s) (RM 1.09) (CP-2) • Complete design, permit and construct proposed year-round pedestrian bridge near parking lot to minimize instream trampling (RM 1.24) (CP-3) • Construct bioengineered revetment at ranch road bank failure (RM 1.28-1.31) (CP-10)

ESR – 30

Project Reach:	Noted Impacts:	Suggested Management Measures:	Suggested Capital Projects:
4. Lower PBS Reach	• Trail access and erosion • Rock dams and instream recreational use • At-grade crossing	• Conduct late spring redd survey (MM-1) • Institute documented spawning reach signage program for minimum of 60 days after spawning survey(s) (MM-1) • If spawning noted at crossing, limit spawning-season vehicle use of Group Camp at-grade ford (MM-1) • Periodically remove rock dams (MM-3)	• Install SH Lifecycle Interpretive Displays at group camp site and at group camp access, at-grade crossing (CP-2) • Construct bioengineered revetment at Hwy 1 road bank failure (CP-9)
5.Campground Reach	• Trail access and erosion • Rock dams and instream recreational use • At-grade crossing • Severe riparian degradation and erosion at several River Sites	• Conduct late spring redd survey (MM-1) • Institute documented spawning reach signage program and closures for minimum of 90 days after spawning survey(s) (MM-1) • Periodically remove rock dams (MM-3)	• Install SH Lifecycle Interpretive Displays at campground and day-use parking lot-river crossing locations (CP-2) • Install exclusionary fencing and institute initial redwood/alder riparian revegetation efforts at main picnic area-campfire area streamside (CP-4) • Install exclusionary fencing and institute initial redwood/alder riparian revegetation efforts at river sites (11,15,17,30,31) (CP-5) • Remove 8 River Sites (13, 35, 37, 148, 149, 151, 152, 154) (CP-6) • Complete design, permit and construct previously proposed year-round pedestrian bridge and/or vehicle bridge in Main Camp to minimize instream trampling [PBSRM 1.50 approx.] (CP-11)

ESR – 30

Project Reach:	Noted Impacts:	Suggested Management Measures:	Suggested Capital Projects:
6. Gorge Reach	• Instream recreational use • Litter	• Support litter enforcement • Conduct periodic waste sweeps with staff and/or volunteers	• Install exclusionary fencing and institute initial redwood/alder riparian revegetation efforts at river sites [187,189,191,192,199, 200, 202] (CP-5)
7. Post Creek	• Trail access and erosion • Rock dams and instream recreational use • Severe riparian degradation and erosion at streamside campsites	• Periodically remove rock dams (MM-3) • Conduct late spring redd survey (MM-1) • Institute documented spawning reach signage program and closures for minimum of 90 days after spawning survey(s) (MM-1)	• Install SH Lifecycle Interpretive Displays at nearby bath facility and road crossings (CP-2) • Complete design, permit and construct both previously proposed Post Creek crossings at campground roads with clear-span bridges to improve SH and high-flow debris passage (CP-7) • Revegetate and install riparian exclusion fencing between camp road crossings (CP-8) • Remove 2 streamside redwood campgrounds (104, 106), revegetate with native species and install temproary riparian exclusion fencing to limit access to informal trails (CP-8)

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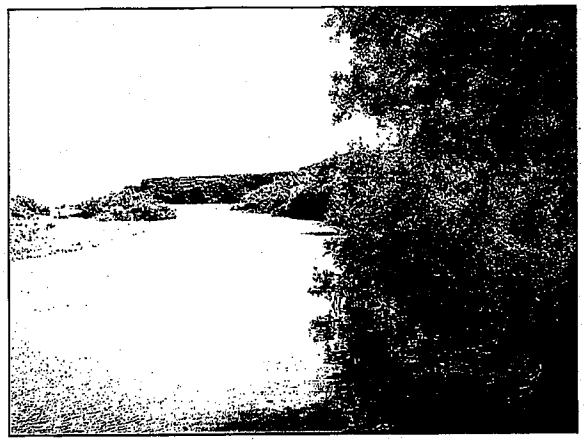
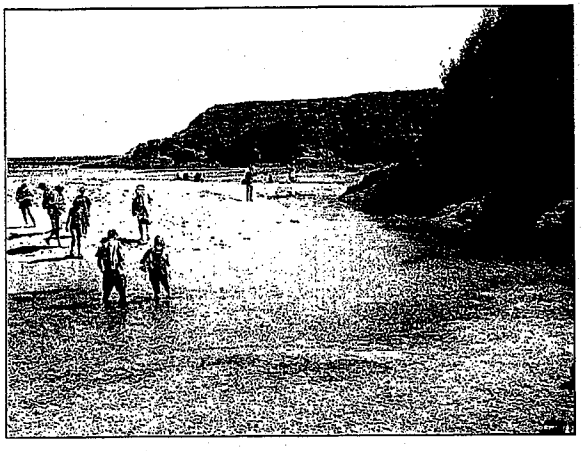
APPENDIX 1

PHOTOGRAPHS

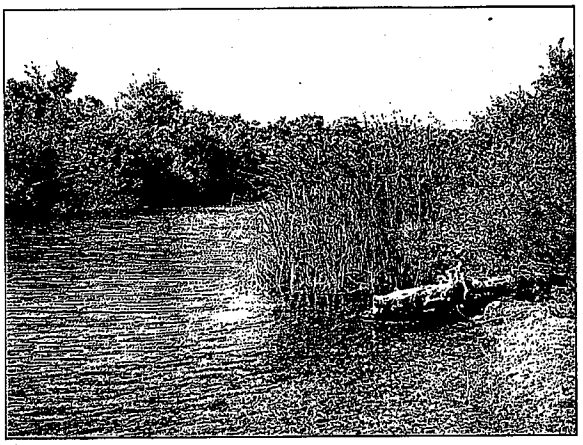


Big Sur Lagoon looking downstream from right bank. (RM 0.10)

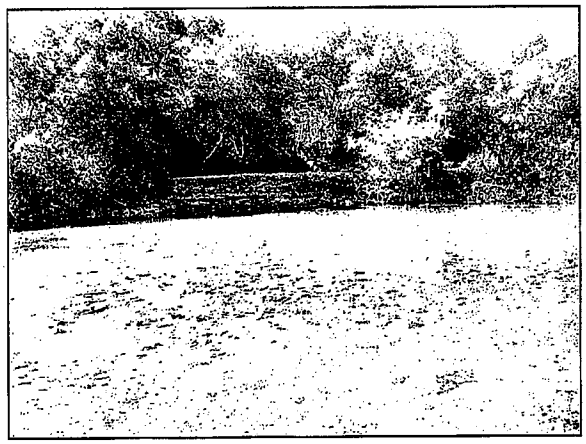
Big Sur Lagoon looking upstream from right bank. (RM 0.10)



Big Sur Lagoon outlet at Molera Beach.



Big Sur Lagoon looking upstream from left bank. (RM 0.04)



Right bank trail-related erosion at RM 0.09 Capital improvement site CP-1.

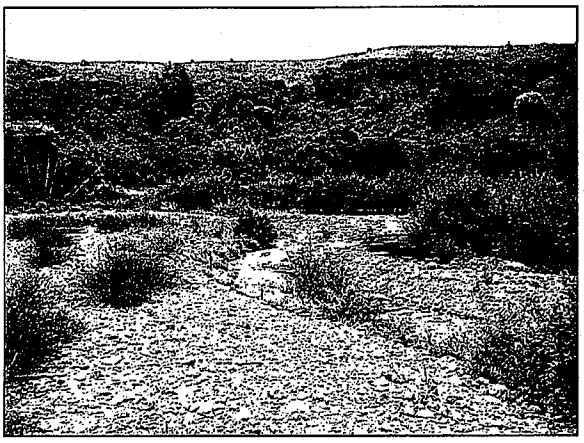
Left bank trail-related erosion at RM 0.18 Capital improvement site CP-1.

	Big Sur River Lagoon	Photo A

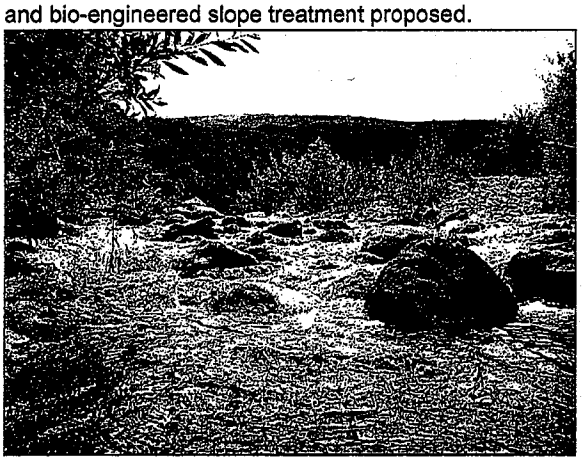
Typical high quality riffle run habitat in Mid Molera reach with intact riparian zone. (RM 1.24)

Typical point bar riffle habitat in Mid Molera reach with intact riparian zone. (RM 1.28)

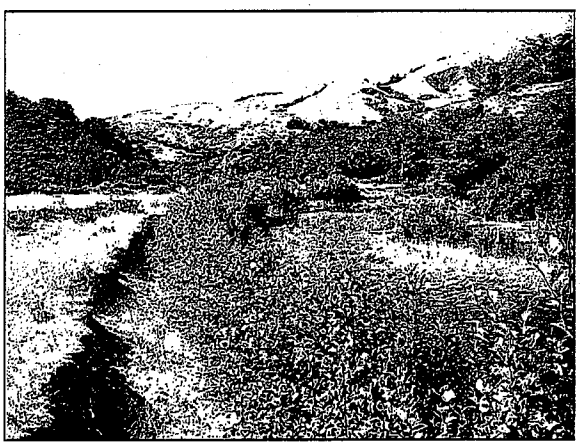
1997-98 Right bank failure at ranch road. (RM 1.29-1.32). Note alder and willow recruitment at toe. Road realignment and bio-engineered slope treatment proposed.



Braided channel in area of severe channel widening (RM 1.38)

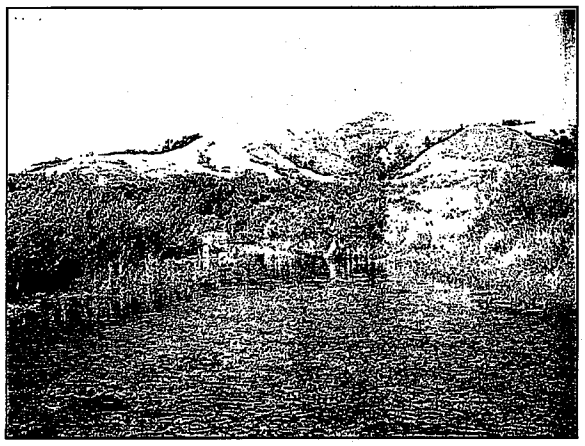


Steep boulder riffle in braided channel. (RM 1.35) Note willow recruitment on cobble bars. Highest density of young steelhead were found in these habitats during informal snorkel surveys.

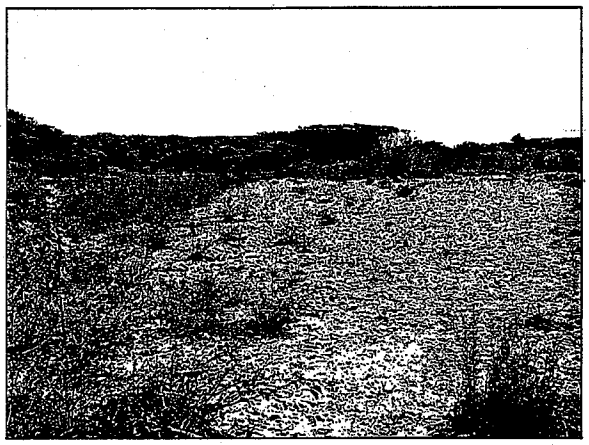


1997-98 left bank failure at (RM 1.48). Note alder and willow recruitment at toe.

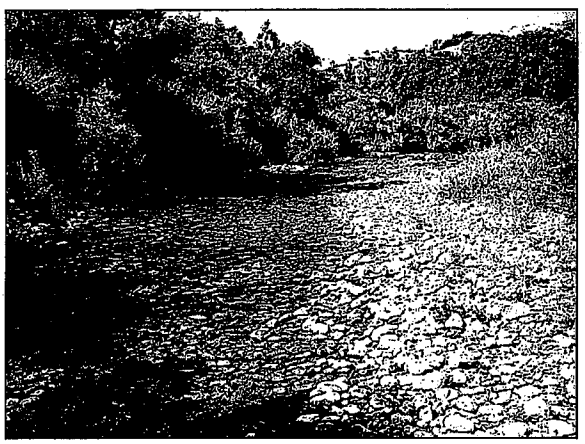
	Mid Molera Reach	Photo A



1997-1998 left bank lateral erosion area into Creamery Meadow. (Looking upstream RM 0.37)



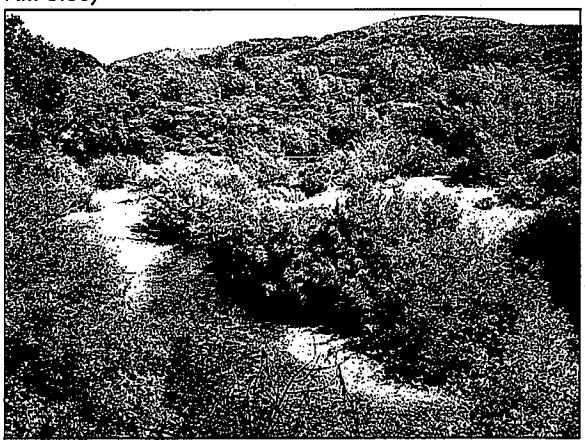
1997-1998 channel migration resulted in broad, bank attached cobble bars. (Looking downstream RM 0.39)



Shallow lateral riffle above the lagoon is unstable channel area. (RM 0.43)

Narrow confined riffle run habitat with continuous willow-alder-cottonwood riparian zone. (Looking upstream RM 0.50)

Andrew Molera main parking lot/crossing location. February 20, 2002 (RM 1.04-1.05)

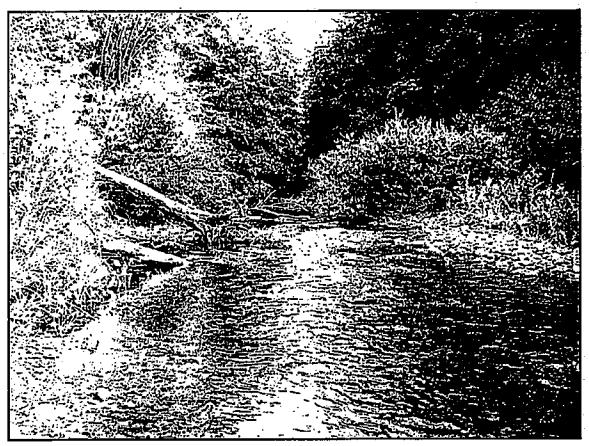


Andrew Molera main parking lot/crossing location August 13, 2002 (RM 1.04 - 1.05)

	Mid Molera Reach	Photo A

Horse trail crossing and recreational use at pool tail with good spawning potential. (RM 2.57)

Large woody debris and boulder channel. (RM 3.16) Upper Molera reach has best retention of large woody debris.



High quality habitat with intact riparian corridor and large woody debris.

Long slow bedrock pools 2-4' deep are common in upper Molera Reach. Looking upstream. (RM 3.46).

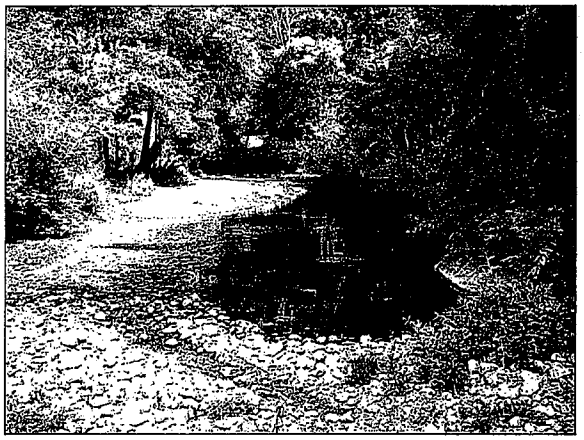
Sycamore scour pool. Near upstream boundary of Andrew Molera State Park. Heavy recreational use and channel modifications evident. Looking upstream. (RM 3.5)

Wide shallow riffle habitat upstream at Andrew Molera State Park boundary. Looking upstream. (RM 3.62)

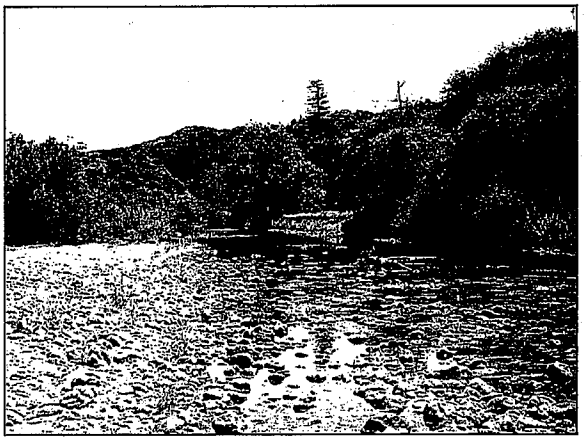
	Upper Molera Reach	Photo B

Bedrock pools and healthy redwood-alder-willow riparian habitat are typical of Upper Molera Reach. (RM 1.71)

Steep boulder-cobble riffle habitat at upstream end of Upper Molera reach. (RM 3.42)



Horse trail crossing at bedrock pool tail with good spawning potential. (RM 1.76)



Braided channel in area of severe channel widening. (RM 1.38)

Long slow run habitat with robust riparian habitat. (RM 2.21).

High quality riparian habitat reference reach. (RM 2.45)

	Upper Molera Reach	Photo B

Intact, multi-storied riparian corridor with minimal trampling effects on banks. (PBSRM 1.46)

Old diversion dam foundation, instream grade control. (PBSRM 1.56)

Intact riparian habitat reach. (PBSRM 1.64)

Denuded riparian habitat and severe bank erosion at river site # 151. (PBSRM 1.72)

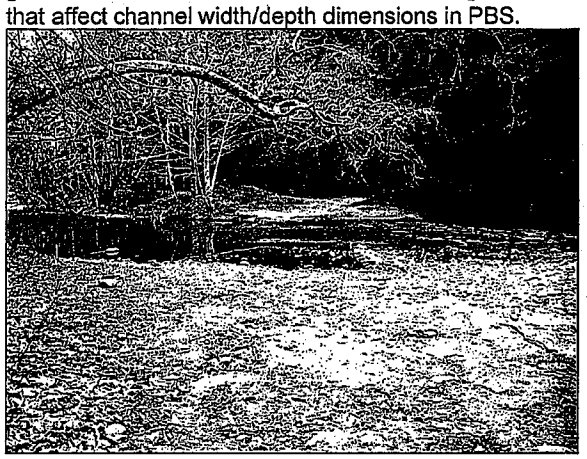
Denuded riparian habitat and severe bank erosion at river site # 152. Deep scour pools here are used as swimming holes. (PBSRM 1.74)

Rock dam passage obstruction at Post Creek confluence. (PBSRM 1.77)

	Campground Reach	Photo C

Old diversion dam site. (PBSRM 0.13) This existing structural grade control feature is one of 8 old instream grade controls that affect channel width/depth dimensions in PBS.

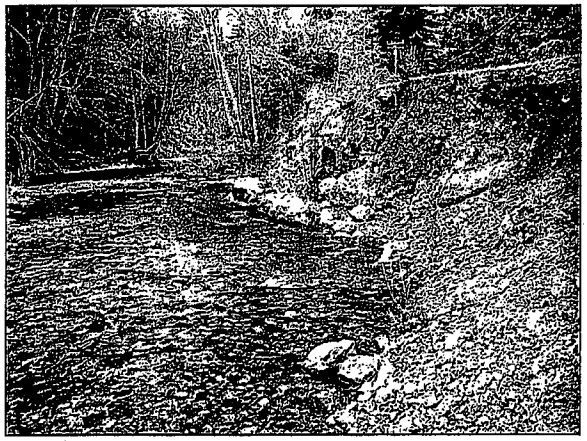
Redwood-alder riparian habitat typifies Lower PBS reach. (PBSRM 0.12)



Group camp at-grade vehicle ford and seasonal footbridge, February 2002 spawning season conditions. (PBSRM 0.26)

Group camp access, late summer 2002 conditions. (PBSRM 0.26)

Highway 1 bank failure near PBS gate. (PBSRM 0.35) Site proposed for bio-engineered log wall to provide habitat, limit erosion and maintain road fill. Looking downstream.

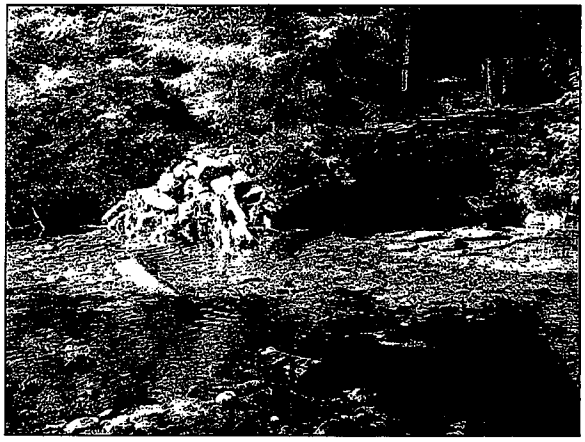


Highway 1 bank failure near PBS gate.

Campground Reach

Photo C

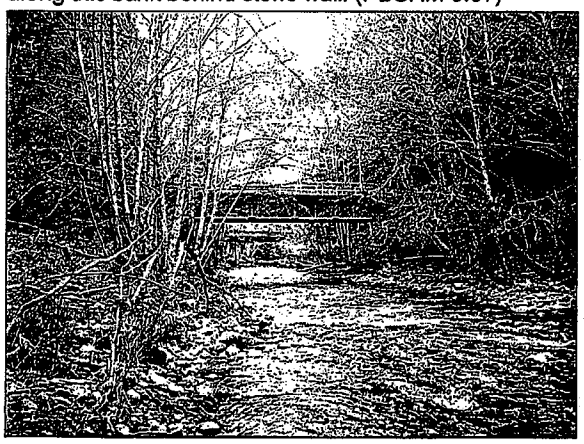
LWD related scour pool. (PBSRM 0.50)



Intact rootwad structure on left bank, protecting stone wall. (PBSRM 0.59)

Service road/trail between Highway 1 bridge and Group Camp, limits left bank riparian habitat. Existing alluvial wells extend along this bank behind stone wall. (PBSRM 0.57)

Riffle run habitat with good spawning potential downstream of Highway 1 bridge. Looking upstream. (PBSRM 0.65)

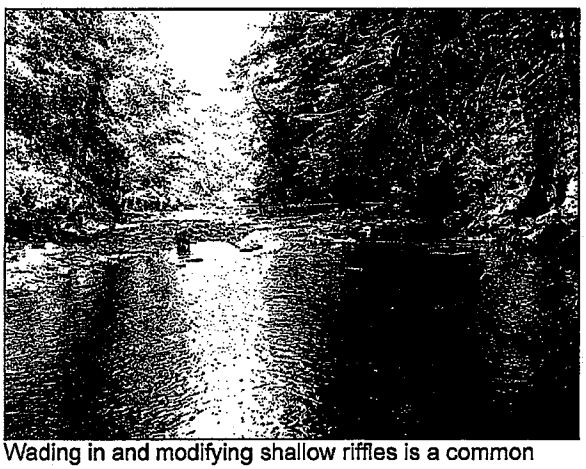


Campground and Highway 1 bridges serve as dividing line between lower PBS and Campground reaches. February 2002 conditions. (PBSRM 0.67-0.72)

Summer conditions beneath Campground Bridge. Looking upstream. (PBSRM 0.67-0.72)

	Campground Reach	Photo C

Campground reach has most intensive recreational use and streambed alterations, such as transitory rock and log dams. (PBSRM 0.86)



Wading in and modifying shallow riffles is a common activity throughout the year. (PBSRM 0.95)

Riparian habitat at day use picnic area, denuded by recreational use. February 2002 conditions. (PBSRM 0.99)

Concentrated recreation use in Main Camp bedrock pool and downstream riffle. (PBSRM 0.99)

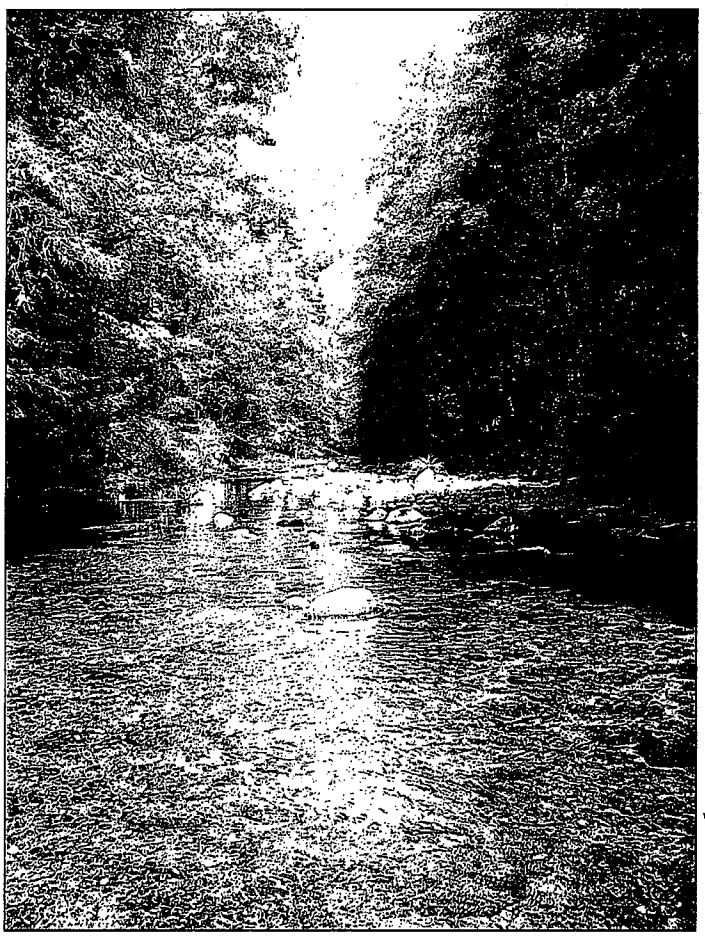
Denuded riparian habitat at river site # 13. (PBSRM 1.29)

Narrow, even-aged alder riparian zone confined by right bank access road. (PBSRM 1.15-1.20)

	Campground Reach	Photo D

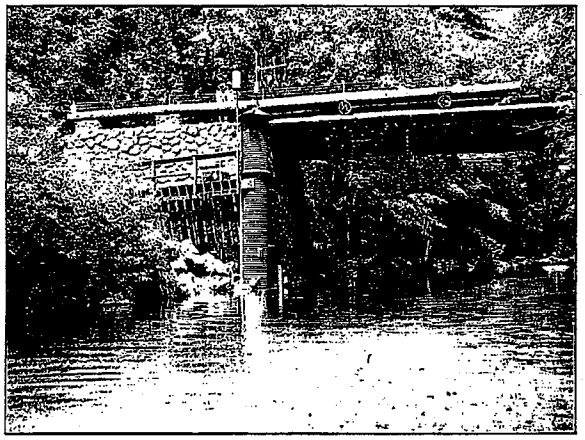
Severe bank erosion and heavy recreational use below Post Creek confluence. (PBSRM 1.81)

Severe bank trampling and heavy recreational use below USGS Big Sur Gage. Persistent modification of downstream control riffle by construction rockdams in the vicinity of PBSRM1.98, limits accuracy of realtime-remote gaged low-flow measurements. As a result, summer baseflows are most often estimated by USGS staff and are considered poor records. (PBSRM 2.02)



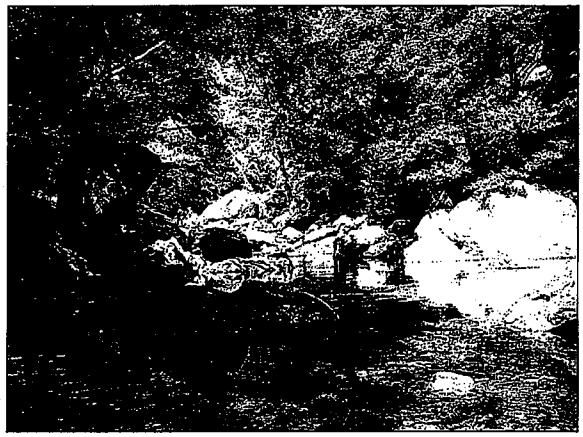
Intact riparian habitat reference reach (PBSRM. 1.94).

	Lower Big Sur	Photo D



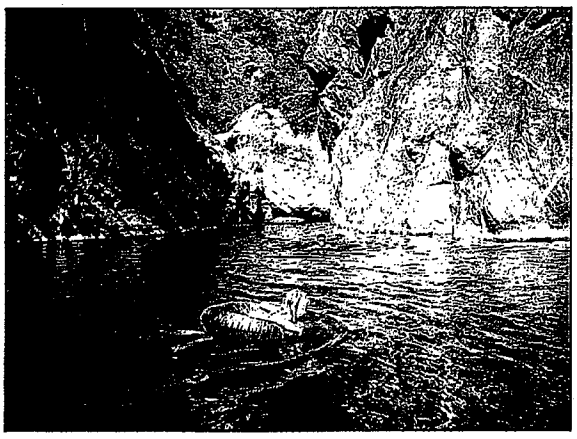
USGS Big Sur River gage at base of Gorge Reach. (PBSRM 2.03)

Camp site and recreational use impacts to riparian corridor below river sites 199 and 200. (PBSRM 2.05)



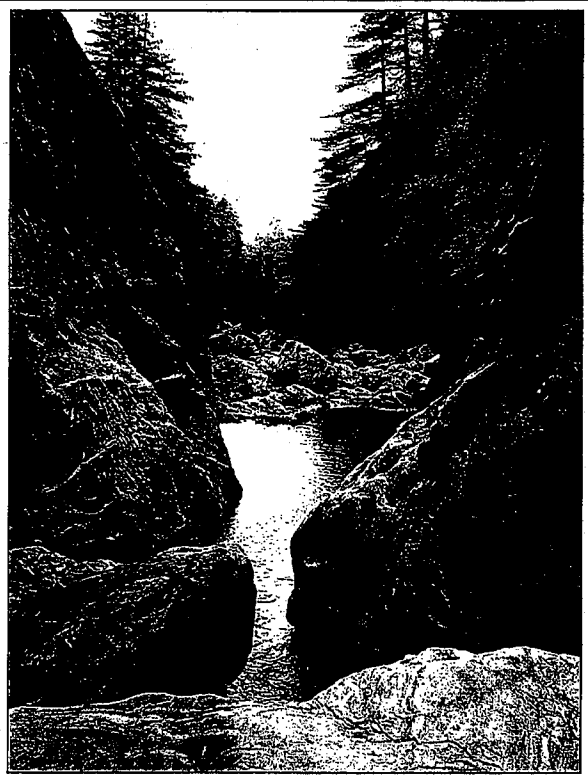
Steep boulder step-pool habitat distinguishes the Gorge Reach. (PBSRM 2.15)

Large woody debris is abundant in the steep Gorge Reach. (PBSRM 2.18)

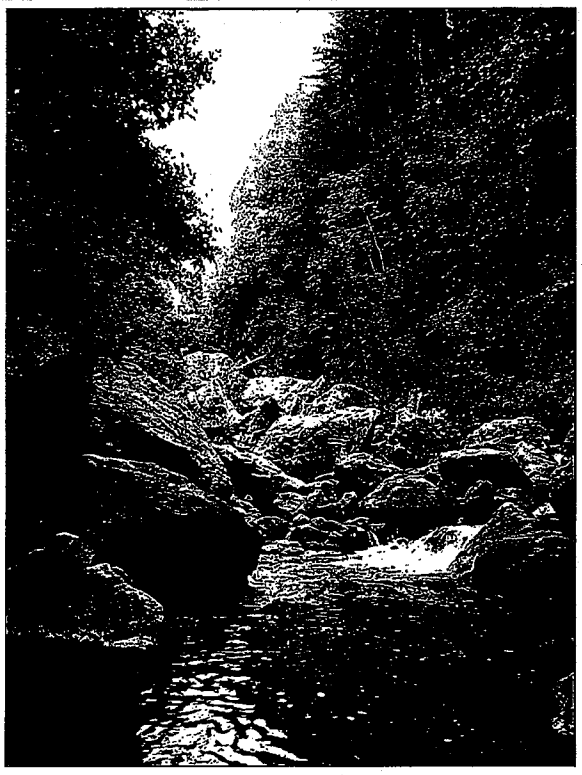


Up to 400 people per day use the Gorge pools, often bringing with them substantial amounts of litter. Despite heavy use, snorkel surveys found YOY, 1+, and 2+ fish abundant in the Gorge's step pools and boulder riffles (PBSRM 2.29).

	Gorge Reach	Photo E



The main Gorge pool looking downstream from the 4'- 6' jump. (PBSRM 2.30)



A complex series of steep boulder cascades, pools and jumps extend throughout the reach above the main Gorge pool. (PBSRM 2.30-2.51)

25-35' tall boulder and log jam barrier at upper end of Gorge. (PBSRM 2.51)

	Gorge Reach	Photo E

Two squashed 36" culverts at downstream camp road crossing are partial barriers. (PCRM 0.009)

Low clearance at upstream camp road crossing results in debris backups and local flooding. (PCRM 0.081)

Post Creek riparian zone between camp roads. (PCRM 0.015-0.025)

Post Creek degraded riparian zone between camp roads. (PCRM 0.025-0.05)

Post Creek degraded riparian zone between camp sites #104 and #106 proposed for removal. (PCRM 0.0865-0.11) Revegetate with native species and install temporary riparian exclusion fencing to limit access to informal trails.

Post Creek near park boundary. Numerous logjams and passage barriers exist between PCRM 0.15 and a large landslide toe at PCRM 0.38..

	Post Creek Reach	Photo F

APPENDIX 2

TECHNICAL STUDY
STREAM BANK RESTORATION PROJECTS

prepared by
Fall Creek Engineering, Inc.

Big Sur State Parks

Stream Bank Restoration Projects

Conceptual plans have been prepared for two stream bank restoration projects along the Big Sur River identified in the field assessment phase of the study. The conceptual plans provide a description of the site and proposed restoration project, a preliminary project analysis that identifies the additional tasks required to implement the project and lastly a preliminary cost estimate for project implementation. The projects are proposed to address bank erosion at each site. One site is located in Andrew Molera State Park and the second site is in Pfeifer Big Sur State Park. The restoration plans utilize biotechnical bank stabilization methods that integrate the use of structural and vegetative techniques to provide long-term bank stabilization and enhancement opportunities by reintroducing native vegetation along the river.

1. ANDREW MOLERA STATE PARK

1.1 Project Setting

The project site is located in Andrew Molera State Park on the westside of Highway One in Big Sur, California, as shown in Figure 1. The proposed project will restore approximately 240 lineal feet of stream bank on the eastside of the Big Sur River.

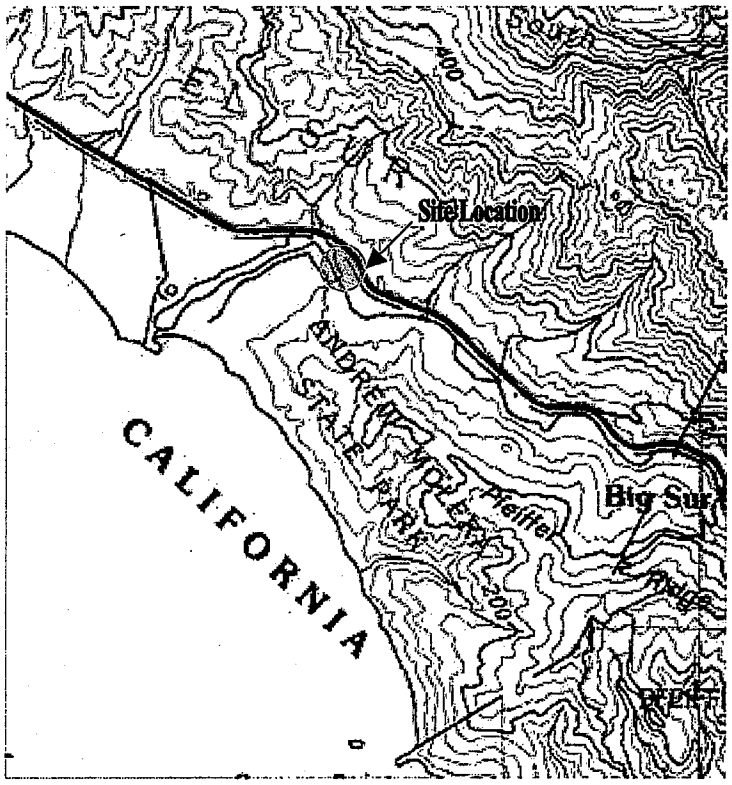


Figure 1. Site Vicinity Map

The site is adjacent to a park access road and the position of the road has confined the river channel and upland riparian corridor to a narrow strip of land. The bank is near vertical along the reach and unstable and the amount, distribution and density of riparian vegetation on the stream bank and upland area are very sparse. Figure 2 presents a photo showing conditions looking downstream from the upstream edge of the site. Confining the channel and riparian corridor to a narrow strip of land reduces the riparian vegetation and bank stability, making the bank susceptible to erosion during high flow events. Erosion of the stream bank material has caused the angle of the bank to increase to nearly vertical. If left unchanged, it is foreseeable that future flows could cause further erosion and bank instability.

Figure 2. Andrew Molera State Park Project Site

1.2 Conceptual Restoration Plan

Project Goals. The overall goals of the conceptual restoration plan for this project site include: providing long-term bank stabilization, reducing future erosion and sedimentation problems, and improving riparian habitat in this section of the river.

To restore the bank to a more stable and natural condition, the proposed project will include:

1. Relocating the park access road approximately 50 feet to the east;

2. Regrading or laying back the stream bank to a 2:1 slope to increase vegetative cover and the stability of the bank;

3. Installing vegetated rip-rap at the toe of bank and along the length of the project reach to protect the bank from scour; and

4. Installing interim erosion control measures to stabilize and protect the bank during the establishment of permanent vegetation.

5. Revegetating the stream bank and upland area between the stream and realigned access road with native riparian plantings.

Willow staking will be placed in between the riprap to provide long-term bank stability. The remainder of the bank will be vegetated with native, locally available plants. Examples of appropriate species include: Elderberry (Sambucus so), Native Blackberry (Rubus ursinus), Mugwort (Artemesia douglasiana), and Willows (Salix sp.). Project plans will designate the complete plant pallete, spacing, sizes, etc. The design goals include protecting the existing vegetation at the toe of the bank. Figure 3 shows the topographic location of the project and Figure 4 shows a conceptualization of the project design.

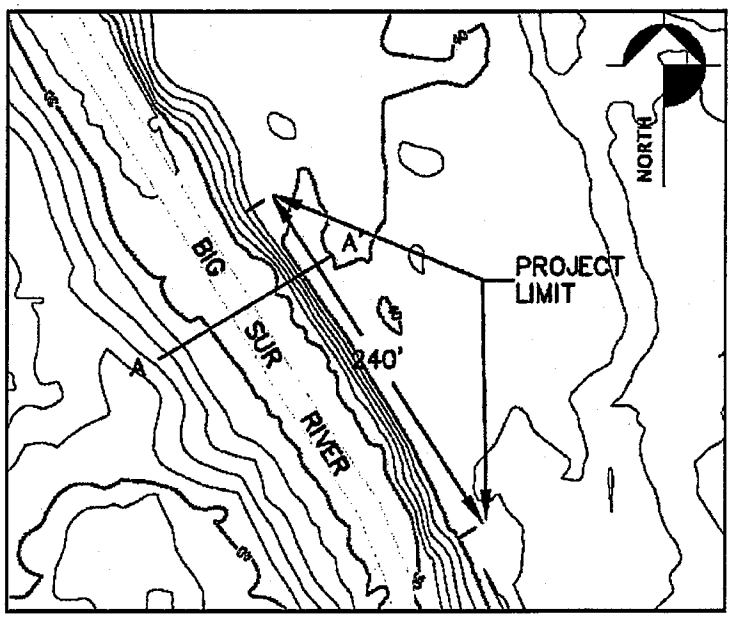


Figure 3. Topographic Location of Andrew Molera Demonstration Project

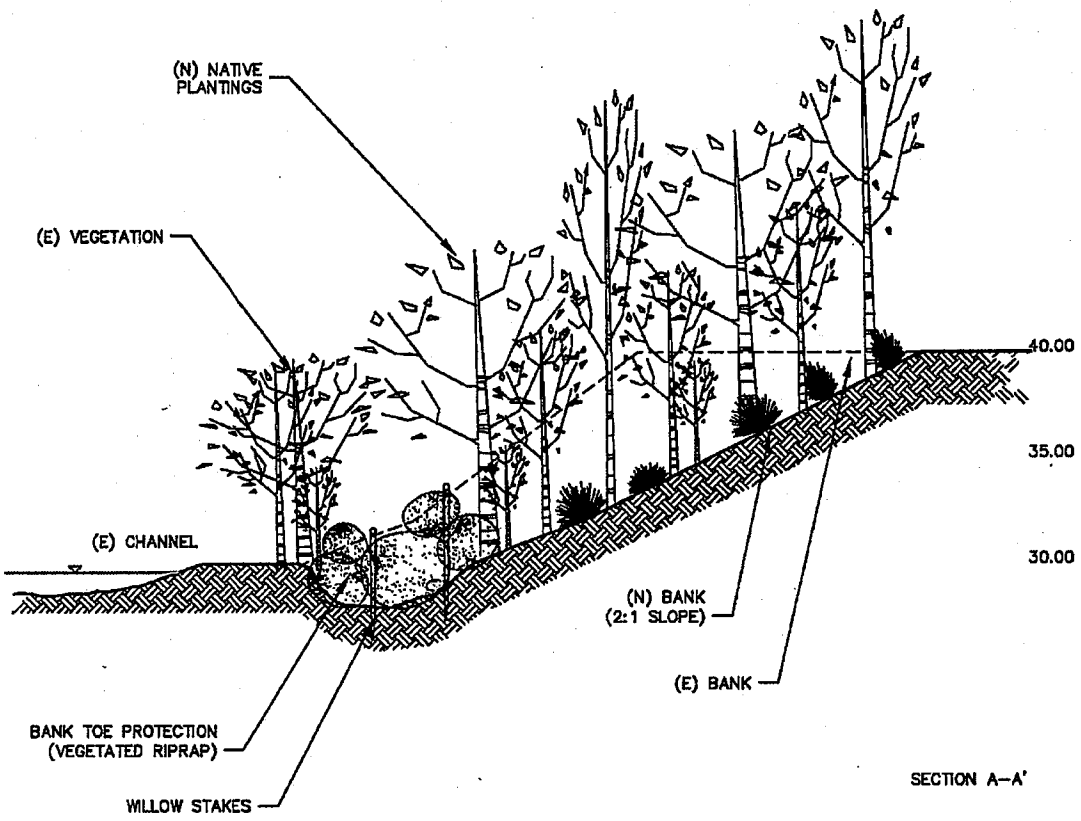


Figure 4. Andrew Molera Conceptual Project Design

After the project has been constructed, the new vegetation will need to be irrigated during the dry season to assure the successful establishment of the plants. Irrigation can be either through overhead spray or through drip emitters placed at the base of the individual plants.

1.3 Project Analysis

Designs Plans and Biotic Survey

Once the project has received funding, detailed design plans, planning and permitting activities will be required.

Design Plans

Detailed design plans and specifications will be required to construct the project. The detailed design plans will include the following:

- Site plan showing the location and extent of the project;
- Grading plan showing the limit of grading, cut and fill volumes, staging areas;
- Restoration plan showing the plans and details of the proposed improvements

- Re-vegetation and erosion control plan; and
- Construction specifications.

Biotic Survey

A biotic survey of the project site will most likely be needed to document biological conditions and identify any potentially sensitive species and to develop mitigation measures, as required, for resource agencies reviewing the project.

Permitting and Review

The project is located in a riparian corridor; therefore several local, state, and federal permits may be required to execute the project.

Monterey County. The County of Monterey may require that a grading permit, a coastal development permit and a riparian exception be obtained prior to their approval of the project.

California Department of Fish and Game (CDFG). A Streambed Alteration Agreement will be required.

US Corps of Engineers (USCOE). A USCOE 404 permit is required to carryout work within any waters of the state.

Regional Water Quality Control Board. A 401 Certification from the Regional Water Quality Control Board (RWQCB) is required, which is part of the 404 permit process, but obtained directly from the RWQCB.

Other Agencies. Because the project will be conducted in a riparian corridor, the project may also be reviewed by other resource agencies, including the National Marine Fisheries Service and the US Fish and Wildlife Service.

1.4 Project Implementation

Project implementation will involve regrading the bank, installation of vegetated riprap, and revegetation of the site. The construction period will likely take between two to four weeks, depending on the final project design and on time restrictions imposed by the County of Monterey and the California Department of Fish and Game.

1.5 Project Monitoring and Maintenance

A pre- and post project monitoring and maintenance program will be required to evaluate the performance of the enhancement project. The project will involve structural improvements, including construction of bank stabilization and erosion control measures, and site re-vegetation. All of which will require ongoing monitoring and periodic maintenance to achieve the long-term restoration benefits provided by the project.

Since the project will be constructed within a dynamic hydrologic setting, the proposed structural improvements, erosion control and re-vegetation measures may experience damage, adjustments, and partial plant survival. A key element of the project will be to implement a long-term monitoring and maintenance program to evaluate the physical and biological condition of the project and to detect and correct situations requiring repair or modification.

The objectives of the monitoring and maintenance program are:

- Repair any minor damages quickly (i.e. erosion or gullies) to maintain the banks in a stable configuration and to avoid severe and costly damage resulting from deferred maintenance.
- Assure the restoration project is maintained to comply with the regulation and guidelines of the California Department of Fish and Game (CDFG), the National Marine Fisheries Service (NMFS), the California Regional Water Quality Control Board (RWQCB), and the County of Monterey.
- Assess the effectiveness of the project.

1.6 Project Cost

Table 1 presents a preliminary engineering cost estimate to design, permit and construct the proposed restoration project.

Table 1 Preliminary Cost Estimate

Description	Unit	Quantity	Unit Cost	Total Cost
1. Design and Permitting				
1.1. Engineering Analysis and Design				
a. Hydraulic Analysis				2,500.00
b. Engineering Design Plans and Specifications				7,500.00
1.2. Biotic Survey				3,000.00
1.3. Project Permitting				3,000.00
1.4. Permit Fees				3,000.00
2. Project Implementation				
2.1. Rough grading	CY	400	12.00	4,800.00
2.2. Install vegetated rip-rap toe protection	LF	240	25.00	6,000.00
2.3. Interim erosion control measures				5,000.00
2.4. Re-vegetation				10,000.00
3. Project Monitoring and Maintenance				5,000.00
Total Project Sub-total =				49,800.00
Contingency (10%) =				4,980.00
Total Project Cost =				54,780.00

2. PFEIFFER BIG SUR STATE PARK

2.1 Project Setting

The project site is located in Pfeiffer Big Sur State Park on Highway One. The site is along the Big Sur River adjacent to Highway One just north of the Pfeiffer Big Sur State Park entrance. The length of the site is approximately 115 feet. Figure 5 presents a site vicinity map.

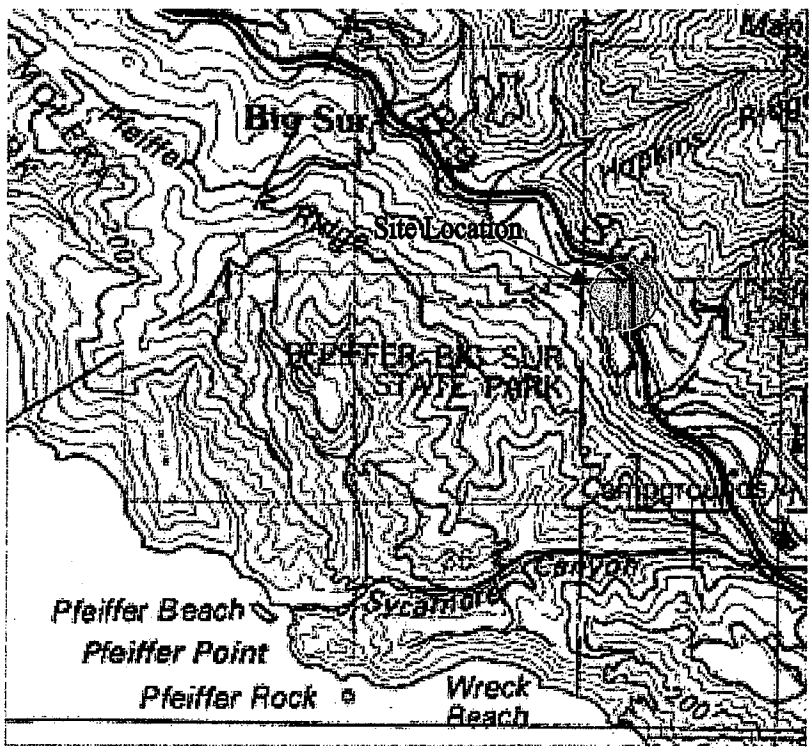


Figure 5. Project Site Vicinity Map

The project site is located on an outside meander bend of the Big Sur River. The bank is under cut and experiencing bank failure, as seen in Figure 6, a photo of current bank conditions. The bank is in close proximity to State Highway One, and if left unchanged, it is foreseeable that future flows could cause extensive erosion and bank instability and impact Highway One.

Figure 6. Pfeifer Big Sur State Park Project Site

2.2 Conceptual Restoration Plan

Project Goals. The overall goals of the conceptual restoration plans for this project site include: providing long-term bank stabilization, reducing future erosion and sedimentation problems, and improving the riparian habitat in this section of the river.

To restore the bank to a more stable and natural condition, the proposed project will include constructing a 115-foot long vegetated log-revetment wall and reshaping and vegetating the top bank to a milder slope. The log-revetment wall will be constructed from a combination of a concrete reinforced footer log and redwood logs. Each cell between each coarse of logs will be filled with a live willow brush mattress and soil, as shown in Figure 7. The logs will be tied to the existing slope using Chance soil anchors that are driven into the slope using an hydraulic auger. As the live willow mattress grow and mature, the root structure will provide long-term bank protection and erosion control. The top of the bank will be vegetated with native, locally available plants. The placement of vegetated rip-rap is proposed set at the toe of the wall to provide additional protection against scour.

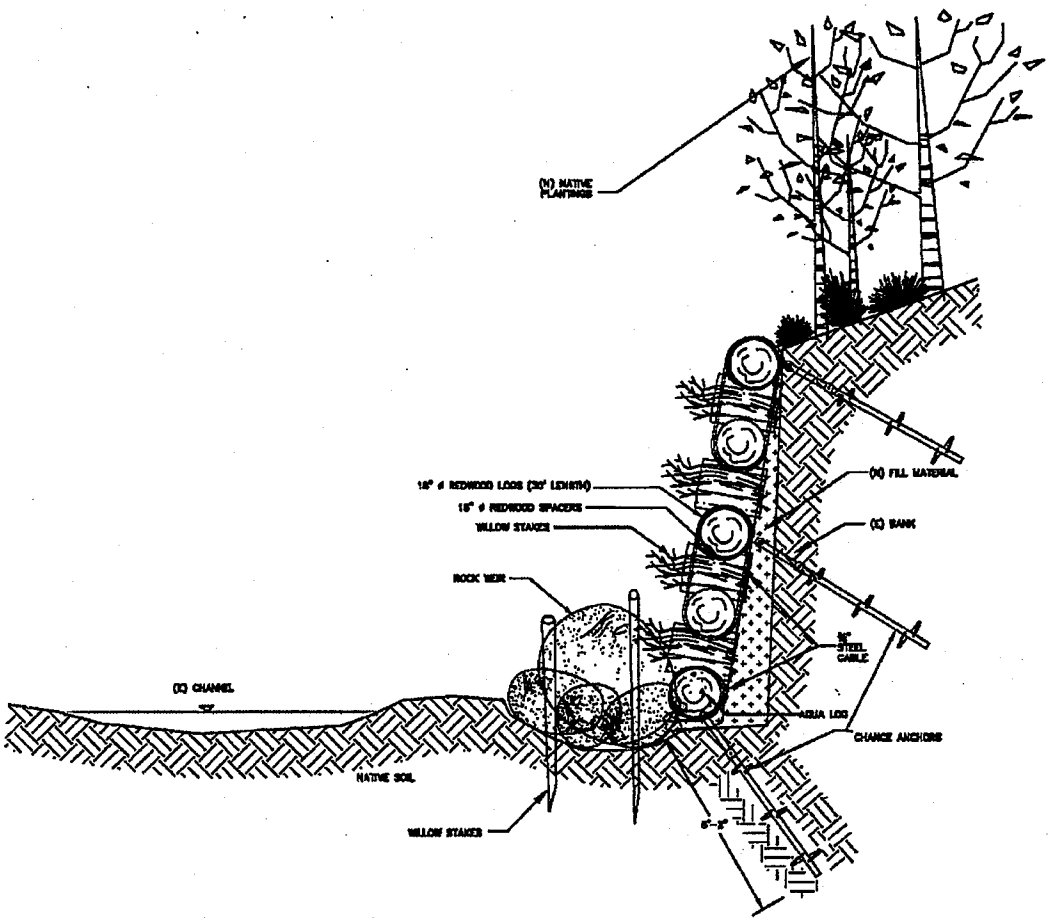


Figure 7. Conceptual Project Design – Log-Wall Revetment

The proposed wall is 12 feet high extending from the water line to tie back edge of the crib wall. The wall is approximately 115 feet long. The slope above the crib wall is to be graded to conform to the existing natural grade. The face of the wall is to have a batter of 6:1 (V:H). The wall main members are 18-inch diameter logs. The top bank above the wall will be back filled to a 1 1/2 :1 (H:V) slope and be re-vegetated with a combination of seed and container stock. Interim erosion control measures will be installed on the top bank to stabilize the bank while the permanent vegetation becomes established.

Designs Plans and Biotic Survey

Once the project has received funding, detailed design plans, planning and permitting activities will be required.

Design Plans

Detailed design plans and specification will be required to construct the project. The detailed design plans will include the following:

- Site plan showing the location and extent of the project;
- Grading plan showing the limit of grading, cut and fill volumes, staging areas;
- Restoration plan showing the plans and details of the proposed improvements
- Re-vegetation plan and erosion; and
- Construction specifications.

Biotic Survey

A qualified biologist will most likely be required to conduct surveys of the project site to document biological conditions for resource agencies that will require permits for the project.

Permitting and Review

The project is located in a riparian corridor, therefore several local, state, and federal permits will be required to execute the project.

Monterey County. The County of Monterey may require that a grading permit, a coastal development permit and a riparian exception be obtained prior to their approval of the project.

California Department of Fish and Game (CDFG). A Streambed Alteration Agreement will be required.

US Corps of Engineers (USCOE). A USCOE 404 permit is required to carryout work within any waters of the state.

Regional Water Quality Control Board. A 401 Certification from the Regional Water Quality Control Board (RWQCB) is required, which is part of the 404 permit process, but obtained directly from the RWQCB.

Other Agencies. Because the project will be conducted in a riparian corridor, the project will also be reviewed by other resource agencies, including the National Marine Fisheries Service and the US Fish and Wildlife Service.

2.3 Project Implementation

Project implementation will involve the some limited grading of the site, installation of the log wall, vegetated riprap, interim erosion control measures, and revegetation of the site. The construction period will likely take between three to six weeks, depending on the final project design and on time restrictions imposed by the County of Monterey and the California Department of Fish and Game.

2.4 Project Monitoring and Maintenance

A pre- and post project monitoring and maintenance program will be required to evaluate the performance of the enhancement project. The project will involve structural improvements, including construction of bank stabilization and erosion control measures,

and site re-vegetation. All of which will require ongoing monitoring and periodic maintenance to achieve the long-term restoration benefits provided by the project.

Since the project will be constructed within a dynamic hydrologic setting, the proposed structural improvements, erosion control and re-vegetation measures may experience damage, adjustments, and partial plant survival. A key element of the project will be to implement a long-term monitoring and maintenance program to evaluate the physical and biological condition of the project and to detect and correct situations requiring repair or modification.

The objectives of the monitoring and maintenance program are:

- Repair any minor damages quickly (i.e. erosion or gullies) to maintain the banks in a stable configuration and to avoid severe and costly damage resulting from deferred maintenance.
- Assure the restoration project is maintained in compliance with the regulation and guidelines of the California Department of Fish and Game (CDFG), the National Marine Fisheries Service (NMFS), the California Regional Water Quality Control Board (RWQCB), and the County of Monterey.
- Assess the effectiveness of the project.

PROJECT COST

Table 2 presents a preliminary engineering cost estimate to design, permit and construct the proposed restoration project.

Table 2. Preliminary Cost Estimate

Description	Unit	Quantity	Unit Cost	Total Cost
1. Design and Permitting				
1.1. Engineering Analysis and Design				
a. Hydraulic Analysis				2,500.00
b. Geotechnical Analysis				4,000.00
c. Engineering Design Plans and Specifications				10,000.00
1.2. Biotic Survey				2,000.00
1.3. Project Permitting				3,000.00
1.4. Permit Fees				3,000.00
2. Project Implementation				
2.1 Site Preparation				3,000.00
2.2 Rough Grading	LF	115	12.00	1,380.00
2.3 70 Foot Vegetated Crib Wall	LF	115	300.00	34,500.00
2.4 Final Grading and Erosion Control				5,000.00
2.5 Re-vegetation				10,000.00
3. Project Monitoring and Maintenance				5,000.00
Total Project Sub-total =				83,380.00
Contingency (10%) =				8,338.00
Total Project Cost =				91,718.00