WATER RESOURCE MANAGEMENT PLAN

REDWOOD NATIONAL PARK

DECEMBER 1985

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REDWOOD NATIONAL PARK

An Amendment to the Resources Management Plan

December 1985

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I. INTRODUCTION

Redwood National Park was established on October 2, 1968, when the President signed Public Law 90-545 in order to "...preserve examples of the primeval coastal redwood (Sequoia sempervirens), forests and the streams and seashores with which they are associated for purposes of public inspiration, enjoyment, and scientific study..." (Fig. 1).

Shortly after the park's establishment, the Secretary of the Interior, acting through the National Park Service, initiated a series of studies to evaluate management options for protection of park resources. Stone and others (1969) recommended specific restrictions on timber harvest and the creation of an organization to stabilize the Redwood Creek watershed. Later, an interagency task force (USDI, 1973) identified channel instability as the greatest potential threat to park resources and recommended further restrictions on private land as well as additional studies of the geomorphic processes and aquatic ecosystems of the newly established park.

In 1973 the National Park Service authorized the U.S. Geological Survey (USGS) to initiate a three-year study on the effects timber harvest practices and natural geomorphic processes have on terrestrial and aquatic ecosystems within the park (Janda, 1975). These studies showed that upstream timber harvest and road construction had detrimental effects on downstream park resources.

In 1978 Congress enacted Public Law 95-250 to expand Redwood National Park by 48,000 acres. The Secretary of Interior was also directed to "undertake and publish studies on erosion and sedimentation" within the Redwood Creek watershed. In addition, a rehabilitation program was authorized to restore lands damaged by logging activities, remove logging roads and return park lands to as pristine condition as reasonably possible. In this sense, Redwood National Park is non-traditional; that is, instead of just preserving a natural ecosystem it is also attempting to restore watersheds damaged through timber harvest activities.

This plan identifies the goals and actions for management of the park's water resources. The plan presents an overview of park water resources and outlines known problems. A Water Resources Management Program is presented that identifies the minimum standards at which the program should be implemented. A Water Resources Project Programming Sheet, List of Continuing and Proposed Projects, Project Statements, and 10-237's and 10-238's are attached (Sections VI and VII).

II. INFORMATION BASE

A. Introduction

The Resources Management Plan and Environmental Assessment (1982) serves as the reference document for this Water Resources Management Plan. Natural Resource Project statements from the Resources Management Plan which consider water resources are used in this plan. As described in the Resources Management Plan (1982): Redwood National Park has two distinctive physiographic environments - the coastline and the Coast Range mountains. The coastline has been largely undeveloped by humans. It is rugged, with stretches of steep, rocky cliffs broken by rolling slopes that are covered by grasslands, shrub or forests. The tidal zone is predominantly rocky and difficult to traverse but is interspersed with sand beaches, including Gold Bluffs Beach, a seven-mile expanse of dunes and sandy beach, Crescent Beach and others.

Inland from the coast lies the Coast Range with major streams and ridgelines trending northwest. The gently rounded mountain summits contrast with steep sideslopes that have been deeply incised by streams. Elevations within the park range from sea level to 3,097 feet at Schoolhouse Peak.

The bedrock beneath Redwood National Park is primarily of the Franciscan assemblage, which is a collection of sandstones, siltstones, and minor amounts of conglomerates. These rocks are thoroughly folded, sheared and jumbled. The Franciscan is bounded on the west by the San Andreas fault, which is several miles off the coast, and on the east by the South Fork Mountain fault. The South Fork Mountain fault runs through the northeast corner of Redwood National Park in the Little Bald Hills area.

The Franciscan assemblage was laid down on the ocean floor as deposits of sand and mud about 150 million to 100 million years ago. Continental drift and associated plate movements caused the Franciscan assemblage to collide with the continent, and eventually it uplifted to become the Coast Range. Continued folding and faulting complicated the Franciscan assemblage.

Just east of Crescent City, Redwood National Park contains small remnants of marine and non-marine sedimentary deposits that are approximately 11 million years old. The park also includes a corner of the Point Saint George marine terrace.

The other major geologic formation in the park is a deposit of loosely consolidated sediments that are primarily fluvial in origin and informally known as the Gold Bluffs formation. It is exposed along Gold Bluffs Beach and in the Prairie Creek drainage basin. The Gold Bluffs formation is thought to be a river delta deposit laid down by the Klamath River more than two million years ago.

The soils in Redwood National Park are derived primarily from the Franciscan assemblage. Residual soils are confined mainly to patches on sloping ridge crests, except for those developed on the Gold Bluffs formation. There are also alluvial soils in the park that developed on floodplains, in alluvial

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valleys and on stream terraces of major streams and rivers. Variations in soil types are controlled by the topography and varying rock types in the underlying Franciscan assemblage. Local variations may result from microclimatic differences influenced by slope and aspect.

B. Description of Water Resources

1. Overview

Water resources in Redwood National Park consist of freshwater (streams and rivers), salt water (the Pacific Ocean) and transitional areas (estuaries and lagoons). Redwood Creek is the main river running through the southern part of the park. The Klamath River crosses a narrow strip of park lands near the coast, and the Smith River runs through the northern part of the park. Redwood National Park also includes many small streams. The western boundary of Redwood National Park extends one-fourth mile beyond the mean high tide line. The State of California has title to all submerged lands and the land below the mean high tide. Those lands are administered by either the State Lands Commission or the Crescent City Harbor District (at Crescent Beach). An ecological survey (Boyd, 1977) was completed for the nearshore marine environment along approximately thirty-five miles of shoreline encompassed by the National Park and two State parks.

No natural ponds or lakes occur within the park, although lagoons, sloughs and marshes occur as a result of oceanic and tectonic processes. One of these, Lagoon Creek Pond, was impounded to deepen the water and create a pond. Also, several stock ponds and one log pond formed by artifical impoundment of surface water remain from before park establishment and expansion.

Water resources within the park have been modified by humans during the last century and resource management problems in the park stem from these changes. For example, land use changes, especially upstream from park lands, have caused an increased sediment load in many of the streams and rivers flowing through the park. Fish populations in local rivers have declined during recent years. Flood levees were built along Redwood Creek near its mouth, and thus changed the drainage patterns of the estuary and damaged estuarine resources. Riparian resources, including old-growth redwood trees, have been damaged by recent river channel changes. The Water Resource Mangement Plan presents proposed actions and alternatives to deal with such problems.

2. Annual Precipitation

Most of the annual rainfall in Redwood Creek occurs between October and April. Annual precipitation amounts near Orick from 1951 through 1982 are shown in Figure 2. Nineteen storage rain gages are located throughout the park. There is considerable difference in annual rainfall between gages due to aspect and elevation. Figure 3 is a summary of rainfall totals for these locations.

3. Surface Waters of Redwood National Park

The lower third of Redwood Creek flows through Redwood National Park. Its headwaters originate at 1500 m (4900 ft), and it runs northwesterly for 108 km

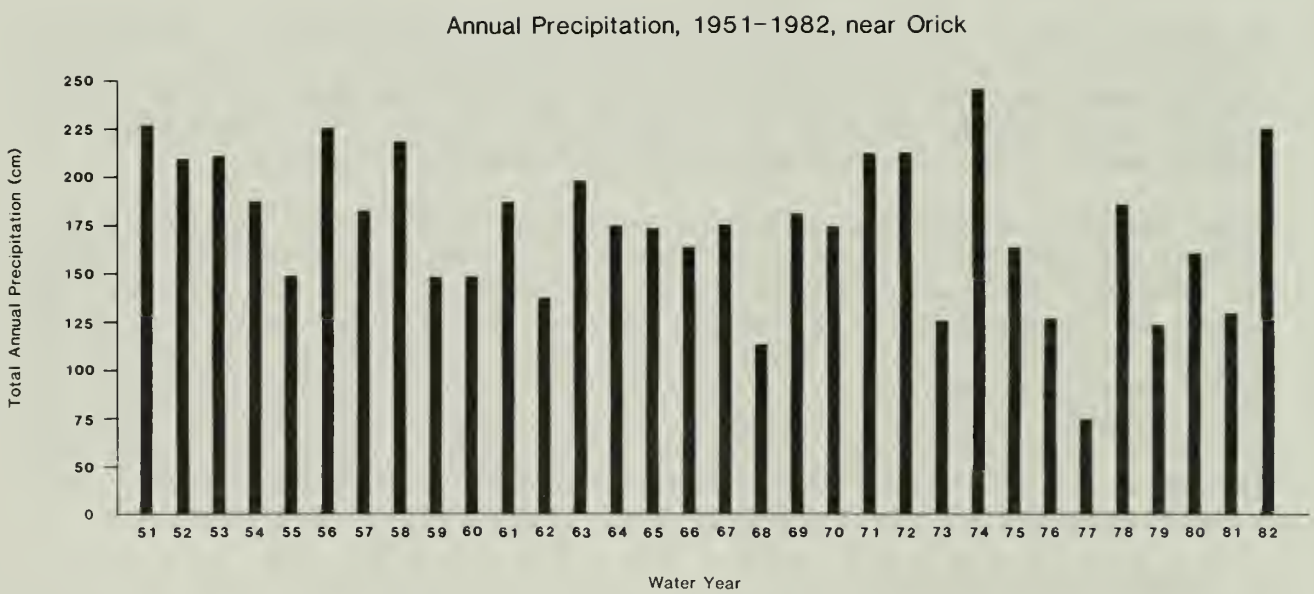

Figure 2: Mean annual precipitation for 1951 through 1982 at Orick.

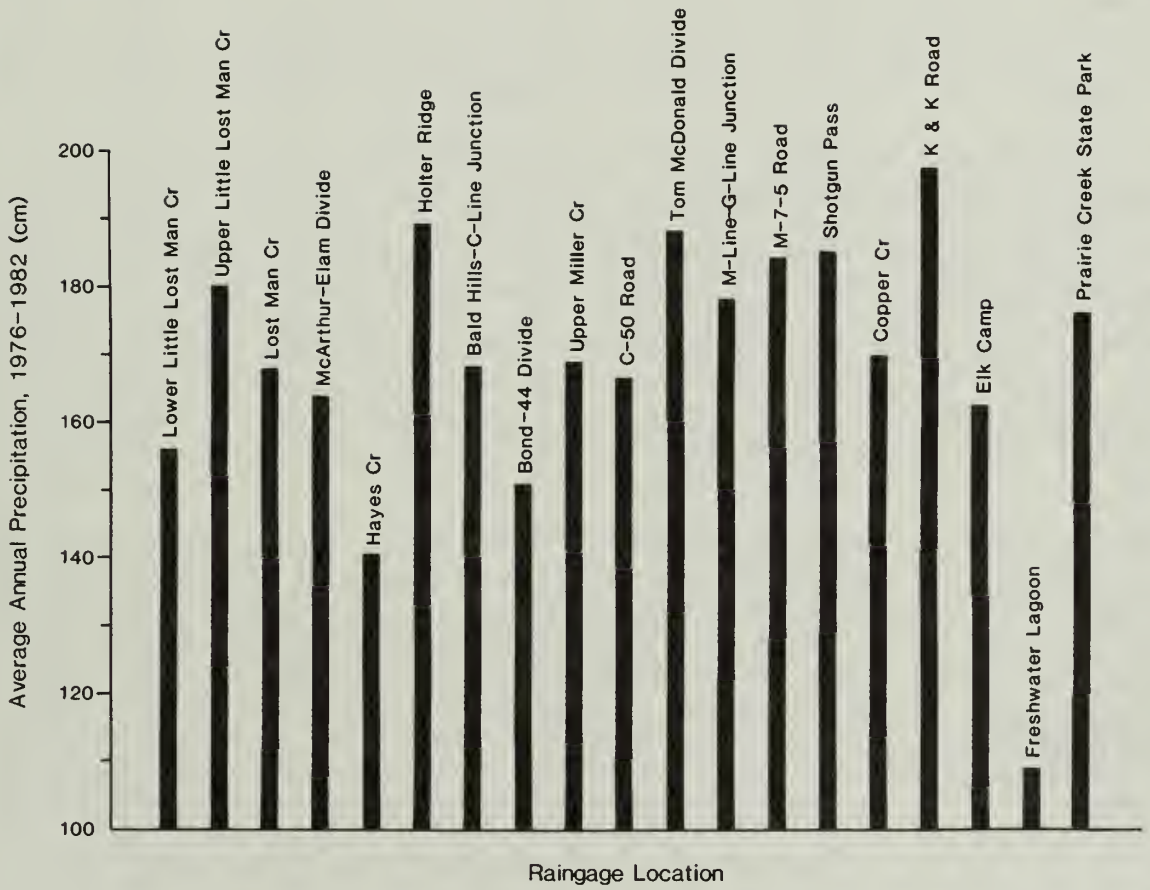

Figure 3: Average precipitation for 1976 through 1983 for Park stations.

Table 1: General Information for Park Rivers and Streams

	Drainage Area (Km^2)	Drainage Area (Mi^2)	Drainage Length (Km)	Drainage Length (Mi)	Average Gradient (m/m)
Smith River	1,640	632	N/A		N/A
Mill Creek	96	37	8.6	5.2	0.025
Klamath River	40,000	15,000	N/A		N/A
Redwood Creek	720	278	108	67	0.013
Eastside Tributaries of Redwood Creek					
1. Prairie	104.0	40.0			.01
2. Hayes	1.5	0.6	2.0	1.3	.24
3. Gans West	0.7	0.3	2.1	1.3	.30
4. Gans South	1.2	0.5	2.0	1.2	.27
5. Chris	1.2	0.5	2.1	1.3	.27
6. Oscar Larson	1.8	0.7	2.1	1.3	.27
7. Cloquet	3.0	1.2	2.8	1.7	.22
8. Miller	3.5	1.3	3.3	2.0	.20
9. Cole	0.8	0.3	1.7	1.1	.29
10. Harry Wier	7.8	3.0	4.4	2.8	.16
11. Donalson	2.2	0.8	2.5	1.6	.28
12. "G"	2.0	0.8	2.4	1.5	.30
13. Airstrip	1.1	0.4	2.3	1.4	.30
14. Slide	3.1	1.2	2.6	1.6	.26
15. Childs	0.7	0.3	2.2	1.3	.23
16. Maneze	0.8	0.3	2.1	1.3	.23
17. Copper	7.4	2.9	4.8	3.0	.18
18. Big Tree	0.8	0.3	2.3	1.4	.32
Westside Tributaries of Redwood Creek					
1. McArthur	9.9	3.8	7.5	4.7	.05
2. Elam	6.5	2.5	4.2	2.6	.09
3. Bond	3.7	1.4	3.0	1.8	.14
4. Forty Four	8.1	3.1	5.1	3.1	.10
5. Tom McDonald	18.0	6.9	7.5	4.6	.07
6. Bridge	29.5	11.4	12.9	8.0	.06
7. Elf	2.0	1.0	2.5	1.5	.29
8. Devils	18.0	7.0	8.0	5.0	.08

(67 mi), where it flows through an estuary and into the Pacific Ocean. For much of its length Redwood Creek follows the Grogan fault, which juxtaposes unmetamorphosed and slightly metamorphosed clastic sedimentary rocks to the east against metamorphic schistose rocks to the west. As a result of this fault, the 720 km² (280 mi²) Redwood Creek basin is elongated, so that most tributaries are short and steep, and drain relatively small areas (Table 1). Tributaries form a trellised drainage pattern (Fig. 2). Drainage density in the basin is 4.8 km/km² (7.7 mi/mi²). Prairie Creek is the largest tributary, draining 104 km² (40 mi²) and entering Redwood Creek 5 km (3 mi) above the mouth.

Most tributaries are low order, high gradient streams (Table 1) with deeply incised channels and narrow, discontinuous floodplains. Average stream gradients range from 0.05 to 0.30 m/m. Average hillslope gradients within these basins range from 0.25 to 0.35 m/m. Topographic relief and average stream gradient are greater in tributaries draining the eastern portion of the basin. Many tributary basins exhibit steep hillslope segments adjacent to channels and more moderate gradients at middle and lower slope positions. Incised inner valleys are particularly susceptible to mass wasting by shallow debris slides and debris avalanches.

The Klamath River has a drainage area of about 4,000 km² (15,000 m²). Placer and lode mining for gold was important from about 1850 to 1950. Chromite and copper were also mined. Although some water is used for irrigation and livestock, most of the economy in the Klamath basin depends on its forest resources. Three major hydroelectric dams in California regulate flow in the Klamath. Water projects such as Clair Engle Lake divert water from the Klamath to the Sacramento Valley. The lower Klamath is part of the Federal Wild and Scenic Rivers System, classified under recreational status. Fishing is important in the Klamath, but fish populations have declined in recent years due to several factors, including destruction of spawning and rearing habitats.

The Smith River drains 1,900 km² (725 mi²) of California and Oregon. It has 5000 km (3,100 mi) of mapped tributaries and 560 km (350 mi) of prime habitat for salmon and steelhead. It is part of the State and Federal Wild and Scenic Rivers System. Nickel, cobalt and chromium are mined in the basin. Timber is a major part of the economy in the Smith River area. Annual precipitation exceeds 300 cm (120 in) in some areas. Forty percent of the drainage has slopes greater than 50%. Several hundred major landslides occurred along the main forks and tributaries of the Smith River. A map showing the major drainages of Redwood National Park is shown in Figure 1.

4. Classification of Surface Water by Existing Uses

Waters are classified below according to their use. (P) indicates primary use and (S) indicates secondary use.

1) Public Water Supply

A. Redwood Creek (P)
B. Smith River (P)
C. Klamath River (P)

2) Non-public Water Supply

A. Prairie Creek (S)
B. Private Wells (P)

3) Maintenance of Ecosystem, General

All water resources of natural origin

4) Maintenance of Ecosystem, Species of Special Interest other than Threatened and Endangered Species

A. Klamath River
B. Smith River
C. Redwood Creek and Estuary
D. Prairie Creek
E. Emerald (Harry Wier) Creek
F. Tom McDonald Creek
G. Bridge Creek
H. Little Lost Man Creek (Research Natural Area)

5) Maintenance of Ecosystem, Threatened and Endangered Species Indigenous to Parks

A. Smith River

6) Recreational Purposes - Contact

A. All rivers and streams except as otherwise noted
B. Occasional use of estuary and lagoons
C. Occasional use of Pacific Ocean beaches

7) Recreational Purposes, Non-contact

A. All natural rivers and streams
B. Estuary (S)
C. Lagoons (S)
D. Pacific Ocean beaches

8) Agricultural, Source of Livestock Water Supply

A. Redwood Creek (S)
B. Smith River (S)
C. Klamath River (S)
D. Prairie Creek (S)

9) Disposal of Sewage Effluent

A. Redwood Creek (S)
B. Klamath (S)
C. Prairie Creek (S)

5. Water Quantity

a. Annual Discharge

Most of the park's streams are steep and drain relatively small areas. Because most of the annual precipitation occurs between October and March, winter flows are high and summer flows are low. Occasionally snow falls at the upper elevations within the park, but a snowpack rarely accumulates to any significant depth for a long duration. Snowmelt within the park has minimal effects on peak flows. The Smith and the Klamath Rivers drain larger, more mountainous areas, and hence are more influenced by snowmelt. Nevertheless, the highest flows still occur during the winter. A summary of water discharge for the major rivers in Redwood National Park is shown in Table 2. Annual peak discharges for Redwood Creek at Orick from 1953 to the present are summarized in Figure 4.

The relation of current water discharges to historic levels is somewhat unclear. Long-term discharge records are not available for Redwood Creek. There are no major diversions of its water. Nevertheless, evidence suggests that levels may have been different in the past. Lee and others (1975) formulated a rainfall-runoff model for Redwood Creek which showed a 20% increase in storm runoff from an intensively logged basin over one where no intensive logging occurred. This modeled conditions in Redwood Creek in the early 1970's and the 1950's, respectively. King (1984) found similar results from a runoff model of Redwood Creek. In addition, local residents have noted lower summer flows in aggraded reaches and extensively disturbed tributaries. These trends of higher peak flows and lower summer flows in logged basins have been documented in other areas, and may be valid for Redwood Creek (Kovner, 1956; Hornbeck and others, 1970; Rothacher, 1970; Harris, 1973; and Coats and others, 1979).

b. Water Balance

A water balance quantifies the amount of water input (precipitation) against the amount of water output (such as river runoff and evapotranspiration). A water balance was constructed for Redwood Creek for the period 1978 - 83 (Best, unpublished data). Based on available records, the balance for this period seems very close to the 36-year average. Balances for the Klamath and Smith River basins are assumed to be similar because the physiography and land use of the basins are similar. Precipitation (input) is balanced against outputs (discharge, evapotranspiration and interception). In this case the unknown quantity is interception, but it turns out to be a minor part of the balance. The percentages shown in this balance probably hold for other streams in the park; that is, three-quarters of the annual precipitation leaves the basin through river discharge.

Redwood Creek Water Balance, 1978 - 83	
Annual precipitation	1961/mm/yr
Actual evapotranspiration	536/mm/yr
Water discharge	1406/mm/yr

Table 2: Water Discharge from Park Streams, based on USGS Records

Gaging Station	Water Year	Daily Discharge (cms) Minimum	Maximum	Mean	Total Annual Discharge (cm)
Redwood Creek near Blue Lake	1973	0.10	52	5.47	1,990
	1974	0.10	105	11.61	4,240
	1975	0.08	237	9.85	3,516
(A=175.1km²)	1976	0.14	58	5.24	1,922
	1977	0.07	14	1.25	456
	1978	0.14	59	7.39	2,702
	1979	0.11	84	3.96	1,447
	1980	0.10	81	7.62	2,791
	1981	0.13	39	3.94	1,438
	1982	0.11	118	10.25	3,740
Redwood Creek at South Park Boundary	1971	0.17	334	25.74	9,390
	1972	0.40	750	27.47	10,057
	1973	0.26	156	15.15	5,913
	1974	0.23	331	34.52	12,599
(A=479km²)	1975	0.13	699	26.45	9,649
	1976	0.31	214	16.96	6,209
	1977	0.27	48	3.68	1,347
	1978	0.42	346	24.32	8,882
	1979	0.31	231	11.72	4,279
	1980	0.31	255	22.14	8,104
	1981	0.28	130	11.04	4,027
Redwood Creek at Orick	1966	0.37	963	24.86	9,070
	1967	0.54	348	29.62	10,808
	1968	0.54	343	18.80	6,882
(A=720km²)	1969	0.60	371	33.67	12,293
	1970	0.37	541	28.40	10,363
	1971	0.31	484	39.93	14,572
	1972	0.45	1,136	41.48	15,183
	1973	0.34	228	21.86	7,981
	1974	0.34	464	48.87	17,837
	1975	0.26	1,090	36.93	13,481
	1976	0.51	257	23.87	8,739
	1977	0.40	64	5.44	1,986
	1978	0.88	430	33.05	12,060
	1979	0.42	262	17.92	6,542
	1980	0.34	382	31.29	11,448
	1981	0.31	153	18.29	6,673
	1982	0.34	501	45.37	16,563
Little Lost Man Creek	1975	0.004	11.92	0.39	143
	1976	0.01	2.72	0.26	94
	1977	0.003	1.08	0.07	25
(A=8.96km²)	1978	0.01	6.34	0.39	141
	1979	0.01	3.40	0.21	76
	1980	0.01	5.80	0.33	120
	1981	0.01	5.66	0.24	89
	1982	0.008	7.31	0.49	180

Table 2: Water Discharge from Park Streams, based on USGS Records (Continued)

Gaging Station	Water Year	Daily Discharge (cms) Minimum	Maximum	Mean	Total Annual Discharge (cm)
Smith River near Crescent City (A=1,577km²)	1966	6.12	3,115	106.87	39,008
	1967	5.95	1,892	122.27	44,632
	1968	7.73	1,574	81.64	29,884
	1969	6.57	1,345	116.69	42,597
	1970	5.75	1,988	118.03	43,082
	1971	5.52	2,574	153.08	55,871
	1972	5.66	4,078	151.07	55,288
	1973	5.89	1,068	75.36	27,506
	1974	5.72	2,138	198.98	72,632
	1975	5.21	2,229	108.99	39,784
	1976	6.00	898	85.77	31,389
	1977	5.35	323	27.61	10,079
	1978	8.16	2,302	145.55	53,129
	1979	6.85	1,549	74.02	27,022
	1980	6.34	1,608	110.18	40,331
	1981	5.75	1,546	72.29	26,390
	1982	6.88	1,846	182.89	66,751
Mill Creek (A=74.2km²)	1974	0.08	81	--	--
	1975	0.07	84	4.16	1,515
	1976	0.09	35	3.06	1,115
	1977	0.10	24	0.91	331
	1978	0.08	77	5.92	2,156
	1979	0.14	54	2.89	1,059
	1980	0.09	70	3.82	1,399
	1981	0.08	49	2.69	982
Klamath River near Klamath (A=31,340km²)	1966	72.2	3,823	398	145,472
	1967	70.8	4,333	468	170,798
	1968	61.2	4,502	347	126,983
	1969	63.4	4,446	592	216,259
	1970	62.9	8,608	564	205,679
	1971	78.7	7,362	728	265,607
	1972	66.8	8,976	615	225,229
	1973	51.3	2,989	374	136,478
	1974	73.6	11,242	992	362,000
	1975	77.9	4,814	541	197,479
	1976	66.5	2,019	336	122,905
	1977	37.1	402	114	41,719
	1978	91.8	7,362	618	225,732
	1979	85.2	1,909	311	113,468
	1980	93.5	6,371	590	215,835
	1981	65.1	1,840	309	112,614
	1982	85.81	9,000	905	330,511

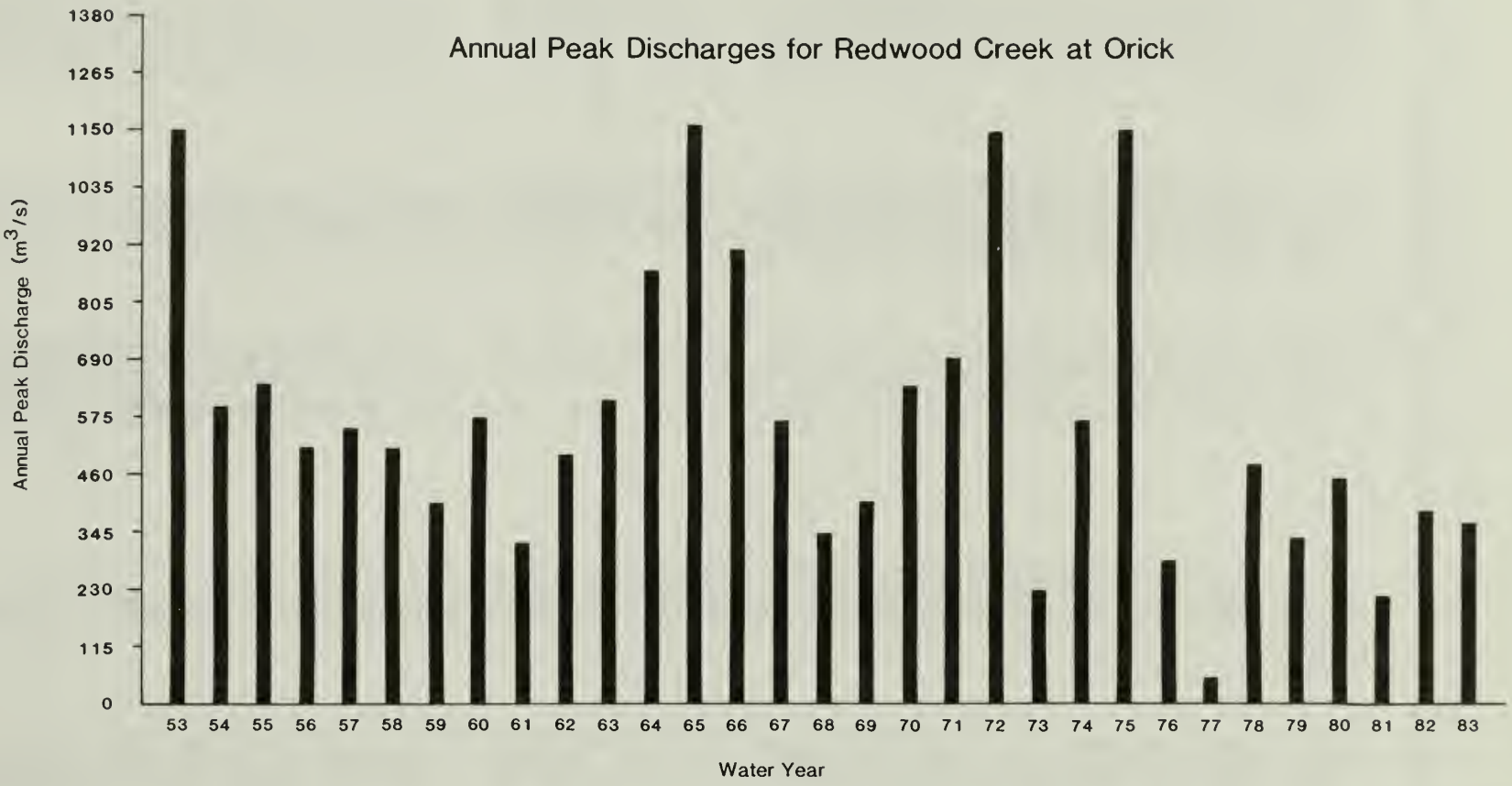

Figure 4: Annual peak discharges for Redwood Creek at Orick, 1953 through 1983.

Precipitation = interception + actual evapotranspiration + streamflow

1961 =	19	+	536	+	1406
100% =	1%	+	27%	+	72%

C. Floodplain Management

The U.S. Army Corps of Engineers has prepared floodplain studies for the lower Smith River, lower Klamath River, and lower Redwood Creek. The Draft Environmental Impact Statement and Resources Map supplement for the General Management Plan (USDI, 1979) describe and map these floodplains. In compliance with E.O. 11990 and National Park Service regulations regarding floodplains and wetlands (45 FR 35916; 47 FR 36718), the National Park Service prepares Statements of Findings for actions in floodplains and coastal hazard zones.

D. Wetland Protection

Wetland areas have been mapped by park staff as a result of vegetation mapping efforts. These maps are available for review at park offices. Primary wetlands include areas near the mouth of Redwood Creek, along Prairie Creek, northern Gold Bluffs Beach, Espa Lagoon, Richardson's Pond, Lagoon Creek and Crescent Beach. Any proposed modification of Federally-owned wetlands by the National Park Service necessitates the preparation of a Statement of Findings (45 FR 35916; 47 FR 36718).

E. Water Quality

Water quality of the Redwood Creek basin was monitored by the U.S.G.S. from 1973-1975. Data on pH, total akalinity, specific conductance, water temperature, dissolved oxygen, dissolved solids, trace elements (aluminum, cadmium, copper, iron and zinc), nitrogen and phosphorus determinations and organic carbon were collected. Samples were collected periodically throughout the year at five stations on Redwood Creek, at tributary stations and on Mill Creek. These data are listed in Iwatsubo et al. (1975) and Iwatsubo et al. (1976).

A summary is given in Bradford and Iwatsubo (1978), from which the following is taken:

"Overall, the chemical water quality of the main stems and the tributaries is excellent, suitable for most beneficial uses. Dissolved-solids concentrations range from 25 milligrams per liter in the Redwood Creek basin and 21 milligrams per liter in the Mill Creek basin during the rainy season to 139 and 49 during the dry season. Water shifts from a mixed calcium-sodium bicarbonatechloride type toward a calcium bicarbonate type from the end of the wet season to the end of the dry season. It shifts back toward a mixed calcium-sodium bicarbonate-chloride type from the end of the dry season to the end of the wet season. The pH shifts with the water type from a median value of 6.80 in the rainy season to 7.37 in the dry season. Nitrogen and phosphorus concentrations are generally too low to support nuisance algae but are high enough, in some streams, to support modest populations, particularly

in the main stem where light levels are high. Trace-metal concentrations are low, typical of clean streams.

"Evidence suggests that dissolved calcium and bicarbonate in stream water is produced by weathering of the Franciscan assemblage underlying the basins but that chlorides are transported inland from the ocean as dry fallout and spray and in rain. Exposure of the surface soils to the elements, either by logging or by natural causes such as sparse vegetation, seems to accelerate weathering, which leads to a calcium bicarbonate water type. Logging accelerates weathering most in the tributary watersheds with regoliths derived from sandstone and least in those with regoliths derived from schist; however, the data suggest that the rate of weathering in a schistose watershed can increase dramatically if soil disruption is extensive.

"Studies during storms indicated that specific conductance and alkalinity were two to three times as likely to decrease at the discharge peak in logged watersheds as in forested ones. This suggests that overland flow containing lower concentrations of soil-derived dissolved solids than flow from other sources is a larger component of peak flow in logged watersheds than in forested watersheds.

"Comparing a storm in November 1974 to one in February 1975, nitrate concentration increased significantly from November to February in a stream draining a logged watershed and decreased significantly in a stream draining a forested watershed. Then from the rainy season to the dry season, nitrate decreased in both logged and forested watersheds. This pattern suggests that soil nitrate produced by fixation and organic decomposition early in the rainy season tends to wash out of logged watersheds but be taken up on tree growth in forested watersheds. As the dry season progresses, base flow containing little nitrate enters the streams, causing a decrease in nitrate concentration. By contrast, the other plant nutrients--phosphorus, Kjeldahl nitrogen, ammonium, and dissolved organic carbon--all decreased in streams from the November 1974 storm to the February 1975 storm and changed little from the rainy season through the dry season. This pattern suggests that these materials tend to accumulate in the soil during the dry season and be washed out and diluted as the rainy season progresses. Very little reaches the water table due to soil absorption so that little appears in the base flow during the dry season."

In addition, the U.S.G.S. collects water quality data on the Klamath River near Klamath and on the Smith River near Crescent City, California. These data are published in the annual Water Resources Data of California Report. Besides the constituents mentioned above, fecal coliform, arsenic, barium, chromium, cobalt and turbidity are measured.

F. Park Biota

1. Overview

The following is a summary of information presented in the Resources Management Plan (1982). Historically, the region encompassing the present park lands was abundantly forested. Prior to 1947, 82% of the Redwood Creek

basin supported virgin coniferous forests. About nine percent of the Redwood Creek basin supported grasslands and another nine percent of the land consisted of oak woodlands. Sitka spruce dominated the forests adjacent to the ocean. Inland of the spruce forests, coast redwood dominated, with Douglas-fir, tan oak, hemlock and grand fir occurring as common associates.

With increasing elevation and increasing distance from the sea, redwoods became less abundant and Douglas-fir, tan oak, madrone and other species increased in importance. Redwood was rare beyond 10 to 15 miles inland where forests were dominated by Douglas-fir, except where serpentine soils gave rise to a specialized vegetation.

Today, 125 years since the permanent settlement of the region by Whites, this general pattern of vegetation persists. While extensive alteration of both the forests and non-forest vegetation has occurred, the general distribution of forest and non-forest vegetation is essentially the same now as described in the first written records. Prairie and oak woodlands of the Bald Hills area, however, have decreased in size since 1850.

Since 1850 more than 50,000 acres of redwood vegetation now within the park have been clearcut or selectively harvested by several methods. Additional forest land has been less modified by limited tree cutting that left a largely intact canopy as well as by prospecting, pasturage, the burning of understory and other minor disturbances.

Of the park lands subjected to timber harvest, essentially all are in some phase of forest regeneration, with native tree species dominating the second growth. Coastal and moist sites support alder and spruce, and the fast growing but short-lived alder eventually is replaced by spruce. Mesic sites away from the immediate coast support second-growth of varying ages, with redwood and Douglas-fir the dominant species but hemlock, spruce and other species are also well represented. Douglas-fir is probably over-represented in the youthful second-growth stands, but examples of second-growth redwood vegetation elsewhere suggest that redwood can be expected to reassume its natural dominance with time. One spruce stand near Crescent City was successfully converted to pasture after logging in the 1920's. The re-establishment of forest there is expected to be slower, probably passing through an old field - coastal brush - forest succession.

Other minor vegetation types include limited serpentine vegetation, chapparal, riparian forest types and near-shore and dune vegetation.

2. Rare, Threatened and Endangered Plants

Coastal bluffs, rock outcrops, streamsides, wet meadows, bogs and serpentine soils host the majority of the rare plants of Redwood National Park. In comparison heavily forested areas contain few rare plant species. The majority of the rare plants in the park occur within one harsh environment, the serpentine/periodotite rock belt stretching across northern Del Norte County. Here few nutrients are available for plant uptake because of the ultra basic (high pH) soil chemistry and its poor water holding capacity. Sparse vegetation survives in this area (Little Bald Hills) despite annual rainfall of 250 cm.

Redwood National Park's list (Table 3) of rare, threatened or endangered plants was developed by combining the following:

a. Species currently listed by the U.S. Fish and Wildlife Service as endangered or threatened (FWS 1983a).

b. Species currently under review for Federal listing as endangered or threatened (FWS 1983b).

c. Species designated as endangered or rare by the State of California (California Department of Fish and Game 1984).

d. California Native Plant Society's (CNPS) list of plants presumed extinct in California or elsewhere (List 1a, Smith and York 1984).

e. CNPS' list of plants rare and endangered in California - common elsewhere (List 1b, Smith and York 1984).

f. CNPS' list of plants rare and endangered in California - common elsewhere (List 2, Smith and York 1984).

g. CNPS' list of "Plants for Which We Need More Information" (List 3, Smith and York 1984).

A species currently under review for Federal listing as endangered or threatened (category 2 or "candidate" species) does not have legal status or protection under the Federal Endangered Species Act of 1973 (16 U.S.C. 1531 et seq). It is National Park Service policy, however, to treat candidate species as if they were listed.

Some species not on Federal lists, but only on State lists, have been included on Redwood's list. Many of the species included in Table 3 have not been noted or collected within the park. Because they have been found nearby in similar habitats, however, it is possible they would also be within park boundaries. They have been included at the recommendation of local botanists familiar with the area. The list is current as of October 1984 and is subject to change from time to time as new information becomes available.

3. Old Growth Forests

One of the prime habitats for coastal redwoods is low-lying terraces adjacent to rivers (alluvial flats) located within 10 - 15 miles of the ocean. These flats are composed of fine-grained floodplain deposits. Extremely large floods may occasionally overtop these flats and deposit fresh layers of silt on their surfaces. The fine-grained soils and abundant moisture encourages the growth of the tallest trees in the world on these sites.

Unfortunately, the proximity of these alluvial flats to rivers draining disturbed watersheds can cause problems for old-growth redwood trees. Aggradation in channel beds can accelerate bank erosion and thus directly topple streamside trees or expose their roots and weaken them. Alternatively, gravel may be deposited in riparian groves, limiting seedling establishment. Also, as the channel bed aggrades, the water table may rise and drown the

Table 3: Rare, Threatened or Endangered Vascular Plants
In or Near Redwood National Park

Taxa	Status USFWS[1]	Status CALIF[2]	Status CNPS[2]	Habitat
Bensoniella oregana (Abrams & Bulig) Morton. Oregon bensoniella	C	R	E	Heads of streams, edges of wet meadows. May be restricted to fog belt 2,000-5,000 feet. This species is probably not in the park, but should not be eliminated from consideration.
Erigeron delicatus Cronq. Del Norte fleabane	-	-	3	Rocky cliffs above rivers and streams in old-growth redwood, Douglas-fir. Known in the park.
Erigeron supplex Gray Supple daisy	C	-	1B	Occurs along Humboldt and Mendocino seacoasts. Has been collected south of the park.
Erigonum pendulum Wats. Waldo erigonum	C	-	2	Serpentine dry slopes or ridge tops, along streams or in disturbed areas, mixed evergreen forests less than 3,100 feet. Collected north of the park.
Grindelia stricta D C. ssp. blakei (Steyerm.) Keck Humboldt Bay gum	C	-	1B	Coastal salt marsh and bluffs, coastal strand, north coastal scrub. Collected north and south of park.
Lilium occidentale Purdy Western lily	C	E	1B	Former range included park lands. Collected south of park in north coastal scrub, coastal prairie.
Lilium vollmeri Eastw. Vollmer lily	-	-	3	Wet areas, serpentine. North coastal coniferous forest.
Oenothera wolfii Raven, Dietrich & Stubbe. Wolf's evening-primose	C	-	3	Coastal bluffs, gravel roadbank near coast. Known in the park.
Phacelia argentea Nels & Macbr. Sand dune phacelia	C	-	1B	Coastal strand, Del Norte to southwest Oregon. Historically collected within present park boundaries. Present status unknown.
Viola lanceolata L. ssp. occidentalis (Gray) Russell. Western bog violet	-	-	1B	Wet area, on and off serpentine, mixed evergreen forest. Has been collected north of the park.

1 - Status of species in 48 FR 34194, July 27, 1983 and 48 FR 53630, November 28, 1983. USFWS. Endangered and Threatened Wildlife and Plants; Review of Plant Taxa for Listing as Endangered or Threatened Species.

C = Candidate species currently under review for listing as endangered or threatened.

2 - Species designated as endangered or rare by the State of California. 1984. Department of Fish and Game. Endangered Plant Program, Sacramento, California.

3 - Species listed as rare or endangered by the California Native Plant Society: Smith, J. P. and R. York. 1984. Inventory of Rare and Endangered Vascular Plants of California. Special Publication No. 1 Third Edition. CNPS. Berkeley, CA.

1B = Plants rare and endangered in California or elsewhere.
2 = Plants rare and endangered in California, common elsewhere.
3 = Plants for which more information is still needed.

roots of redwoods in the riparian zone. Thus changes in the water and sediment regimes of rivers in Redwood National Park can threaten old-growth redwoods.

4. Fisheries

Anadromous salmonids are one of the most important aquatic species in Redwood National Park because they are a prominent commercial and recreational resource in northern California. Major species include steelhead trout (Salmo gairdneri), Coho (silver) salmon (Oncorhynchus kisutch), Chinook salmon (O. tshawytscha), and coastal cutthroat trout (Salmo clarkii). Other residence fish include threespine stickleback (Gasterosteus aculeatus), prickly sculpin (Cottus asper), and Humboldt sucker (Catastomus occidentalis humboltianus).

Before salmonids smolt and migrate to sea, a part of their lives are spent as juveniles in nursery areas of rivers and tributaries. After hatching, silver salmon and steelhead trout remain in the river from one to four years before entering the ocean. Thus summer low flow conditions (water temperature, availability of cover and occurrence of pools) are important in determining the survival of the young. Filamentous algae (Cladophora) serves as a substrate and energy source for aquatic invertebrates in the creek, which in turn serve as fish food organisms. Streams also provide spawning habitat for anadromous fish. Appropriate sites require proper bed material, bed stability and a lack of barriers (natural or man-made). Park staff evaluated spawning and nursery habitat for site quantity and quality in the Redwood Creek watershed (Figure 5). Limited information is available from other agencies for other rivers in the park.

Redwood Creek estuary is an especially important rearing habitat for juvenile chinook salmon and steelhead. Maximum utilization of the estuary by chinook salmon occurs in the summer. Other estuarine fish include starry flounder (Platichtys stellatus) and staghorn sculpin (Leptocottus armatus). Food of the juvenile salmonids is primarily chironomid larvae and pupae, although amphipods (Corophium spp.) are the most abundant benthic organism when estuarine conditions occur. Production of benthic organisms in the estuary is inhibited by the substrate instability and saltwater intrusion that occurs during the summer months.

Invertebrates in park waters are an important fish food. They also serve as indicators of watershed recovery. Invertebrate populations were sampled in logged and unlogged reaches of North and South Fork Slide Creek in Redwood National Park. The species present and their functional groups are listed in Table 4. This distribution of species is probably similar for other park tributaries as well.

G. Water Rights

Due to legal complexities involved with water rights, a complete analysis of the rights involving Redwood National Park will be developed later. A 10-238 is included in this report, which proposes a study on water rights issues of Redwood National Park by specialists from Fort Collins, Colorado.

TABLE 4: Summary of the Functional Group Classification and Occurrence of Benthic Invertebrates in the Logged and Unlogged Portion of North and South Fork Slide Creek, Humboldt County, Summer 1981. (From Harrington, Davis 1982)

CLASS Order Family Subfamily Genus species	Functional Group	OCCURRENCE Slide Creek North Fork Logged	North Fork Unlogged	South Fork Logged	South Fork Unlogged
ARACHNOIDEA					
Acari	Predator	x	x	x	x
GASTROPODA					
Basommatophora					
Planorbidae					
Gyraulus sp.	Grazer	x			
Unknown	Grazer	x	x		
Mesogastrapoda					
Bulimidae					
Amnicola sp.	Grazer	x	x		
Pleuroceridae					
Juga sp.	Grazer	x	x	x	x
INSECTA					
Coleoptera					
Dytiscidae					
Rhantus/Colymbetes	Predator	x	x		
Elmidae					
Heterlimnius koebelei	Collector	x	x	x	x
Lara avara amplipennis	Shredder		x	x	x
Narpus concolor	Collector			x	x
Zaitzevia parvula	Collector	x	x		x
Hydraenidae					
Hydraena vandykei	Collector	x	x		
Psephenidae					
Eubrianax edwardsi	Grazer	x	x	x	x
Staphylinidae	Predator		x		
Collembola	Collector	x			
Diptera					
Chironomidae					
Chironominae					
Rheotanytarsus sp.	Collector	x	x	x	x
Orthocladiinae					
Eukiefferiella sp.	Collector	x	x	x	x
Tanypodinae					
Paramerina fragilis	Predator	x	x	x	x
Procladius sp.	Predator	x	x	x	x
Dixidae					
Paradixa sp.	Collector		x		x
Empididae	Predator	x	x	x	x
Psychodidae					
Culicoides sp.	Predator		x	x	
Simuliidae					
Simulium sp.	Collector	x	x	x	x

TABLE 4: (continued)

CLASS Order Family Subfamily Genus species	Functional Group	OCCURRENCE Slide Creek North Fork Logged	 Unlogged	 South Fork Logged	 Unlogged
Diptera (continued)					
Tipulidae					
Limonia sp.	Shredder			x	
Tipula sp.	Shredder		x		
Unknown	Shredder		x		
Unknown 1	Unknown		x		
Unknown 2	Unknown			x	
Ephemeroptera					
Baetidae					
Baetis sp.	Collector	x	x	x	x
Centroptilum sp.	Collector		x		
Ephemerellidae					
Ephemerella coloradensis	Collector	x	x	x	
Heptageniidae					
Cinygma sp.	Grazer	x	x	x	x
Ironodes sp.	Grazer	x	x	x	x
Leptophlebiidae					
Paraleptophlebia sp.	Collector	x	x	x	x
Siphlonuridae					
Ameletus sp.	Collector		x		
Megaloptera					
Sialidae					
Sialis sp.	Predator		x		
Odonata	Predator			x	
Plecoptera					
Chloroperlidae					
Alloperla sp.	Predator	x	x	x	x
Nemouridae					
Leuctrinae					
Leuctra augusta	Shredder	x	x	x	x
Nemourinae					
Amphinemoura sp.	Shredder	x	x	x	x
Peltoperlidae					
Peltoperla sp.	Shredder		x		
Perlidae					
Calineuria californica	Predator	x	x	x	x
Trichoptera					
Brachycentridae					
Amiocentrus aspilus	Collector		x		
Micrasema aspilus	Shredder	x	x		x
Calamoceratidae					
Heteroplectron californicum	Shredder	x	x	x	x
Glossosomatidae					
Agapetus sp.	Grazer	x	x	x	x
Glossosoma sp.	Grazer	x	x		x

TABLE 4: (continued)

CLASS Order Family Subfamily Genus species	Functional Group	OCCURRENCE Slide Creek North Fork Logged	 Unlogged	 South Fork Logged	 Unlogged
Trichoptera (continued)					
Hydropsychidae					
Hydropsyche sp.	Collector	x	x	x	x
Hydroptilidae					
Hydroptila sp.	Collector	x			
Lepidostomatidae					
Lepidostoma sp.	Shredder	x	x	x	x
Limnephilidae					
Apatania sorex	Grazer	x	x	x	x
Farula sp.	Grazer	x	x	x	x
Hydatophylax hesperus	Shredder		x		x
Pseudostenophylax edwardsi	Shredder	x			
Psychoglypha sp.	Collector	x			
Odontoceridae					
Namamyia plutonis	Collector		x		
Polycentropodidae					
Polycentropus sp.	Predator	x	x	x	x
Rhyacophilidae					
Rhyacophila sp. 1	Predator	x	x	x	x
Rhyacophila sp. 2	Predator	x	x		x
OLIGOCHAETA	Collector		x		
PELECYPODA	Collector		x		

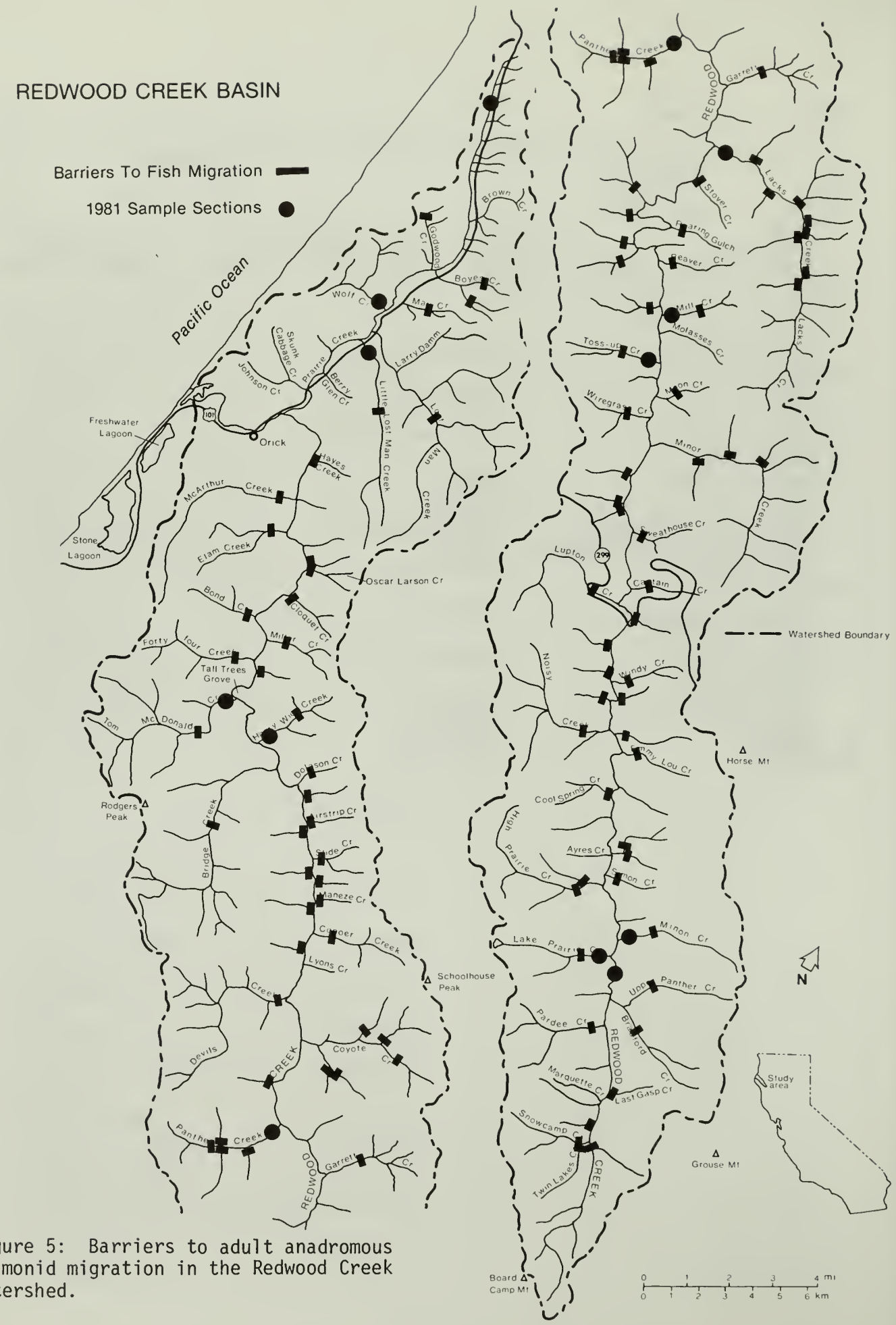

Figure 5: Barriers to adult anadromous salmonid migration in the Redwood Creek watershed.

H. Legal Jurisdictional Authority for Water Resources

The National Park Service acquired rights to park waters through legislative taking. Redwood National Park exercises proprietary jurisdiction over park waters. Activities affecting the park's waters are regulated by several state and Federal agencies. Table 5 summarizes key federal and state laws, Executive Orders and regulations affecting water management. Of primary importance is the State of California, Water Resources Control Board, which regulates water quality in Redwood National Park through the North Coast Regional Water Quality Control Board. Redwood National Park activities fall under the jurisdiction of two Water Quality Control plans prepared by the Regional Board: the Klamath River Basin (1A) (Smith River, Klamath River and coastal streams north of the Humboldt/Del Norte County line) and the North Coastal Basin (1B) (including Redwood Creek and coastal streams between Freshwater Lagoon and the Humboldt/Del Norte County line).

Water quality objectives of both plans are the same. In summary, they are to maintain existing high water quality and to preclude degradation of water quality through man's controllable activities. The key procedure for implementing these objectives is the issuance of waste discharge requirements for activities affecting water quality. Redwood National Park obtains waste discharge permits for sewage treatment systems within the park.

In regard to other activities affecting water, Redwood National Park obtains appropriate U.S. Army Corps of Engineers Section 404 permits, California Fish and Game streambed alteration permits and Consistency Determinations from the California Coastal Commission. The State Lands Commission is consulted on activities in the tidal areas up to one mile upstream of the mouths of rivers.

Table 5: Federal and State Laws and Executive Order affecting Water Management in Redwood National Park

Act	Pertinent Provision
Clean Water Act, as amended (P.L. 95-217)	Sec. 101 (g) requires Federal agencies to cooperate with State and local agencies to eliminate pollution. Section 404 requires a permit for discharge of dredge and fill material into navigable waters.
E.O. 12088 (October 13, 1978) (Federal Compliance)	Sec. 1-201 requires Federal agencies to cooperate with State, interstate and local agencies in the prevention, control and abatement of environmental pollution. Sec. 1-101 requires prevention, control and abatement of pollution from Federal facilities.
E.O. 11988 (May 24, 1977) (Floodplain Management)	Requires Federal agencies to avoid to the extent possible development and modification of floodplains.
E.O. 11990 (May 24, 1977) (Wetland Protection)	Requires Federal agencies to avoid to the extent possible adverse impacts to wetlands.
Rivers and Harbors Act of 1899	Section 10 addresses excavation and filling of navigable waters.
E.O. 22574 (Dec. 23, 1970) (Admin. of the Refuse Act Permit Program)	Requires permit for discharge of pollutants and dredge and fill activities.
Marine Protection, Research, and Sanctuaries Act of 1972, as amended	Sec. 103 requires Corps of Engineers permit for dumping dredged material into ocean waters. Sec. 102 requires EPA permit for dumping other material into oceans.
Safe Drinking Water Act, as amended	Requires EPA to establish primary and secondary drinking water standards. Sec. 1447 requires Federal agency compliance with Federal, State, and local drinking water requirements.
Coastal Zone Management Act of 1972	Sec. 307(c) (1) requires Federal agencies to be consistent with approved State managment programs.

Table 5: Federal and State Laws and Executive Order affecting Water Management in Redwood National Park (Continued)

Act	Pertinent Provision
Fish and Wildlife Coordination Act	Urges consultation by Federal agencies with states regarding impact of projects on fish and wildlife.
California Fish and Game Code	Sec. 1601-1606 require permit for lake, river or stream bed alteration.
Porter-Cologne Water Quality Control Act	Sets overall objectives for protection and enjoyment of State waters. Issuance of Waste Discharge permits provided in Article 4.
California Coastal Act	Article 4 established policies for protection of the marine environment, including coastal wetlands, lakes and estuaries.

I. Park Potable Water Supply Systems Summary

Location/ Facilities Served	Raw Water Source	Treatment	Remarks
Hiouchi Q1196 Q1056 B1151	Myrtle Creek		Big Rock Community Services District Public Water System
Crescent City Headquarters	City		Municipal Public Water System City of Crescent City
Flint Ridge Campground	Spring	Chlorine	3,000 gal reservoir - NPS
De Martin Campground	Springs	Chlorine	3,000 gal reservoir - NPS
Redwood Ranger Station B1050 Q1051 Q1052 Q1053 Q1054 Q1055	Wells		Redwood Park Community Services District Public Water System
Wolf Creek Compost Site Outdoor School	Well	Chlorine	135' well drilled 8/74 - NPS
Prairie Creek	Well	Softener	70' well drilled 1/73 - NPS C L O S E D - out of service, to be dismantled and capped in FY85
Enderts Beach North District Ranger	Cushing Creek	Chlorine	Surface system - NPS Scheduled well FY85
Orick Orick Information Station	Well		Public Water System Orick Community Services District

I: Park Potable Water Supply Systems (Continued)

Location/ Facilities Served	Raw Water Source	Treatment	Remarks
Hiouchi	Spring	Chlorine	C L O S E D - Dismantled in 1982, NPS
Lagoon Creek Lagoon Creek Picnic Area	Well	Chlorine	Submerged pump - NPS
Enderts Beach Q1124 Crescent Beach Area	Well	Chlorine	NPS
Howland Hill Outdoor School	Well	Chlorinator	12" pipe casing in grnd approx 27 ft with gas pump NPS
Hiouchi	Spring	Chlorine	C L O S E D Dismantled in 1982, NPS
Hiouchi Q1180	Well	Chlorine	12" pipe casing in grd NPS
Orick Old Zuber Residence	Spring	N/A	600 gal holding tank C L O S E D Dismantled in 1980, NPS
Klamath Requa Maint Area (Salt Creek)	Surface Salt Creek	Filtration Chlorine Microfloc	Public System - NPS
Lane Ranch Residence	Spring	Chlorine	NPS

J. Park Waste Treatment or Waste Disposal Systems Summary

Table 4: Park Waste Disposal Systems

Location	Type Treatment/ Disposal	Capacity
Headquarters - Crescent City	City - Activated Sludge	
Requa Facilities and Housing	Activated Sludge	Design 21,000 gpd Present use 9,000 gpd
Lagoon Creek Picnic Area	Septic Tank	1,200 gal.
Klamath Beach Road Residences	Septic Tank	Tanks destroyed in 1982
Superintendent's Quarters	Septic Tank	1,200 gal.
Hiouchi Ranger Residence	Septic Tank	
Enderts Beach House	Septic Tank	1,200 gal. 150 ft. of leach line
Redwood Ranger Station	Package Plant	Design 7,000 gpd
Hiouchi Information Station	Septic Tank	4,000 gal.
Youth Hostel (De Martin House)	Septic Tank	
Hiouchi Ranger Interpreter Office	2 Separate Septic Tanks	2 ea 750 gal. ea. Tank has 10 cu. ft. disposal pit
Hiouchi Residence #1180	Septic Tank	1,200 gal.
Redwood Creek Information Station	Septic System with Mound Disposal	Under Construction
Lane Residence	Septic Tank	1,200 gal. 150 ft. of leach line
Wolf Creek Trailer Residence	Septic Tank	1,200 gal. 100 ft. of leach line

J: Park Waste Disposal Systems (Continued)

Location	Type Treatment/ Disposal	Capacity
South Operation Center	Septic Tank	To be replaced with a new septic system Approximately 2 ea. 1,200 gal. in tandem with 200 ft. of leach line
Lady Bird Johnson Grove	Chemical Toilets	6 ea. Wastes are composted
C-Line - Tall Trees Trailhead	Chemical Toilets	4 ea. Wastes are composted
Tall Trees Grove	Pit privy	To be replaced with compost toilet 1 tank and 1 toilet
Orick Information	Septic Tank - Private Leased Facility	
Wolf Creek Compost Site	Holding Tank and Leach Field	1,200 gal.
Wolf Creek Outdoor School Grey Water Only	Grease Trap and Leach Field	60 gal. and 150 ft. of leach line
Lost Man Creek	Chemical Toilets	4 ea.
Howland Hill Outdoor School	Chemical Toilets Single tank, two toilets	To be replaced with compost toilets
Crescent Beach	Chemical Toilets	6 ea.
Wolf Creek Outdoor School	Non-flush Chemical toilets	6 ea. To be replaced with flush-type with central holding tank
Klamath Overlook	Chemical Toilets	4 ea.
Redwood Creek Trailhead	Chemical Toilets	4 ea.

J. Park Waste Disposal Systems (Continued)

Location	Type Treatment/ Disposal	Capacity
Redwood Creek Picnic Area	Chemical Toilets	1 building with 4 units Central holding tank approx. 2,000 gal.
Flint Ridge Campground	Compost Toilet	Single tank with one toilet
De Martin Campground	Compost Toilet	1 ea.
Nickel Creek Campground	Compost Toilet	1 ea.
Arcata Office	City - Municipal Treatment	

K. Diversions of Park Waters

There are several diversions of water originating on park lands for other uses. Some of these water diversions are covered by Special Use Permits, others by revestment through final settlement documents. Known water diversions are tabulated as follows:

Water User	Type Usage	Remarks
Rellim Redwood Company	Water Diversion	Special Permit (8480-225)
Gewell L. & Leah Floyd	Residential Use	Special Permit (8480-202)
Carl Peterson	Residential Use	Special Permit (8480-203)
Selma Dixon	Residential Use	Special Permit (8480-204)
Robert Kirby	Residential Use	Special Permit (8480-205)
Dean & Susan Davidson	Residential Use	Special Permit (8480-206)
Regan & Joyce Huyck	Residential Use	Special Permit (8480-210)
Cal. Dept. Parks & Recreation	Water Pipeline	Special Permit (8480-214)
Massel C. Fortain	Water Line from Stream	Special Permit (8480-190)
Rellim Redwood Company	Water Diversion	Special Permit (8480-200)
Rellim Redwood Company	Water Diversion	Special Permit (8480-166)
Don & Stacy Waterson	Storage & Distribution Systems	Special Permit (8480-170)
Joseph S. Romanini	For Cattle Operations	Lifetime estate revestment Settlement agreement. Civil No. C-78-2252 MHP (N.D. CA).

III. PARK-SPECIFIC OBJECTIVES FOR MANAGEMENT OF AQUATIC/WATER RESOURCES

A. Goals

To restore or maintain natural aquatic and riparian environments in which physical, chemical and biologic processes function with as little artificial influence as possible, and to inform all visitors and employees of riparian and aquatic resources, hazards and restrictions.

B. Objectives

1. To restore watersheds damaged or disturbed by logging or road construction to pre-disturbance conditions, wherever possible.

2. To inventory and classify aquatic environments by physical and chemical characteristics and biotic communities present.

3. To maintain long-term monitoring stations in representative aquatic environments to record water and sediment discharge and to document changes and trends in physical and chemical characteristics and biotic communities.

4. To locate and document the magnitude and direction of changes in aquatic environments which are caused by upstream land use activities on private lands or by management activities, and to develop and implement management programs to mitigate those activities.

5. To understand the rehabilitation potential of individual streams and the Redwood Creek watershed as a whole in terms of fisheries, and to develop management alternatives for fisheries restoration and maintenance.

6. To monitor recovery of fishery resources in streams within the Redwood Creek watershed.

7. To investigate the importance of cold pools to rearing juvenile salmonids within the mainstem of Redwood Creek.

8. To provide background data necessary for development of rehabilitation alternatives for the Redwood Creek estuary, and to monitor effectiveness of management actions in terms of estuarine productivity when rehabilitation techniques are implemented.

9. To monitor the quality of water entering and leaving the park with regard to compliance with local, State and Federal standards.

10. To comply with State and local water quality requirements at the park's water and sewage systems.

11. To acquire sufficient knowledge about the park's water quality and to provide information for State and local water management planning.

12. To detect and evaluate conditions or characteristics of external influences, such as acid precipitation.

13. To recognize aquatic conditions that are potentially hazardous to human health and safety, to implement programs to advise visitors of health hazards and to take corrective action where the cause is not natural.

14. To understand indirect stream influences upon streamside vegetation and other resources which result from human activities, such as the effect of aggradation on alluvial redwood groves.

C. Specific Management Problems

1. Effects of Upstream Land Use Activities on Downstream Park Resources

The major rivers running through park lands originate outside of park boundaries. Land use activities upstream of park boundaries, such as logging, road construction, grazing and mining or development, have adversely affected park resources. Such adverse effects include increased peak flows, increased sediment loads in rivers, a higher incidence of bank erosion, aggradation of channel beds, destruction of pool-riffle sequences, a decrease in the available streamside shade canopy and an increase in water temperature. These changes can damage or kill old-growth redwood trees growing along streams and can result in reduced fish populations.

It is necessary to know how much sediment is entering park waters from upstream sources, when the most critical changes occur and what can be done to prevent or ameliorate damage to park resources from these effects.

Other problems that may affect park waters are the changes in water quality due to sewage disposal, herbicide spraying and runoff from pasture land upstream of park boundaries. Such activities may pose a health problem for visitors in the park who drink and swim in park waters downstream of the potential pollution sources.

2. Effects of Watershed Rehabilitation Program on Water Resources

In 1978, Redwood National Park was expanded to include 36,000 acres of logged land. A watershed rehabilitation program was initiated to control erosion. A main thrust of the rehabilitation program has been to excavate road fill material from stream channels and reconstruct channels to mimic pre-road conditions. During the first few years after rehabilitation work, newly excavated channels adjusted to carry the available water and sediment loads supplied to them. In addition, where the road network diverts water from its natural course and causes gullying, these problems have been corrected. The Watershed Rehabilitation Plan (1981) gives details of the sites, projects and schedule of work.

It is necessary to monitor these stream channels to determine how much sediment was removed, how much was prevented from eroding and entering streams and how channels have adapted after rehabilitation. There may be an initial increase in sediment transport after rehabilitation as streams adjust to new conditions.

Many of these streams are too small to support fish, but they contribute sediment to larger streams that do have fish. The effects of rehabilitation on aquatic organisms is being evaluated.

3. Management of Redwood Creek Estuary

Since 1953, the Redwood Creek estuary changed drastically in response to several large floods, increased sediment loads and the construction of flood levees in 1968. With streamflow confined between levees, the former embankment partially filled with sediment, reducing the volume of aquatic habitat. Another result of channelization was that riparian vegetation, which supplies nutrients, reduces instream temperatures and provides streamside protection for fish, was destroyed. During summer low flows, a sand berm builds across the mouth of Redwood Creek and forms an embayment that serves as rearing habitat critical for juvenile salmonids. In the past, private landowners breached the sand berm to drain the embayment, reducing available summer habitat for juvenile salmonids.

Management actions must be designed and evaluated to maintain rearing habitat and prevent flooding of private property resulting from natural embayment formation. Fish populations must be monitored to determine summer utilization levels in the estuary.

4. Effect of Herbicide Spraying on Park Waters

A common practice on logged lands upstream of park boundaries is to spray recently harvested plots with an herbicide to increase conifer production. Depending on the spraying techniques and the area, residual herbicides may enter park streams. Some park streams are used for human consumption (see Classification of Surface Waters, Section II.B.3). If herbicide concentrations are high enough, damage to aquatic organisms can occur. The most commonly used herbicide is 2, 4-D.

Monitoring of herbicide levels in park streams during and after spray operations would be beneficial to detect any levels above the prescribed amounts in park waters.

5. Effect of U.S. Hwy. 101 Bypass Construction on Park Streams

In 1984 construction began on a 12 mile, 4-lane bypass of U.S. Hwy. 101 around Prairie Creek Redwoods State Park. Large road cuts and fills on unstable soils pose potential erosional problems which may affect May, Boyes, Brown and Prairie Creeks. Increased sedimentation could reduce the aquatic productivity of the streams, with a resulting net loss to fisheries. Specific erosion control measures are planned for the construction sites to limit adverse impacts from the bypass.

Biological monitoring of highway construction effects is planned. In conjunction with instream biological monitoring, quantification of hillslope erosion is necessary to determine the amounts and timing of sediment input to streams. The California Department of Transportation will monitor surface erosion, but an evaluation of slope instability, another important source of sediment, is needed. The different segments of the monitoring program could then be integrated to provide a whole picture of erosional and biological impacts of highway construction on park streams.

6. Restoring Fisheries Habitat

The mainstem of Redwood Creek has been extensively altered in recent years due to increased sedimentation, bank erosion and streamside landsliding. As a result, fisheries habitat was severely impacted, both in the mainstem and in tributaries. The potential for restoring streams that historically supported large fish populations needs to be studied. Cold pools form in the mainstem of Redwood Creek and provide juvenile salmonid rearing habitat in an otherwise inhospitable stream environment. Cold pool investigations will provide information on how these pools form and how they can be enhanced for fish habitat.

7. Gasquet Mountain Mining

The California-Nickel Corporation has proposed a cobalt-nickel mine and processing plant on Gasquet Mountain, 10 kilometers northeast of the park. Approximately 2,300 acres would be mined over a twenty year period (or about 5.2 million tons of laterite soils per year). An on-site processing plant would use a sulphuric acid leach procedure to extract cobalt, nickel, chromium and manganese from the soil. Energy would be supplied through an on-site, coal-burning power plant. High sulfur coal would be trucked to the site from Coos Bay, Oregon. Water would be supplied from a series of dams on a tributary of the previously undammed Smith River.

Water quality problems would originate during mining, processing and tailing disposal. Mining would generate fugitive dust and particulates which could increase stream turbidity during winter storms. Processing could result in an accidental spill of sulphuric acid into a water course. Disposal of tailings could result in groundwater contamination by leaching of heavy metals. Another potential problem is the possibility of failure of disposal site dikes.

Redwood National Park objectives have been to work with the local, State and Federal agencies responsible for permitting the project, in an attempt to insure water quality standards are met, to insure proposed mitigation and monitoring is in fact implemented and to ultimately insure downstream park resources would not be adversely impacted.

8. Sewage Treatment

Waste water from Redwood National Park facilities is handled in one of five ways, depending on the location and size of the facility (see Table 4). Effluent from the Crescent City park headquarters and Arcata office are treated at municipal plants. The Requa maintenance facility and the Redwood Ranger Station have their own, on-site treatment plants. Other facilities have either on-site septic tanks and leach fields or chemical-type vault toilets. Many of Redwood's visitor facilities (trailheads and picnic areas) are relatively small (10 to 15 cars), are remote, lack a reliable water source or would have technical problems with on-site sewage disposal. As a result, self-contained chemical toilets are used at these sites. The toilets use a formaldehyde-based inhibitor. Unless the storage tanks in the toilet or the waste transport truck fails, there is no possibility for a spill of the

chemical toilet waste. Effluent from the chemical toilets is trucked to the park's Wolf Creek Compost Facility where it is mixed with sawdust and composted to achieve tertiary treatment. Backcountry facilities are served by either pit or self-composting toilets. Self-composting toilets are being installed in newer or more heavily used backcountry sites.

Output from sewage facilities will be monitored for environmental impacts, such as downstream nutrient enrichment. Other factions monitored may include fecal bacteria, chlorophyll, dissolved oxygen, chloride, pH, conductivity and indicator organisms.

Water quality problems resulting from these treatment systems are rare when they are operating effectively. Redwood National Park's objectives are to insure that State and Federal water quality standards are met or exceeded and to insure that park waters are not degraded. To this end, monitoring of these systems, as prescribed by State and local regulations, occurs on a routine basis.

9. Acid Rain

No specific acid precipitation problems are known for Redwood National Park, however many redwood trees exposed to northwesterly winds display differential die back of upper foliage. Because of the park's coastal setting and prevailing wind direction, it has been assumed that ambient precipitation is of the highest natural quality and that rainfall in the park could be used as a baseline for other areas influenced by continental air pollution. The recent increases in global forest damage due to acid rain suggests that some effort should be made to identify the chronology and causes of recent tree crown die-back in and near the park.

As part of a national acid rain monitoring program sponsored by the Institute for Ecosystem Studies at the Cary Arboretum at the New York Botanical Gardens, a monitoring station was established in Redwood National Park. Rainfall samples are tested monthly by Humboldt State University students.

10. Diversions and Dams

A number of man-created or enhanced stock or log ponds are scattered throughout the park. Most of the stock ponds are in the Bald Hills area and are remnants of the previous cattle ranching operations. Most of these have been removed in conjunction with nearby watershed rehabilitation projects. The remainder will be recontoured on an equipment-available basis.

The log ponds (Richardson's Pond, Lagoon Creek) are adjacent to former mill sites and have artifically high water levels due to small earthen or wooden dikes. Both ponds will be evaluated for removal; however, they do contain wetland habitat and two endangered species of snails may inhabit the Richardson's pond area. A survey will be conducted and an environmental assessment will be prepared during the evaluation. In addition, a 1972 agreement with Del Norte County regarding the transfer of Lagoon Creek to the Federal government requires fishing access be provided until 1993.

IV. MANAGEMENT ACTIONS

A. Monitoring

1. Long-term Monitoring of Water Resources

Long-term monitoring will be conducted through a cooperative U.S. Geological Survey and National Park Service program on three Redwood Creek stations and on four tributaries to Redwood Creek. Water discharge suspended sediment and bedload are measured at these stations. In addition, the U.S.G.S. operates gaging stations on the Klamath and Smith Rivers, and data from these stations are available through annual U.S.G.S. publications. Water quality has been monitored in the past for several park streams, so some background information is available (see list of references).

The following is a list of monitoring elements in the U.S.G.S.-N.P.S. cooperative program:

a) Mainstem stations:

1) Redwood Creek near Blue Lake:
Continuous Water Discharge
Daily Total Load Samples, October 1 - April 30.

2) Redwood Creek above Panther Creek:
Continuous Water Discharge
Monthly Total Load Samples, October 1 - April 30.

3) Redwood Creek at Orick:
Continuous Water Discharge
Daily Total Load samples, October 1 - April 30.

b) Tributary Stations:

Panther, Lacks, Coyote and Little Lost Man Creeks:
Continuous Water Discharge
Monthly Total Load Samples, October 1 - April 30.

c) Precipitation:

1) One rain gage in upper basin (daily readings).
2) Storage rain gages throughout basin (monthly readings).
3) Continuous recording gages (15 minute readings) at selected locations within the park.

d) Groundwater Monitoring

Thirteen piezometers were established on alluvial flats at and upstream of the Tall Trees Grove in cooperation with the U.S.G.S. They monitored groundwater levels throughout the year, and will be related to surface water, channel bed elevations and tree mortality. These were replaced in 1984 by five NPS piezometers in the same locations.

e) Channel Bed Elevations

Channel configurations are monitored by annual surveys of 50 main channel cross sections and over 30 tributary cross sections. Data on bank erosion, changes in streambed elevation (aggradation or degradation) and changes in bed material size and lithology are collected at each station.

2. Monitoring of Watershed Rehabilitation Projects

The effects of watershed rehabilitation projects on water resources are monitored in several ways:

a) Over 420 tag line cross sections document changes at 163 stream crossings on 33 rehabilitation sites where in-stream excavations occurred between 1979 and 1984.

b) Over 300 additional stream crossings are qualitatively monitored through sequential photo-documentation.

c) Cross sections and longitudinal profiles are surveyed on Emerald, Copper and Bridge Creeks.

d) Seventeen small streams, ranging in size from 10 to 300 ha, are gaged during winter high flows.

e) Over 100 piezometers monitor groundwater levels on eight potential debris flow locations. Sixteen of these are continuous recording stations; the remainder are checked periodically.

f) Surface erosion from rehabilitation sites was monitored with 17 sediment troughs on five types of sites.

g) Precipitation is measured with six storage rain gages and two continuous recording gages located throughout the park (see Appendix A).

3. Groundwater Monitoring

Groundwater wells were installed on several alluvial flats along lower Redwood Creek to monitor groundwater levels. Five were originally located on the Tall Trees Grove in 1976, but two were subsequently destroyed by falling limbs. The remaining three are still active. Three more wells are located 2 km upstream of the Tall Trees Grove. In 1978 eight wells were installed near Harry Wier (Emerald) Creek. Five of these are instrumented to provide 15-minute readings and the remaining three are checked periodically. Summer low flow levels are the critical data to collect, because they can directly affect the health of riparian old-growth redwood trees. In 1984 these mechanical recorders were replaced by a network of five pressure transducer-electronic data loggers operated by the N.P.S.

4. Fisheries Monitoring

a) Redwood Creek Estuary

The estuary is monitored to assess juvenile salmonid utilization of the estuary and salmonid growth. Seining and sampling fish populations occur throughout the summer months when most salmonids utilize the estuary.

b) Long-term Fish and Invertebrate Monitoring

A few permanent monitoring sites were established throughout the park. New sites will be established in streams as time and budget permit. Monitoring of fish and invertebrate populations at these sites will be dependent upon fiscal restraints.

B. Management

1. Facility Design

Facilities will be designed, located and maintained for minimum impact on the aquatic environment. As technologies improve, existing structures will be reevaluated for upgrade as a means of further reducing environmental degradation. Whenever existing facilities are found to be causing unacceptable impacts, funds will be sought to correct the problem. If necessary, the facility will be closed.

2. Land Use Activities Upstream of Park Lands

Park management will continue to provide input and contribute suggestions to private landowners and other agencies whose land use activities may impact park resources. Input may take the form of timber harvest reviews, cooperative agreements, reviews of environmental documents, County hearings, informal discussions with landowners and reviews of local and State water quality standards.

3. Visitor Management and Education

Visitors will be informed about Giardia and other water contaminants, and methods for treating water prior to consumption will be recommended. Such information will be provided at visitor contact stations and in the park's newspaper, and printed information will be included with Backcountry Use Permits. Camping is prohibited in certain areas, such as Redwood Creek at the Tall Trees Grove, and will continue to be closed to protect riparian resources.

4. Participation in Establishment of State and Local Water Quality Standards

Park staff will participate in the revision or development of State and local water quality standards. Personnel will seek standards that are realistic and compatible with NPS objectives to restore and maintain acceptable water quality. Standards for NPS waters must not only consider human health and safety but also the protection of park resources.

5. Estuary Water Levels

Water levels in the estuary will be managed to provide juvenile salmonids with

summer rearing habitat, and at the same time prevent flooding of adjacent pasture lands. Management alternatives include modifying the present flood levees with floodgates or spillways, controlled breaching of the spit, dredging parts of the estuary or no action.

C. Research

1. Estuary Research (RM-19*)

Research would continue into physical and biological processes occurring in the Redwood Creek estuary. This is necessary to provide data for the development of long-term rehabilitation alternatives and to monitor the effectiveness of interim management. Basic hydraulic engineering analyses of long-term alternatives will continue, with the involvement of the U.S. Army Corps of Engineers.

2. Redwood Creek Nursery Area Study (N-70)

All of the species of anadromous fish in Redwood Creek spend a rearing period in freshwater before entering the ocean. This rearing period varies from three to four months to as much as four years depending upon species. Availability and quality of nursery habitat determines the availability of juvenile fish to survive this critical period in their life history. Increased sedimentation in streams has severely impacted nursery habitat in the Redwood Creek watershed. Studies undertaken to determine the quantity, quality, and distribution of nursery habitat within the Redwood Creek basin found that many tributary streams are not availabile to anadromous salmonids either for spawning and/or rearing. Besides degradation of habitat by erosion-caused sedimentation, many barriers to upstream migration exist near stream mouths, both natural and man-caused, and reduced summertime flows and increased water temperatures severly impact rearing habitat. Initial surveys revealed that within park boundaries only three Redwood Creek tributary streams (excluding Prairie Creek and its tributaries) are free of upstream migration barriers but even these have severely degraded rearing habitat.

Continued research will refine existing information such that restoration alternatives developed for any one individual stream will complement, rather than duplicate or exclude, specific stream habitat characteristics that will make the greatest contribution toward fisheries restoration in the Redwood Creek basin as a whole.

3. Fisheries Habitat (N-85)

Erosion and sedimentation damaged fish spawning and rearing habitat in different ways and to varying degrees within individual tributary streams. Stream surveys were conducted to identify potential spawning sites, rearing area availability, type and quality of cover and fish food availability. Permanent sampling sites were established for long-term monitoring of stream conditions. Physical and biological characteristics as well as stream

*Numbers refer to project numbers listed in the Resource Management Plan.

stability of sampling sites were recorded. Stream stability was an extremely important characteristic affecting the duration and cost-effectiveness of management measures designed to improve spawning and rearing habitat. Because many streams are unstable, having constantly readjusting channel, riffle and pool locations, widely used fish enhancement measures like gabion weirs or egg hatch boxes would not effectively improve fisheries in Redwood Creek. Also, these enhancement measures do not necessarily restore fisheries, as their goal is generally to maximize production, whereas the goal of the rehabilitation program is the restoration of the aquatic community, not favoring one species or group of organisms over another. The most effective restoration alternatives will be those specifically tailored for individual streams based on existing habitat quality information derived from stream surveys.

4. Cold Pools (N-70)

During Redwood Creek fishery habitat studies, the existence of cold pools was discovered. These pools serve as summertime habitat for juvenile salmonids. When the mixing of cold groundwater with mainstem water was retarded by a gravel bar or large organic debris, a cold pool formed. During summertime low flow conditions, mainstream temperatures increased to levels harmful to juvenile fish. Cold pools provide sanctuaries from elevated summertime water temperatures and therefore provide important nursery habitat. Cold pool research was designed to investigate the distribution, abundance and use by fish of naturally occurring cold pools. This research revealed that conditions favoring cold pool information occurred infrequently. During the summer 1982, only three cold pools were found in the lower 18 miles of Redwood Creek. Because of elevated mainstem temperatures, these three cold pools encompassed almost all of the quality nursery habitat available in the creek mainstem. Continued research will investigate the formation and maintenance of cold pools and further document their importance to juvenile fish. Additionally, the necessity of developing measures to ensure protection of these critical habitats will be considered.

5. Groundwater (N-47)

In 1975, in cooperation with the U.S.G.S., a network of groundwater wells was established in alluvial groves along Redwood Creek to examine the relationship between stream bed elevation and damaged streamside trees. Wellwater levels, water surface elevation and alluvial features were mapped and surveyed. Research is continuing on patterns of groundwater fluctuations and its relationship to the health of old-growth redwood trees.

6. Sediment Sources and Transport (N-40)

Severe erosional problems have occurred in the Redwood Creek basin due to intensive land use and several large storms. As a result, large quantities of sediment were deposited in Redwood Creek, threatening riparian and aquatic resources. Research continues to inventory erosional problems, sediment sources and sediment transport characteristics in the Redwood Creek basin. How long sediment problems will remain and what can be expected in the future are major questions that need to be answered.

7. Coastal Erosion Processes (N-98)

Elevated sediment yields from north coastal streams have had an unknown effect on riverine estuaries and coastal, nearshore landforms and ecosystems. As accelerated continental sediment production declines, there will likely be gradual or episodic changes in many of the coastal beaches and nearshore areas. Identification of early historical conditions will help delineate shorelines which may be most susceptible to natural adjustment or which have reacted to past changes. Expensive mismanagement can be avoided if such changes are anticipated or at least expected.

8. Mill Creek Evaluation (N-106)

The effect of upstream land use practices on park resources in the Mill Creek basin is unknown. A series of maps outlining the geology, road systems, erosional problems and monitoring stations in the basin will be compiled. Data from eleven cross sections within the basin will be analyzed for changes in channel bed elevations and bank erosion over time. Possible threats to park riparian and aquatic resources will be evaluated.

9. Physical Control of Fisheries Habitat (N-103)

Channel-forming processes in tributaries that are important to fisheries will be evaluated. The relations between large roughness elements, organic debris, channel bed material and pool-riffle formation will be studied. The effects of fluvial processes (flooding, bank cutting, channel scour and deposition, battering of riparian vegetation and the stability of log jams) on aquatic habitat will be assessed. Fluvial processes in an unlogged watershed will be documented for comparison.

10. Cooperation With Educational Institutions

Students from Humboldt State University and other colleges and universities often choose study projects and thesis topics on park-related matters. These include a large range of subjects, many of which involve water resources. Aquatic invertebrates, fisheries, stream processes and groundwater have all been investigated in the past and additional studies will occur in the future.

V. MINIMUM STANDARDS

At minimum standard, the aquatic/water resources program will retain the ability to detect and evaluate changes in aquatic systems resulting from management actions, upstream activities or visitor use. It will recognize water which is unsafe to drink and identify inconsistencies between ambient conditions and water quality standards.

Table 6: Standards and Reponsibilities

Components	Standards	Responsibilities
Health	Areas that management suspects (based on heavy visitation) as being biologically unsafe to drink will be tested for for fecal coliform and fecal streptococcus using a mimimum of two replicates taken during late summer, and when possible, one day after a rain, and the public using such areas will be advised of unhealthy conditions	Tech. Services (monitoring) Protection (advise public of hazards)
	Recognize environmental conditions that cause waters to be unsafe for consumption	Maintenance Tech. Services (monitoring) Protection (advise public) Safety (prepare brochures)
Park Mgmt.	Streams associated with park facilities with any potential to pollute will be monitored at a minimum of one station both upstream and downstream of the site with a minimum sampling of once during the spring, late summer, and during or immediately following a major fall storm. A minimum of two replicates will be sampled for fecal coliform, fecal streptococcus bacteria, and nuturients. Every five years additional sampling shall include major constituents and other constituents appropriate for the site (e.g. pesticides, heavy metals, etc.)	Maintenance Tech. Services

Table 6: Standards and Responsibilities (Continued)

Components	Standards	Responsibilities
Standards	All major streams flowing either into or out of these Parks will be sampled.	Tech. Services
Long-term Monitoring of Natural Systems	All natural aquatic systems need to be inventoried and classified on the basis of chemical composition, physical characteristics, and biota.	Research/Tech. Services
	A minimum of two long-term monitoring stations on the mainstem of Redwood Creek (upstream of park boundaries and at the mouth of Redwood Creek) will continue to monitor water and sediment discharge. A minimum of two tributaries (one logged, one pristine) must also be monitored for the same constituents.	Research/Tech. Services
	Estuary water levels will be managed to provide optimum rearing habitat without flooding adjacent, privately owned lands, until a long-term solution is implemented.	Res. Mgmt.

VI. PROGRAMMING SHEET

The following table summarizes the on-going and proposed projects that deal with water resource management problems in Redwood National Park. Many of the projects are also included in the Natural Resources Management Plan, and where this is the case, the identifying number from that plan is used in Table 7. Since the last revision of the Natural Resources Management Plan in April 1984, some project costs have been revised and additional projects proposed. As a consequence, figures in Table 7 may not be identical to those in the Natural Resources Management Plan. These changes will be incorporated in future revisions of the Natural Resource Management Plan, however.

Table 7: Water Resources Management Planning Sheet

NRMP No.	Project Title	Project Type	NRMP Priority Number	10-237 (10-238) Number	Funding Status	Program Costs (in $1000's) 1986	1987	1988	1989	1990
N-40	Sediment Source & Transport	Res	3		1	87	87	87	87	87
					2	0	0	0	0	0
N-41	USGS Stream Data Collection	Mon	4	132	1	85	85	85	85	85
					2	39	39	39	39	39
RM-3	Timber Harvest Plan Review and Inspection	Mon	5		1	13	13	13	13	13
					2	0	0	0	0	0
RM-19	Estuary Research and Management				1	103	103	103	103	103
	a) Study Estuary Restoration	Res/Mit	7	(243)	2	24	0	0	0	0
	b) Estuary Fish Research	Res	8	(244)	1	0	0	0	0	0
					2	30	30	30	30	30
N-47	Status of Tall Trees Grove and Alluvial Forests	Mon	10	(246)	1	0	0	0	0	0
					2	25	25	10	0	0
N-102	Cal-Nickel Monitoring - Water Quality	Mon	11	(249)	1	1	1	1	1	1
					2	5	5	5	0	0
N-45	Rehabilitation Evaluation:	Mon	14		1	60	60	60	40	20
					2	0	0	0	0	0
	Landslide/Stream Erosion Control Studies	Mon	15		1	47	47	47	0	0
					2	0	0	0	0	0
N-109	Flood History of Alluvial Flats	Res	24		1	24	24	24	24	0
					2	0	0	0	0	0
N-106	Evaluation of Mill Creek Watershed	Res/Mon	25		1	17	17	0	0	0
					2	0	0	0	0	0
N-103	Large Roughness Elements	Res	31		1	9	0	0	0	0
					2	0	0	0	0	0
RM-17	Removal of Impoundments	Mit	34		1	0	0	0	0	0
					2	0	0	0	0	0

1 = Within Base
2 = Requested from Region

Table 7: Water Resources Management Planning Sheet (Continued)

NRMP No.	Project Title	Project Type	NRMP Priority Number	10-237 (10-238) Number	Funding Status	Program Costs (in $1000's) 1986	1987	1988	1989	1990
Plan	Little Lost Man Creek RNS	Plan	35		1	0	0	0	0	0
					2	0	0	0	0	0
N-61	Long-Term Tributary Monitoring	Mon	37		1	0	0	0	0	0
					2	0	0	0	0	0
N-70	Redwood Creek Fisheries and Cold Pools Study	Res	39		1	0	0	0	0	0
					2	0	0	0	0	0
N-42	PPZ Sediment Source Analysis Management Plan	Res	41		1	0	0	0	0	0
					2	0	0	0	0	0
N-82	Surface Water Quality Testing for Public Health	Mgmt	42	130	1	0	0	0	0	0
					2	55	40	35	35	35
N-85	Fisheries Resource Investigations	Res	44		1	0	0	0	0	0
					2	0	0	0	0	0
N-98	Coastal Erosional Processes	Res	45		1	0	2	2	2	2
					2	0	0	0	0	0
N-104	Terraces and Erosion Rates in Redwood Creek	Res	50		1	0	15	10	5	0
					2	0	0	0	0	0
N-107	Water Rights Study and Report Preparation	Mit	55	(258)	1	0	0	0	0	0
					2	30	0	0	0	0
N-108	Design Parkwide Water Quality Sampling Program	Mon	56	(257)	1	0	0	0	0	0
					2	30	0	0	0	0

NRMP - Natural Resources Management Plan Number
Action Mgmt - Management
Mon - Monitoring
Res - Research
Mit - Mitigation

Funding: 1 = Within Base
2 = Requested from Region

VII. WATER RESOURCES PROJECT STATEMENTS

The following project statements are from Redwood National Park's approved Resources Management Plan.

1. Park and Region: Redwood National Park, Western Region

2. Project Name and Number:

   Sediment Sources and Sediment Transport in the Redwood Creek Basin, N-40

3. Statement of the Problem:

   Severe erosional problems have occurred in the Redwood Creek basin, due to intensive land use and several large storms. As a result, large quantities of sediment were deposited in Redwood Creek, threatening riparian and aquatic resources. An inventory of erosional problems in the watershed is needed to assess potential future damage to park resource within Redwood National Park from erosion originating upstream due to both natural and man-induced causes. An inventory in the form of a sediment budget would quantify sediment sources in the basin, changes in sediment storage in stream channels, and sediment transport in the mainstem and tributaries. Also needed is the development of a model of sediment transport in the Redwood Creek basin that will have the capability of predicting probabilities and magnitudes of future sediment movement. The model would be based on field data collected in the basin between 1979 and 1982.

4. Alternative Actions and Their Probable Impacts:

   (a) No Action:

   Failure to finish this project will leave park management with no information on how land use in the upper Redwood Creek basin could adversely affect park resources. In addition, without the data from this project, park management will not know future expected changes along the main channel of Redwood Creek from past storms and land use activities.

   (b) Develop Sediment Budget and Sediment Transport Model:

   Under this alternative, field data collected on 945 tributary landslides, 900 mainstem landslides, hundreds of gullies on prairies and forested lands, 60 miles of main channel mapping, and mapping of 23 tributaries will be analyzed and incorporated into a sediment budget.

   Additional data for this project include main channel cross sections that are surveyed annually and extensive water and sediment discharge data collected on the mainstem and tributaries. In conjunction with the sediment budget, a mathematical model will be developed of sediment transport on hillslopes and in the channel of Redwood Creek, based on the data gathered during

construction of Redwood Creek sediment budget. The model will eventually have a predictive capability that will be useful for resource management.

5. Recommended Course of Action:

   Continue and complete sediment budget and sediment transport model for Redwood Creek basin.

NATURAL RESOURCE PROJECT STATEMENT

1. Park and Region: Redwood National Park, Western Region

2. Project Name and Number:

   U.S. Geological Survey/National Park Service Cooperative Monitoring Program, N-41

3. Statement of Problem:

   In order to determine sediment transport rates in Redwood Creek and its tributaries (an essential component of the sediment budget project), records of streamflow and sediment discharge must be collected. A significant portion of this data is collected by the U.S. Geological Survey. The monitoring program includes operation of gaging stations along the mainstem of Redwood Creek, and on selected tributaries; establishment and monitoring of channel cross-sections; and collection of precipitation data. This information is necessary to calculate sediment storage areas in Redwood Creek.

4. What Has Been Done:

   The monitoring program is an on-going project that began in 1973. Some stations have been deleted and others added since then. The following is the monitoring program in the Redwood Creek basin up to 1980.

   Mainstem Redwood Creek

   (a) Three continuous recording stations exist at Orick, near Panther Creek and the O'Kane Bridge.

   (b) Three periodic gaging stations are maintained at Miller Creek, Emerald Creek and Slide Creek (old south park boundary). These stations, in conjunction with the continuous recording mainstem stations, are sites of synoptic sampling events during storm periods.

   (c) Fifty channel cross-sections were established on Redwood Creek in 1973, and are resurveyed annually.

   (d) Groundwater recorders were established along Redwood Creek and are serviced regularly.

   General

   (a) Water and sediment discharge are measured at three tributary sites. In addition, a continuous recording stream gage exists on Little Lost Man Creek.

   (b) Sixty cross-sections were established on tributary channels and are resurveyed annually.

(c) The U.S. Geological Survey established 18 storage precipitation gages and three recording precipitation gages in the Redwood Creek basin.

(d) Water discharge and periodic total sediment load were measured at Mill Creek. Fifteen channel cross-sections were established and resurveyed annually.

(e) Hygrothermograph stations were installed and were serviced on a monthly basis.

5. Description of Work to be Undertaken:

(a) Continue operation of mainstem recording and periodic sampling stations.

(b) Resurvey all main channel cross-sections annually.

(c) Continue monitoring piezometers along Redwood Creek.

(d) Continue operation of tributary gaging stations.

(e) Continue servicing of precipitation gages.

(f) Compile 1980 - 1981 storm total load at synoptic sites, and monthly total load at mainstem and tributary periodic sites.

(g) Prepare annual graphic and tabular summaries of Redwood Creek channel changes.

6. Length of Time Needed: Ten years of monitoring.

7. What Will Happen if the Project is not Undertaken:

Failure to continue with the monitoring program will leave the National Park Service with a serious gap in its data base. Management decisions regarding riparian and aquatic resources are based on flow and sediment data collected by the U.S. Geological Survey. Without this data, changes in the channels of Redwood Creek and its tributaries cannot be documented, and threatened areas cannot be identified. The sediment budget project could not function without the data support compiled by the U.S. Geological Survey. Finally, results of this project provide a solid data base for other park professionals (Aquatic Biologist, Plant Ecologist, etc.) to use in their work.

8. What are the Alternatives:

(a) Discontinue all monitoring and have no data on current water and sediment yield trends in Redwood Creek.

(b) Discontinue cooperative effort with USGS and continue monitoring program with park personnel.

(c) Continue project as is, and modify monitoring requirements according to changing data needs.

9. Personnel:

U.S. Geological Survey staff, with support of National Park Service Geologists and Physical Science Technicians (five people) during synoptic storm sampling.

10. Administration and Logistics:

Funding	Year in Program Sequence				
	1982	1983	1984	1985	1986
USGS Personal Services and Other Than Personal Services	$70,000	$50,000	$50,000	$50,000	$25,000

11. References and Contacts:

(a) Mary Ann Madej, Geologist

(b) Harvey Kelsey, Geologist

12. Date of Submission: October 20, 1981

NATURAL RESOURCE PROJECT STATEMENT

1. Park and Region: Redwood National Park, Western Region

2. Project Name and Number:

   Timber Harvest Plan Review, Inspections and Follow-Up, RM-3

3. Statement of Problem:

   From 10 to 20 Timber Harvest Plans (THP) are submitted annually to the California Department of Forestry to harvest timber and build roads within the 30,000 acre Park Protection Zone (PPZ) upstream from Redwood National Park. In addition, 10 to 20 THP's are submitted annually to conduct operations within the Redwood Creek basin upstream from the PPZ.

   Accelerated erosion and sediment yield resulting from such land use activities has been and is continuing to threaten the downstream resources of Redwood National Park. Detection of the deleterious effects of timber harvesting and road building within the Redwood Creek basin led to the Congressional expansion of Redwood National Park (P.L. 95-250) in 1978. In this legislation, Congress mandated an inspection program on private lands within the 30,000 acre PPZ to provide protection to the downstream resources of Redwood National Park. If it can be demonstrated that the park could be adversely affected by land-use activities, the law provides for land acquisition.

   Since August 1976, over 150 THP's have been reviewed and field inspected by National Park Service professional staff to improve harvesting and road construction proposals, to minimize the potential for accelerated erosion and sediment yield and to protect the downstream resources of Redwood National Park. A State review process is currently administered by the California Department of Forestry with input from California Department of Fish and Game, California Division of Mines and Geology, and Regional Water Quality Control Board.

   National Park Service involvement has been instrumental in improving the delineation of unstable, landslide-prone ground, providing additional protection to stream channels while advocating the construction of temporary roads and stream crossings and their removal following operations, all which reduce potential impacts to the downstream resources of Redwood National Park. The following list details general accomplishments of the program:

   (a) On-the-ground review of virtually all proposed timber harvest proposals in 30,000 acre PPZ (20 - 30 per year).

   (b) On-the-ground review of critical or sensitive plans upstream from the PPZ (roughly 10 - 15 per year; as of 1983, access to most privately-owned timberlands above the PPZ has been denied and field inspections are no longer possible).

(c) In the past, virtually all timber harvesting plans reviewed by National Park Service have been modified to reduce potential erosion.

(d) Road construction, yarding methods and silvicultural plans are significantly altered in response to National Park Service concerns and recommendations in roughly 25 percent of plans inspected.

(e) Major areas proposed for timber harvesting and road building on erosionally sensitive terrain have been deleted from present plans or substantially modified at the request of National Park Service professionals (roughly 5 percent - 10 percent of plans reviewed).

As a result of reduced cooperation from landowners and the California Department of Forestry in 1983, National Park Service aerial reconnaissance and aerial photography of timber harvest and other proposed land use sites has taken on renewed importance. These two tools will now become primary resource investigation methods by which areas may be reviewed for potential sources of erosion which could damage park resources. Large scale aerial photography is essential for conducting watershed rehabilitation, evaluation of timber harvest plans, stream channel dynamics, erosion sources and other uses in protection and rehabilitation of the natural and cultural resources of Redwood National Park, especially the aquatic and riparian resources of Redwood Creek.

Black and white or color aerial photography at various scales exists for various portions of the park through 1981. Changing landuse patterns, regrowth of vegetation, and modification of erosional patterns continue to occur, making older photography less and less useful for making current rehabilitation and resource protection decisions.

4. Alternative Actions and Their Probable Impacts:

(a) Continue to perform office and field reviews of timber harvest and road building proposals in the Park Protection Zone. This involves participating in California Department of Forestry pre-harvest field inspections (when permitted), developing site specific recommendations, expressing National Park Service concerns at California Department of Forestry review team meetings and, when permitted, inspecting on-going operations as they are conducted and completing post-harvest compliance inspections. Park professionals will continue to review "critical" plans upstream from the PPZ and provide California Department of Forestry with site specific recommendations when access can be obtained from private landowners. Additionally, contract for color aerial photography of the Redwood Creek (scale = 1:6000) in June 1984 and approximately every 4-5 years thereafter. Contract for monthly aerial reconnaissance of proposed and ongoing landuse operations upstream from the park.

The actions described above are those judged minimally required in order to provide protection from present and future landuse activities occurring on lands tributary to the park.

(b) No action. Terminate Redwood National Park involvement in the Timber Harvest Plan review process and leave responsibility of protecting downstream park resources to State regulatory agencies (an option which has been continually rejected as unsatisfactory, and one rejected by Congress in P.L. 95-250 Legislative History). To comply with the Congressional mandate to provide protection to the downstream resources of Redwood National Park, Timber Harvest Plan reviews and inspections must continue to be performed. Unmonitored land-use activities could result in permanent and irreparable damage to park values. Outdated aerial photography will increase errors, increase ground reconnaissance time requirements and impair resource management rehabilitation and research planning, execution and decision making. Increasing difficulty with obtaining access to private lands mandates an up-to-date set of large-scale aerial photographs and renewed aerial reconnaissance of erosion sources and proposed harvest areas.

5. Recommended Course of Action:

Implement alternative 4.(a), as described above.

NATURAL RESOURCE PROJECT STATEMENT

1. Park and Region:

   Redwood National Park, Western Region

2. Project Name:

   Redwood Creek Estuary Research and Management, RM-19

3. Statement of the Problem:

   The Redwood Creek estuary has been greatly disturbed by man's efforts to control flooding and protect adjacent agricultural lands. Research has shown that aquatic resources, particularly anadromous fish populations, have and are suffering severely.

   Because of the estuary's importance to all species of anadromous fish, a compromising situation at the estuary decreases the overall effectiveness of any other fisheries and erosion control rehabilitation efforts occurring upstream. Restoration of the fishery resources of Redwood Creek and its tributaries, an ultimate objective of the resources management program and a desired outcome of the combined efforts of each specific watershed rehabilitation project, could never be fully achieved. Short-term and eventually long-term alternatives must be identified, analyzed, and implemented to manage and restore the resource, while protecting private property.

4. Alternatives and their Probable Impacts:

   (a) No action. Under this alternative research and management at the estuary would end. No follow-up data would be obtained beyond what was collected in preliminary research. Without active management it is unlikely that significant improvements in the status of Redwood Creek's king salmon fishery would occur.

   (b) Continue research and management. Research would continue into physical and biological processes to provide data necessary for development of long-term rehabilitation alternatives, and to monitor the effectiveness of interim management. Summertime estuarine water levels would be manipulated to prevent flooding of private property and to provide critical summertime fish habitat. Sediment that accumulates in critical areas of the estuary would be removed as needed to help maintain a more nearly natural aquatic system. Basic hydraulic engineering analyses of preliminarly identified long-term alternatives should begin. This will undoubtedly require the involvement of the Corps of Engineers.

   Present runs of chinook salmon and steelhead trout are substantially reduced from historic runs and from what is representative of the natural system. Without implementation of this project the fish runs would likely stay at their present, depressed levels.

5. Recommended Course of Action:

   Implement Alternative 4.(b).

NATURAL RESOURCE PROJECT STATEMENT

1. Park and Region:

   Redwood National Park, Western Region

2. Project Name and Number:

   Status of the Tall Trees and Alluvial Forests, N-47

3. Statement of Problem:

   The World's Tallest Tree and other very tall redwoods in alluvial groves along Redwood Creek were the focus of public attention leading to the creation of Redwood National Park in 1968. Renewed public concern over actual and potential damage to the alluvial groves due to watershed and stream alterations resulting from upstream and upslope logging lead to the expansion of the Park in the Redwood Creek drainage in 1978. At the same time a watershed rehabilitation program was created as the combined results of logging and flooding in 1965, 1972 and 1975 were observed. These included damaged or drowned trees along the streambanks and in alluvial flats due to lateral erosion or elevated water tables associated with the aggrading stream channel. Since 1975 annual rainfall and stream flow has been less than normal. No overbank flooding has occurred and some deepening of the stream channel has been reported, and damage to the alluvial groves has not increased.

   Several important questions need to be examined: Has the damage to the groves stabilized? Is the Tall Tree itself recovering from the effects of conditions which lead to top dieback? Are other damaged trees recovering or continuing to decline. Can this damage be related to bed elevation or were other factors responsible? What is the expected longevity of trees in alluvial groves? What are the natural mortality and replacement rates of trees? Indeed, how long do alluvial flats persist before lateral erosion removes them, and the cycle of formation begins again?

4. Alternative Actions and Their Probable Impacts:

   (a) No action:

   No investigation would be conducted. There would be no reliable evaluation of the effects of watershed changes upon these valued resources and no basis upon which to evaluate future changes in the streamside groves, including tree mortality, and to discriminate between natural change and man induced damage.

(b) Initiate project:

Work cooperatively with Park Service geologists to define the history of erosion and deposition (Project REDW-N-104) using tree ages and other vegetation markers in the alluvial groves. Determine the present condition and growth rates of the alluvial redwoods and the Tall Trees. Examine and compare growth rate changes for the period including the floods of 1861, 1955, 1964, 1972 and 1975 using tree ring analysis. Relate changes in stream bed elevation, ground water elevation and tree condition and develop a predictive model for long term management in the alluvial forests. Develop an estimate of the tree mortality and replacement rate for alluvial groves to permit management to evaluate whether changes in groves are within expected natural ranges or if changes may be due to other causes (i.e., watershed changes, overuse of groves by visitors, etc.). Prepare reports and recommendations. Anticipated costs for FY 1987, 88 and 89 are $25,000, $25,000 and $12,000.

5. Recommended Course of Action:

Initiate project in FY 87 with park geologists. (Continue ground water data collection FY 86). Utilize graduate student participants in field studies to minimize project costs.

6. Sources of Information:

Stephen D. Veirs, Jr. Research Scientist, Redwood/C.P.S.U.

Public Laws 90-545 and 95-250 and Legislative History

Status of Natural resources in Redwood Creek basin, Redwood National Park. Milton Kilipinski, E. Helley, L. Leopold, S. Veirs, G. Witucki and R. Ziemer, December 10, 1975.

Grosvenor, Melville Bell. World's Tallest Tree Discovered. National Geographic. July, 1964. 126(1):1-9.

Helley, Edward J. and V.C. La Marche, Jr. 1973. Historic Flood Information for Northern California Streams form Geological and Botanical Evidence. Geological Survey Professional Paper 485-E. Washington, D.C.

Janda, Richard J. 1975. Recent Man-Induced Modifications of the Physical Resources of the Redwood Creek Unit of Redwood Park, California, and the Processes Responsible for Those Modifications. U.S. Geological Survey, Open File Report. Menlo Park, California.

Zahl, Paul A. Finding the Mount Everest of all Living Things on Redwood Creek, California. National Geographic. July, 1964. 126(1):10-51

NATURAL RESOURCE PROJECT STATEMENT

1. Park and Region: Redwood National Park, Western Region

2. Project Name and Number: California Nickel Corporation Monitoring, N-102

3. Statement of the Problem:

The California-Nickel Corporation proposes to mine laterite ore from the Gasquet Mountain area, 10 kilometers northeast of the park. Through an on-site plant using a sulfuric-acid leach process, they would extract cobalt, nickel, mangeneze, and chromium from the ore. Sulfuric-acid would be obtained by removing sulfur from coal which will be burned on-site to produce power for the acid and processing plants. Coal would be trucked to the site.

California-Nickel has claims on 8,000 acres of U.S. Forest Service land and would mine 150 acres per year. They would obtain water from three dams and reservoirs constructed on a tributary of the Smith River.

The facility is the first large source of sulfur dioxide to be proposed near the northern end of the park. It would contribute an estimated 706 tons of sulfur to the atmosphere each year. In addition, the plant would produce 791 tons of particulates; 1,993 tons of nitrogen oxides; and 149 tons of carbon monoxide.

Redwood National Park contains both Class I and Class II land under the Clean Air Act, as amended. the nearest Class I lands to the project are found in the Little Bald Hills area of the park, approximately 10 kilometers southwest of Gasquet Mountain. In addition, Class I lands are located in the Hiouchi Area (12 kilometers southwest) and the Howland Hill area (16 kilometers southwest).

It has not been determined if the expected emissions would have an adverse impact on the air quality related values of Redwood National Park. However, the Little Bald Hills area contains Jeffrey pine and lichens which are known to be sensitive to sulfur dioxide. Long-term exposure to sulfur dioxide by these species could result in a reduction of species diversity and abundance in this area. The immediate impacts of the Cal-Nickel project could be exacerbated by mining and processing of other laterite deposits in the vicinity of Gasquet Mountain. Mining and processing these other ores could either extend the life or enlarge the emission rates expected from the Cal-Nickel project itself.

In addition to air quality impacts, water quality of the Smith River could be degraded by the mining activities. Mass movement and surface erosion in the mining area, along with groundwater seepage, could result in increased turbidity, sedimentation, and heavy metal concentrations in the Smith River. Preliminary studies indicate few problems should be experienced in the main fork of the Smith as it passes through the park, primarily because of dilution.

4. Alternative Actions and Their Probable Impacts:

(a) No Action:

No specific monitoring for the Cal-Nickel project would occur. Park staff would continue to work with Air and Water Quality Division and Regional personnel to respond to permit applications and environmental documents. Approximately $1,000 per year would be committed towards the project. As a result, little independent verification of the company's claims or studies would be available. In addition, the park would not be able to determine readily if damage was occurring to park resources.

(b) Vegetation Monitoring:

A vegetation monitoring program would be initiated under the direction of Air and Water Quality Division scientists. Permanent sampling plots, concentrating on lichens, would be established and monitored in the Little Bald Hills area. The plots would allow changes to be measured quantitatively; however, it would be difficult to correlate changes in lichens and other vegetation without corresponding meterology and pollution monitoring information. Approximately $3,000 would be required initially to set up the permanent plots.

(c) Vegetation, Meterology, and Air Quality Monitoring:

In addition to the permanent vegetation plots described in Alternative (b), meteorological monitoring would be re-instituted and monitoring of sulfur dioxide would be initiated in the Little Bald Hills area of the park. Through this alternative, problems and their sources could be specifically identified and action potentially taken to mitigate adverse impacts. Approximately $60,000 per year would be required for this program.

(d) Air and Water Quality Monitoring:

In addition to the air quality related monitoring described under Alternative (d), water quality monitoring of the Smith River would be initiated in cooperation with the U.S. Geological Survey. The emphasis would be on detection of heavy metals emanating from the mine. The cost of a water quality monitoring program has not been estimated.

5. Recommended Course of Action:

Alternative (c), vegetation, meterology, and air quality monitoring, should be implmented to provide a comprehensive program to monitor potential adverse impacts from the mine. Through all three, changes in vegetation could be directly related to weather patterns and deposition of sulfur dioxide in the park.

NATURAL RESOURCE PROJECT STATEMENT

1. Park and Region: Redwood National Park, Western Region

2. Project Name and Number:

   Rehabilitation Evaluation, N-45

3. Statement of Problem:

   Millions of dollars will be spent on watershed restoration and erosion control projects over the next decade. Detailed, objective evaluation of the relative effectiveness and cost-effectiveness of program elements and specific techniques is necessary to assure the most efficient utilization of available funds. Stretching the congressionally authorized $33-million is necessary to address erosion control on private lands upstream from the park, as authorized in P.L. 95-250. Results and descriptions of successful techniques, if fully evaluated and reported, can lead to improved land use on private timber lands adjacent to Redwood National Park, further protecting threatened park resources.

4. What Has Been Done:

   A description and qualitative evaluation of 1978 rehabilitation work has been published (Redwood National Park Technical Report Number 1, May 1980). Permanent erosion monitoring stations and equipment are installed on 1978, 1979, 1980 and 1981 project sites. An initial cost and effectiveness evaluation of labor-intensive erosion control techniques has been distributed "in-house." Work is now in progress on the 1979 and 1980 yearly evaluation reports, as well as on a project report on the 1980 Devils Creek rehabilitation contract.

5. Description of the Work to be Undertaken:

   The following elements are planned:

   (a) Yearly project descriptions and cost analyses including recommendations on improving effectiveness and reducing costs.

   (b) Systematic evaluation of the effectiveness and cost-effectiveness of labor-intensive erosion control techniques and heavy equipment operations with frequent reports to Resources Management operations.

   (c) Quantitative evaluation of the erosional impacts and beneficial effects of watershed rehabilitation practices on sediment yields.

   (d) Continue to monitor and evaluate levels and changes in erosion and sedimentation rates from cutover lands within Redwood National Park.

N-45 (continued)

6. Length of Time Needed:

   At varying intensities, the project will continue throughout active rehabilitation work and, at diminished levels, for up to five succeeding years.

7. What Will Happen if the Project is not Undertaken:

   Disturbance by rehabilitation activities could outweigh the benefits derived by these erosion control efforts. Not only could hundreds of thousands of dollars be wasted, the work could also degrade park resources even beyond their present state. Without knowing the actual increase in their ability to slow erosion, we have little or no basis for choosing which techniques are used and in what circumstances they are most effective. New and more "cost effective" erosion control techniques will be introduced into the program as they are developed.

   Erosion problems must be quantified to allow us to treat the worse sources of erosion and to decide on the level of erosion control. Without quantitative evidence, the rehabilitation program cannot be defended in terms of its success in controlling or slowing erosion rates and, hence, in protecting resources of Redwood National Park. Establishing present erosion rates from cutover lands will increase our knowledge of the impacts of on-going timber harvest practices in the Park Protection Zone upstream from the park, and will allow us to better reduce those impacts in the future.

8. What are the Alternatives:

   (a) Proceeding with rehabilitation practices as they currently exist, improving only where obvious flaws exist. Do not formally describe and publish results for use by in-house and other agencies, as well as State and private entities.

   (b) Evaluate and monitor rehabilitation at a reduced intensity to generate qualitative information which would probably be valid enough for in-house consumption only.

   (c) Carry out proposed monitoring and evaluation work.

9. Personnel:

   Staff Geologists plus three temporary Technicians.

10. Administration and Logistics:

Funding	Years In Program Sequence 1982	1983	1984	1985	1986
Personal Services . .	$ 93,000	$106,000	$104,000	$114,000	$125,000
Other	15,000	15,000	15,000	15,000	15,000
TOTAL	$108,000	$121,000	$119,000	$129,000	$140,000
Funds Available in Park Base . . .	$108,000	$108,000	$108,000	$108,000	$108,000
Funds Requested from Regional Office . .	$ 0	$ 13,000	$ 11,000	$ 21,000	$ 32,000

10-237 Inc. No. _____

10-238 Pkg. No. _____

11. References and Contacts:

(a) Park Files

(b) Redwood National Park Technical Report Series

(c) William E. Weaver

12. Date of Submission: November 1, 1981

NATURAL RESOURCE PROJECT STATEMENT

1. Park and Region: Redwood National Park, Western Region

2. Project Name and Number:

   Flood History of Alluvial Flats in Redwood National Park, N-109

3. Statement of Problem:

   Floods are those flows which overtop the banks of a channel and spread out across a low-lying terrace such as the Tall Trees Grove. These floods generally deposit sediment on the terrace and depending on the quality of the sediment, can affect the vigor and longevity of the trees. A knowledge of the magnitude and frequency of flood recurrence in such groves will provide a much longer record (on the order of several hundreds of years) of pre-historic flood history, as well as provide a basis to predict how frequently the low-lying terraces will be inundated in the future. A long-term comparison is needed to place the apparent post-1950 increases in erosion rates, sediment yield and terrace flooding frequency in perspective.

   Several methods are commonly used to analyze flood events. These include: flood frequency analysis, based on U.S.G.S. stream gaging recording; the use of historical data to extend the base period for which a given flood frequency is attempted, and interpretation of geological and botanical evidence preserved on low-lying terraces to obtain pre-historical flood histories. Stream gaging records on Redwood Creek do not exist prior to 1953, and historical data is spotty and only available for about 100 years. However, alluvial flats, such as the Tall Trees Grove, can provide an excellent record of pre-historical flood depositional events from a stratigraphic analysis of the series of silt layers deposited through time on these low terraces.

   This project will investigate the long-term flooding history of Redwood Creek through the mapping and analysis of the deposits left in the geologic record. The project will provide insights for managing and preserving superlative redwood groves growing on alluvial flats based upon an understanding of their relation to the dynamic processes of flooding and sediment deposition which has created and sustained them. Likewise, physical evidence of specific flood events can be identified and dated, and may permit estimations of past flood peak discharges.

4. Alternative Actions and Their Probable Impacts:

   (a) No investigation would be conducted. Abandon any attempts at placing the sequence of six post-1950 floods and periods of Tall Trees Grove inundation in perspective with those that occurred prior to 1950. Continue attempting to predict long-term frequency

of flooding at the grove based on U.S.G.S. discharge data (which are highly skewed because of the short period of record) and based on channel recovery as determined by channel surveying.

(b) Initiate project by mapping the boundary conditions surrounding the Tall Trees Grove. Proceed with detailed stratigraphic mapping of terrace and channel banks to determine lateral continuity of deposits. Utilize a portable auger or take core samples (if possible) to determine extent to which a given marker bed or stratigraphic horizon exists beneath the terrace as well as the depth to underlying bedrock. Collect samples for analyzing bulk density, particle size distribution and lithology in order to identify distinct flood events preserved in the stratigraphic record. Collect organic debris which may be datable by Carbon-14 methods in order to obtain absolute age controls on periods of overbank deposition. Utilize seismic profile techniques in an attempt to observe the nature of bedrock/alluvium contact so as to define the process of Tall Trees Grove meander development. Prepare reports, maps and make management recommendations.

5. Recommended Course of Action:

Initiate flooding history project in FY86. Enlist graduate student participation in soils aspect of the study. Funds and most staff are available in the division base to carry out the project. Work should be completed by FY88.

NATURAL RESOURCE PROJECT STATEMENT

1. Park and Region: Redwood National Park, Western Region

2. Project Name and Number:

   Evaluation of Mill Creek Watershed, N-106

3. Statement of the Problem:

   The objective of this study is to evaluate the stability of the Mill Creek watershed in terms of upstream land use and downstream park resources. Channel changes will be investigated and long-term trends of sedimentation and erosion will be evaluated where possible.

4. What Has Been Done:

   Some hydrologic data has been gathered in the past by the USGS. Cross sections of the main channel of Mill Creek and its major tributaries were resurveyed, and a geomorphic description of the channel was written.

5. Description of Work to be Undertaken:

   Cross sections will be resurveyed. Hydrologic data will be compiled and analyzed. Air photos will be interpreted for sediment sources, land use patterns, and channel shifting.

NATURAL RESOURCES PROJECT STATEMENT

1. Park and Region: Redwood National Park, Western Region

2. Project Name and Number:

   Effect of Large Roughness Elements (Natural Obstructions) on Channel Form, Channel Stability, Sediment Size, and Anadramous Fish Habitat, N-103

3. Statement of the Problem:

   Natural obstructions (larger roughness elements, or LRE) in the channel deflect and divert stream flow. They strongly influence channel form, bank stability and sediment size. These obstructions are common in most all Redwood Creek tributaries. Because these obstructions determine local gradient, bank stability and sediment size distribution, they also determine quality of habitat for invertebrate fauna and both anadromous and resident fish. The problem is what sort of obstructions, or roughness elements, exist in tributary streams and in what ways do they influence channel character and channel bank erodability. The channel obstruction question bears directly on fish habitat. Evaluating faunal habitat, particularly for spawning fish, depends on knowing which stream reaches naturally assume a channel shape suitable for spawning. Understanding the role of large roughness elements allows prediction of both stream erodability and favorable spawning habitat.

4. What Has Been Done:

   A study of tributary landsliding and sediment storage in the Redwood Creek basin is completed (Pitlick, 1982). No work has been done in the park on large roughness elements and how they influence channel form and sediment size. Research in a nearby watershed (Lisle and Kelsey, 1982) demonstrates the promise of further study in Redwood Creek tributaries. Harvey Kelsey (NPS) and Tom Lisle (USFS, Redwood Sciences Lab, Arcata) have conducted preliminary surveying and inventorying of a small watershed in Arcata, California. In addition, general pertinent pieces of research (Graf, 1981; Church, 1981) promise useful results from this study. Furthermore, a graduate student in the Watershed Management Program at Humboldt State University is working on a related aspect of this study, and one of her proposed study streams is Bridge Creek in Redwood National Park. Terry Hofstra, Redwood National Park Fish and Wildlife Ecologist, has indicated a willingness to cooperate with assessing fish habitat at a future date after the intial surveys of physical stream condition.

5. Description of the Work to Be Undertaken:

   Work to be undertaken in this project includes:

   (1) Literature search of pertinent previous research (has already been largely completed).

(2) Selection of study sites and further surveying of the existing study site.

(a) The existing study site is Jacoby Creek, 1 kilometer south of Arcata and 80 kilometers south of Redwood National Park.

(b) Bridge Creek, the second largest tributary basin in Redwood National Park, is tentatively selected for detailed study. Bridge Creek is a good choice because:

[1] It is an anadromous fish stream.

[2] It has excellent access and could logistically be the subject of later channel improvement, if the study results, and park policy, deem improvement desirable.

[3] It is typical of many Redwood National Park tributaries and what is learned there is applicable elsewhere.

(c) Prairie Creek, the largest tributary in Redwood National Park, is another potential study site because:

[1] Easy access.

[2] Prairie Creek is the most important tributary anadromous fishery in Redwood National Park.

[3] There has been previous U.S. Forest Service research on sediment size distribution and spawning round quality in this stream.

(3) Conduct plane table and transit surveys of selected study reaches to determine channel gradient, pool-riffle sequences, large roughness element locations, and sediment size.

(4) Analyze survey data and correlate data with channel form, bank erodability, and reaches of suitable fish habitat. The Redwood National Park Fish and Wildlife Ecologist will cooperate in fish habitat assessment.

(5) Appraise the influence of channel large roughness elements on channel form and character. Based on conclusions, assess the viability of stream improvement efforts for tributary streams.

6. Length of Time Needed:

Four years.

7. What Will Happen if the Project is Not Undertaken:

Failure to do this project results in lack of knowledge of what controls pool formation, riffle formation, bank erosion, and sediment

size distribution in Redwood Creek tributaries. Without this information, there will be an inadequate data base to carry out effective stream improvement projects aimed at improving spawning habitat.

8. What are the Alternatives:

   Do nothing about improving the understanding of channel process in tributaries. As a consequence, any stream improvement attempts must be with a limited data base from the literature and with no first-hand data for Redwood Creek tributary processes.

9. Personnel:

   National Park Service Staff: Geologist, Fish and Wildlife Ecologist.

   U.S. Forest Service Hydrologist (cooperating investigator).

10. Administration and Logistics:

    Personal services and other than personal services:

YEAR IN PROGRAM SEQUENCE			
1984	1985	1986	1987
$ 14,000	$ 14,000	$ 14,000	$ 14,000

11. References and Contacts:

(a) Harvey Kelsey, Geologist, NPS
(b) Terry Hofstra, Fish and Wildlife Ecologist, NPS
(c) Tom Lisle, Hydrologist, U.S. Forest Service, Redwood Sciences Lab, Arcata
(d) Church, M., 1981, Pattern of instability in a wandering gravel bed channel: Second International Converence on Fluvial Sedimentology. University of Keele, U.D., September 1981.
(e) Grat, W. L., 1981, Channel instability in a braided, sand bed river: Water Resources Research, v. 17, p. 1087-1094.
(f) Lisle, T. E. and Kelsey, H. M., 1982, Effects of large roughness elements on thalweg course and pool spacing, Jacoby Creek, northwestern California: American Geomorphological Field Group. 1982, Conference Guidebook. 134 pp.
(g) Pitlick, J., 1982, Sediment routing in tributaries of the Redwood Creek basin: northwestern California; Redwood National Park Technical Report Number 8.

12. Date of Submission: June 23, 1983.

NATURAL RESOURCE PROJECT STATEMENT

1. Park and Region: Redwood National Park, Western Region

2. Project Name and Number: Removal of Impoundments, RM-17

3. Statement of the Problem:

No natural ponds or lakes occur within the park, although lagoons, sloughs, and marshes occur at the mouths of creeks as a result of oceanic processes. However, several stock ponds and three log ponds were formed by artificial impoundment of surface water prior to park establishment and expansion. In addition, one small, rock-filled dam was constructed prior to park creation on Lost Man Creek, a tributary of Prairie Creek in the Redwood Creek Watershed.

The stock ponds, remnants of cattle grazing, are located on DeMartin Prairie, Ganns Prairie, Elk Camp Prairie, and near Schoolhouse Peak. They vary in size with the seasons, from almost dry to several hundred square feet in the Spring. The three log ponds, Marshall Pond, the ARCO pond, and Lagoon Creek, are all former mill ponds. The saw mills at both Marshall Pond (Richardson's Creek) and Lagoon Creek have long since been removed. The ARCO pond sits on park land and adjacent to the log deck of the existing Arcata Redwood Company mill in Orick, but it is not used for mill purposes.

There are restrictions on removing two of the impoundments. Lagoon Creek pond has a use restriction which would delay removal. When an adjacent fishing access was donated by Del Norte County to the National Park Service in 1972, the county stipulated that the access would remain until 1993. The other ponds have no use restrictions; however, the U.S. Fish and Wildlife Service, in a Section 7 (Endangered Species Act) consultation regarding the General Management Plan, stated that a survey for two candidate species of snail must precede any actions along the lower Klamath River and nearby coast. Such a survey would occur prior to removal of Marshall Pond.

All the ponds are artificial relics of the park's grazing and logging past and some are host to exotic fish (to this system) including resident trout, catfish, and green sunfish.

4. What Has Been Done: Stock ponds on the Bald Hills (near watershed rehabilitation sites) have been removed on an equipment-available basis.

5. Alternative Actions and Their Probable Impacts:

(a) No action:

None of the remaining ponds would be removed. Although localized species diversity would remain enhanced, the impoundments would remain as artificial features in natural zones of the park.

(b) Remove all ponds immediately:

With the exception of Lagoon Creek, all the stock ponds, mill ponds, and the Lost Man Creek dam would be removed at once. In effect, removal of all impoundments would become a watershed rehabilitation site for one season. An immediate loss of species diversity on the Bald Hills and increased sedimentation in Lost Man Creek would occur. However, several acres of artificial habitat would be restored to a naturally-functioning ecosystem. Creation of wetland habitat at Marshall Pond would offset the loss of surface water. Careful excavation of accumulated sediment behind the Lost Man Creek dam would minimize downstream impacts. Total cost would be approximately $30,000.

(c) Remove all ponds over course of Rehabilitation Program:

All ponds and artificial impoundments would be removed over the next 5 to 7 years, during the remainder of the watershed rehabilitation program. Stock ponds would be removed on an equipment-available basis by park crews. Removal of larger impoundments would be scheduled into the watershed rehabilitation program. Total cost would be slightly higher than alternative (b) due to price increases over the delayed program.

6. Recommended Course of Action:

Implement alternative (c) so that all artificial ponds are removed by the conclusion of the watershed rehabilitation program.

NATURAL RESOURCE PROJECT STATEMENT

1. Park and Region: Redwood National Park, Western Region

2. Project Name and Number:

   Little Lost Man Creek Research Natural Area Management Plan (No Number)

   A management plan would be prepared to provide overall objectives and guidance to research activities in the Research Natural Area. The plan will be prepared using existing staff in FY 83.

NATURAL RESOURCE PROJECT STATEMENT

1. Park and Region: Redwood National Park, Western Region

2. Project Name and Number:

   Long-Term Tributary Monitoring, N-61

3. Statement of the Problem:

   The aquatic community present in a stream is the result of stream geomorphology and other physical factors that: (1) impose physical limitations on the types of organisms that may withstand such stresses, and (2) control the types and abundance of food resources available to these organisms. It has been hypothesized that in this way the stream community represents an adaptation to the mean, or most probable, position of the physical system (Vannote, et al. 1980). Given this hypothesis, changes in the aquatic community are preceded by changes in controlling physical factors. A thorough understanding of changing physical factors therefore is required in order to understand the "hows" and "whys" of biological changes. In order to fully understand stream community dynamics, a study should integrate biological investigations with stream geomorphology and other physical factors. The results of such a study would be invaluable in terms of quantifying and understanding the process of watershed recovery and the effects on the aquatic community.

4. What Has Been Done:

   Candidate streams for the study have been selected. Background data on aquatic invertebrate sampling, sediment storage, geology and fisheries has been collected.

5. Description of Work to be Undertaken:

   The following information would be gathered at permanently established study sites on the selected tributary: geologic, forest, stream geomorphic, soils, and vegetation mapping; determination of types, quality, and quantity of organic detrital inputs to and detrital storage reservoirs within the stream; determination of seasonal and diel water quality changes; documenting meterological and stream hydrologic conditions; determination of organic/inorganic ratios of particulate loads; determination of aquatic community structure.

6. Length of Time Required: Minimum of five years.

7. What Will Happen if the Project is not Undertaken:

   Information regarding the linkages between biological and controlling physical processes will be lacking. Within the context of watershed management and rehabilitation, this information would be invaluable.

(continued)

8. What are the Alternatives:

   (a) No action.

   (b) Limit study to fewer factors or fewer streams.

   (c) Implement proposal.

9. Personnel: Park staff and university personnel.

10. Administration and Logistics:

Funding	Years In Program Sequence				
	1982	1983	1984	1985	1986
Personal Services . .	$ 16,000	$ 74,810	$ 71,000	$ 71,000	$ 71,000
Other	3,000	5,000	5,000	5,000	5,000
TOTAL	$ 19,000	$ 79,810	$ 76,000	$ 76,000	$ 76,000
Funds Available in Park Base . .	$ 19,000	$ 25,810	$ 22,000	$ 22,000	$ 22,000
Funds Requested from Regional Office . .	$ 0	$ 54,000	$ 54,000	$ 54,000	$ 54,000

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11. References and Contacts:

(a) Vannote, R. L., G. W. Minshall, K. W. Cummins, J. R. Sedell, and C. E. Cushing. 1980. The River Continuim Concept. Can J. Fish. Aquat. Sci. 37:131-137.

(b) Terry Hofstra, Aquatic Ecologist, Redwood National Park

12. Date of Submission: October 1, 1980

NATURAL RESOURCE PROJECT STATEMENT

1. Park and Region: Redwood National Park, Western Region

2. Project Name and Number:

   Redwood Creek Fisheries Studies, N-70

3. Statement of the Problem:

   Quantitative data should be obtained regarding fisheries productivity of Redwood Creek and tributaries. Such information would allow for a better assessment to be made of existing conditions of aquatic resources as they relate to past land uses within the basin and potential rehabilitation alternatives.

4. What Has Been Done:

   Bridge Creek, Tom McDonald Creek and Emerald Creek within Redwood Creek basin have been electrofished with species identified, enumerated, weighed, measured and populations estimated. A nursery area study was begun.

5. Description of Work to be Undertaken:

   Complete nursery area study. Establish additional permanent sampling sites for fisheries investigations in other tributary streams within Redwood Creek. Conduct adult spawner surveys.

6. Length of Time Required: Three years.

7. What Will Happen if the Project is not Undertaken:

   Quantitative data regarding existing levels of fisheries productivity will be lacking.

8. What are the Alternatives:

   (a) No action.

   (b) Complete nursery area study only.

   (c) Establish additional sampling sites and conduct spawner surveys.

9. Personnel: Three Biological Technicians

10. Administration and Logistics:

Funding	Years In Program Sequence			
	1982	1983	1984	1985
Personal Services . .	$ 14,000	$ 16,000	$ 18,000	$ 20,000
Other	3,000	3,000	4,000	4,000
TOTAL	$ 17,000	$ 19,000	$ 22,000	$ 24,000

N-70 (continued)

11. References and Contacts:

    (a) Terry Hofstra, Redwood National Park

    (b) Richard Ridenhour, Humboldt State University

12. Date of Submission: October 1980

NATURAL RESOURCE PROJECT STATEMENT

1. Park and Region: Redwood National Park, Western Region

2. Project Name and Number:

   Park Protection Zone Sediment Source Analysis and Erosion Control Planning, N-42

3. Statement of Problem:

   National Park Service knowledge of sediment source areas within the PPZ is spotty, primarily because no attempt has been made to analyze each of the basins to determine which portions have a higher potential for sediment input. Proposed land management practices are reviewed and inspected as separate projects on separate plots of ground even though a project could cause adverse impacts outside its proposed boundaries. Also, hundreds of miles of roads, many of which are abandoned or unused, exist within the PPZ and are considered to be a major sources of sediment, yet the National Park Service has little knowledge as to their condition and stability. Without this analysis, there will be no information to guide future rehabilitation activities or to judge the continuing, cumulative impact to park resources mandated by P.L. 95-250.

   The tributaries within the PPZ (Park Protection Zone) are some of the most erosive basins in Redwood Creek. Based on USGS basin-wide studies and Redwood National Park hydrologic and sediment budget studies for Redwood Creek, the sediment yield from the PPZ tributaries are among the highest in the entire watershed. Initial field observations suggest there are many areas where small rehabilitation projects could substantially reduce erosion rates and sediment yield. Additionally, Congress, in P.L. 95-250, authorized rehabilitation of lands upstream from Redwood National Park.

   Currently, only personal knowledge of potential sediment source areas exist. This information was derived through the Timber Harvest Plan (THP) review process. Detailed mapping of ground conditions has only been performed on individual THP units. No PPZ-wide erosion maps have been prepared to guide future National Park Service personnel to potentially high sediment source areas or to identify highly sensitive regions.

   No plans or work have been done to control erosion in the PPZ. Specific high sediment yield locations have been observed outside of Timber Harvest Plan(THP) boundaries. In 1978, Redwood National Park contributed $400,000.00 to the California Forest Improvement Program (CAL-FIP) and specifically requested the funds be used for erosion control work within the Redwood Creek watershed. As of this time, few erosion control projects have been carried out by private landowners within the watershed.

4. Alternative Actions and Their Probable Impacts:

(a) Inventory the erosional features within the PPZ as they relate to land management and potential erosion control. Produce an "erosion map" that will guide future land management decisions. Analyze the road network within the PPZ and classify it according to its potential as a source of erosion and sedimentation.

Based on the delineation and analysis of sediment sources in the PPZ, those erosion control projects will be developed which show the greatest potential for rapidly reducing accelerated erosion rates with the minimum investment of capital. Landowners will be contacted and shown where major sediment sources exist on their land. Cooperative cost-sharing or full cost reimbursement agreements erosion control plans will be developed.

Areas of excessive erosion must be managed more carefully than low-erosion areas. The identification of erosion sources will aid in their eventual treatment as a part of proposed harvest operations and/or to outline certain portions of the PPZ where specific land-use practices may be inadvisable. Without the knowledge of the location and characteristics of erosion sources, land-use activities which would cause long-term damage to the park could continue to occur. Without the information, unidentified erosion processes will continue to impact the park and erosion control activities may not be directed to the most critical locations.

According to P.L. 95-250, Congress authorized the rehabilitation of areas upstream from Redwood National Park. Recommendations for erosion control work aimed at reducing accelerated erosion rates within THP boundaries are often strongly argued against because it cuts into timber harvesting profits. Without this program, it would be impossible to rehabilitate a highly erosive parcel of land where no timber harvesting is proposed.

(b) Continue to review and inspect areas of proposed land-use as they arise and make no attempt to delineate and analyze the sediment source areas of the PPZ as a whole. Carry out rehabilitation only on areas familiar to National Park Service staff without regard to relative erosional severity. Ignore cumulative impacts. Abandon the concept of reducing accelerated erosion rates on lands within the PPZ not proposed for timber harvesting activities.

Adoption of this alternative is not in keeping with the stated concerns and directions of Congress regarding park protection (see P.L. 95-250, Legislative History). Existing and potential sources of sediment and areas of extreme erosion would remain unidentified.

5. Recommended Course of Action:

Inventory erosion features, evaluate potential erosion sources and prepare erosion control prescriptions for areas within the Park Protection Zone.

NATURAL RESOURCE PROJECT STATEMENT

1. Park and Region: Redwood National Park, Western Region

2. Project Name and Number:

   Surface Water Quality for Public Health, N-82

3. Statement of the Problem:

   Surface water of Redwood National Park is utilized by park users for drinking and cooking. Often water is consumed without purification. An assessment of health risks posed by consumption of untreated surface waters must be determined. A microbiological survey of park surface waters for enteric micro-organisms followed by a routine monitoring program is required. Recommendations for park management, water resource preservation and visitor protection will be prepared utilizing information obtained.

4. What Has Been Done:

   Limited bacteriological testing of park surface waters for coliform organisms was undertaken for the park by the USGS. High coliform levels were found in the mainstem of Redwood Creek and in Prairie Creek.

5. Description of Work to be Undertaken:

   Selected sites along the mainstem of Redwood Creek, principal tributaries, and known visitor water use areas near trails or campsites will be sampled and tested for enteric organisms on a regular basis during the tourist season. Routine testing frequency will be determined following a period of intensive sampling of selected sites to elucidate seasonal variations of enteric organism levels and the identification of contaminate sources. Time of travel studies will likely be required as will differentiation of human versus animal versus natural background levels of certain indicator micro-organisms.

6. Length of Time Required: Five years.

7. What Will Happen if the Project is not Undertaken:

   There have already been speculative claims and charges made that drinking of park surface waters has caused illness. The park must identify safe drinking water supplies and those which are unsafe without disinfection. The National Park Service is liable for tort claims and law suits should park visitors be able to show a relationship between illnesses and drinking of contaminated park surface waters.

(continued)

8. What are the Alternatives:

(a) No action.

(b) Contract for needed studies and monitoring.

(c) Monitor only most-used surface water areas.

9. Personnel: University and park staff.

10. Administration and Logistics:

Funding	Years In Program Sequence 1983	1984	1985	1986
Personal Services . . .	$ 13,500	$ 13,500	$ 13,500	$ 13,500
Equipment/Supplies . .	9,500	2,500	1,200	1,200
Logistical Support . .	2,750	1,850	1,750	1,750
TOTAL	$ 25,750	$ 17,850	$ 16,450	$ 16,450
Funds Available in Park Base	$ 0	$ 0	$ 0	$ 0
Funds Requested from Regional Office . . .	$ 25,750	$ 17,850	$ 16,450	$ 16,450

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11. References and Contacts:

(a) Redwood National Park, Arcata Office

(b) L. Lee Purkerson, Chief, Technical Services, Redwood National Park

12. Date of Submission: January 16, 1981

NATURAL RESOURCE PROJECT STATEMENT

1. Park and Region: Redwood National Park, Western Region

2. Project Name and Number:

   Fisheries Resource Investigations, N-85

3. Statement of the Problem:

   Little is presently known about the fisheries resources of park streams outside of the Redwood Creek basin. For some streams, California Fish and Game laws may be inadequate to achieve self-propagating populations of native species. Existing laws generally provide protection only to species of sport or commericial importance and not to other species. Information concerning the status of all native species needs to be collected for all of the major streams within the park.

   Some forms of log jams are a natural part of a forest ecosystem. In coastal streams supporting anadromous fisheries, these log jams may represent barriers to upstream migration. Above such jams, resident populations of non-migrating rainbow and cutthroat trout may develop. Population density is generally low, while individual size is relatively large, therefore representing a rather unique sport fishery. Because of population size and isolation, the impacts of fishing could be significantly adverse. Therefore, investigations into the dynamics of these resident populations should be undertaken. Such investigations would yield the information needed to make informed decisions regarding management of this resource (e.g. creel and size limits, stream closures) that would ensure its continued existence as a natural part of the redwood forest ecosystem.

4. What Has Been Done:

   Barriers to upstream migration of anadromous fish have been identified in most of the tributaries within the Redwood Creek basin. Some quantitative population sampling has been completed.

5. Description of Work to be Undertaken:

   Determine the distribution and estimate population sizes of native fishes within the entire park. Habitat evaluations will be completed with regard to existing quality and potential for use by fish. Factors precluding use by fish will be identified and, where feasible, recommendations will be made for dealing with these limiting factors. Identify one or two study streams and begin investigations of population dynamics of resident fish species.

6. Length of Time Required: Three years.

(continued)

7. What Will Happen if the Project is not Undertaken:

Management decisions will be based upon limited information.

8. What are the Alternatives:

(a) No action.

(b) Undertake proposed study.

(c) Conduct studies on a portion of park waters.

9. Personnel:

University personnel, park staff

10. Administration and Logistics:

Funding	Years In Program Sequence 1982	1983	1984	1985	1986
Personal Services . .	$ 55,000	$ 55,000	$ 55,000	$ 55,000	$ 55,000
Other	0	0	0	0	0
TOTAL	$ 55,000	$ 55,000	$ 55,000	$ 55,000	$ 55,000
Funds Available in Park Base . . .	$ 0	$ 0	$ 0	$ 0	$ 0
Funds Requested from Regional Office . .	$ 55,000	$ 55,000	$ 55,000	$ 55,000	$ 55,000

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11. References and Contacts:

Redwood National Park, Terry Hofstra, Aquatic Ecologist

12. Date of Submission: October 27, 1981

NATURAL RESOURCE PROJECT STATEMENT

1. Park and Region: Redwood National Park, Western Region

2. Project Name and Number:

   Coastal, Beach, Nearshore Processes of Redwood National Park, N-98

3. Statement of the Problem:

   Elevated sediment yields from north coastal streams have had an unknown effect on riverine estuaries and coastal, nearshore landforms and ecosystems. As accelerated continental sediment production declines, there will likely be gradual or episodic changes in many of the coastal beaches and nearshore areas. Identification of early historical conditions will help delineate shorelines which may be most susceptible to natural adjustment or which have reacted to past changes. Expensive mis-management can be avoided if such changes are anticipated or at least expected.

4. What Has Been Done:

   A preliminary study of coastal slope stability and mass movement processes was completed for the General Management Plan in 1977. On-going contract work is looking at the dynamics of the Redwood Creek estuary system near Orick, California.

5. Description of Work to be Undertaken:

   Aerial photographic and dendrochronologic analysis of the causes, rates and timing of major slope mass movement processes from Orick to Crescent City will be conducted. A study will also be designed and implemented to describe the mode and rate of coastal sediment movement in relation to storms, coastal cliff erosion and coastal stream sediment yields; to describe seasonal changes in beach morphology; and to evaluate the impact of extremely high sediment yields from the Klamath River on historical changes in local beach morphology, especially near the Gold Bluffs.

6. Length of Time Required: Three years.

7. What Will Happen if the Project is not Undertaken:

   Planned development along the coast (e.g. Freshwater Lagoon, Gold Bluff Beach, Enderts Beach, etc.) must be designed to accommodate expected beach and coastal slope processes. Constant erosion in some areas continues to enlarge and threaten park resources. Potential rehabilitation of the Redwood Creek Estuary could be futile or wasted without a clear understanding of the natural factors associated with the timing and characteristics of coastal sediment movement.

(continued)

8. What are the Alternatives:

   (a) No action. Implement coastal projects (trails, campsite improvements, estuary reclamation, etc.) without research information.

9. Personnel: Staff personnel plus one technician.

10. Administration and Logistics:

Funding	Years In Program Sequence 1984	1985	1986
Personal Services . .	$ 16,000	$ 8,000	$ 8,000
Other	8,000	5,000	7,000
TOTAL	$ 24,000	$ 13,000	$ 15,000
Funds Available in Park Base . . .	$ 0	$ 0	$ 0
Funds Requested from Regional Office . .	$ 24,000	$ 13,000	$ 15,000

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11. References and Contacts:

   (a) Park Files

   (b) Coastal Slope Stability Study, General Management Plan

   (c) W. E. Weaver, Geologist

12. Date of Submission: November 1981

NATURAL RESOURCE PROJECT STATEMENT

1. Park and Region: Redwood National Park, Western Region

2. Project Name and Number:

Terraces and Erosion Rates in Redwood Creek, N-104

3. Statement of Problem:

Since park scientists began work in Redwood Creek in 1976, a large number and variety of elevated terraces have been observed along Redwood Creek and its major tributaries. These terraces, if analyzed closely, can yield important information on rates of geologic uplift and natural rates of important information on rates of geologic uplift and natural rates of stream channel erosion over the last several thousand years. These long-term comparisons are important tools needed to place the recent long-term comparisons are important tools needed to place the recent (post-1850) increased erosion rates and sediment yields in perspective. Results of such a study can help reveal man's influence on erosion. The principal objective would be to map and describe elevated alluvial terraces and deposits in Redwood Creek and its tributaries and to relate these findings to rates of uplift and/or erosion.

Elevated terraces and alluvial surfaces can be used to estimate rates of tectonic uplift and "natural" stream erosion. Low terraces may also signify major climatic and hydrologic events. This project will attempt to use geomorphological analyses to reveal natural erosion rates in Redwood Creek and, hence, will provide a basis for evaluating the effect recent land use has had on these same processes.

4. Alternative Actions and Their Probable Impacts:

(a) No Action:

No investigation would be conducted. This project is the third of three projects identified to yield information on long-term erosion rates in the Redwood Creek basin (see also N-90 and N-91). Establishing the magnitude of natural, background erosion rates for the basin has been given major importance (see P.L. 95-250 and Legislative History). It is the only reliable way to differentiate the influence of man's activities from natural processes. This project is aimed at providing estimates of long-term erosion rates and will provide the park (and Congress) with information deemed necessary to protect the park and signal significant changes in the current status of impacted stream channels. No action on this project will make it more difficult to provide Congress with reliable information as to the magnitudes and differentiation of causes of erosion and sedimentation in the Redwood Creek basin.

(b) Initiate Project:

Map terraces and alluvial deposits, correlate deposits from area to area (if possible), date surfaces or deposits (if possible) and prepare reports and recommendations. Expected costs (mostly technical and professional labor) are estimated to be $25,000; $25,000; $10,000 and $5,000 in the years 1985-1988, respectively.

5. Recommended Course of Action:

Initiate study in FY 85. Enlist graduate student participation to conduct field aspects of the project and to keep costs within projected estimates.

6. Sources of Information:

William Weaver, Engineering Geologist, Redwood National Park.

Public Law 95-250 and Legislative History.

NATURAL RESOURCE PROJECT STATEMENT

1. Park and Region: Redwood National Park, Western Region

2. Project Name and Number: Water Rights, N-107

3. Statement of the Problem:

Portions of two moderate-sized rivers (Smith and Klamath), the lower third of a large creek (Redwood), and portions of six coastal streams flow through Redwood National Park. All have fishery resource management problems, two have poor water quality problems, and the most pristine (the Smith) has a large, cobalt-nickel processing plant proposed within its watershed along with concurrent mining. In addition some of the rivers are affected by in-stream gold dredging activities. Although there are few water use or water management problems which directly threaten park resources, the park also has little information regarding its water rights with which to help make management decisions.

4. Alternative Actions and Their Probable Impacts:

(a) No Action:

A specific study of the water rights and water laws for Redwood National Park would not be undertaken. Rather, water related questions would be addressed on a case by case basis as a particular issue arose. The result would be a piecemeal approach to water problems. Current problems would not be addressed and some resource restoration projects would not be undertaken.

(b) Conduct Water Rights Study:

Water rights specialists from the Regional Office and Water Quality Division, Ft. Collins, Colorado, would gather information about the park's water rights, interpret that information, and prepare a report on the water rights and laws. Such a report would be of great assistance in understanding the park's water rights status and assist park management in evaluating the impact of threats to park resources.

5. Recommended Course of Action:

Implement Alternative B and conduct the water rights study.

NATURAL RESOURCE PROJECT STATEMENT

1. Park and Region: Redwood National Park, Western Region

2. Project Name and Number: Design Water Quality Sampling Program, N-108

3. Statement of the Problem:

Too little information exists on the quality of rivers and streams which flow through the park for the detection of any changes which may occur over time due to industrial developments, land use changes, waste discharges, or other activities which degrade water quality. Degraded water quality may affect aesthetic qualities, degrade aquatic life and fisheries, be harmful to legitimate water users, or may adversely impact human health. Without sufficient basic resource information, changes in water quality cannot be detected, causes identified, nor remedial actions taken.

Currently, available information consists of a short term, limited data base on enteric/microorganisms, now several years old, is available for Redwood Creek. In addition, an extensive data base on water and sediment discharge is available from USGS gaging stations. Portions of the Smith River have been sampled to obtain baseline data for the Cal-Nickel mine and processing plant. These data are too limited in depth, scope, location, and frequency to provide information required to support park programs or management actions.

The first step in the data collection process is encompassed by this project: to design a sampling program which would provide park management with the necessary information to evaluate potential problems with park waters.

4. Alternative Actions and Their Probable Impacts:

(a) No Action:

A water quality monitoring design would not be developed and no specific monitoring of park waters would occur to determine the extent of pollution. As a result, park management would rely on the existing data base or additional short term studies to try and respond to potential threats to park waters. Those short term studies would be hindered by the lack of overall direction provided by a study design.

(b) Implement Parkwide Water Quality Design Program:

The study would involve designing a parkwide water quality sampling program. A review of the existing data base along with State of California, EPA, and National Park Service water plans and regulations

would be accomplished. Water quality specialists from the Regional Office and the Water Quality Division would be consulted in developing the program. It is expected that the design would take three to six months to develop. The result would be a sample design which could be implemented both to obtain long term baseline water quality information or provide a guide to respond to short term emergencies.

5. Recommended Course of Action:

Implement Alternative B and conduct a design to complete water quality sampling program for park waters.

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Anadromous Salmonid Nursery Habitat in the Redwood Creek Watershed
G. Anderson, R. A. Brown

An Evaluation of Techniques for Collection and Analysis of Benthic Invertebrate Communities in Second-Order Streams in Redwood National Park
J. M. Harrington

Aquatic Resources Rehabilitation, Redwood National Park
T. D. Hofstra, J. M. Harrington

Summer "Cold Pools" in Redwood Creek Near Orick, California and their Importance as Habitat for Anadromous Salmonids
E. Keller, T. D. Hofstra

Water Quality and Productivity of the Redwood Creek Estuary
J. Larson, J. McKeon, T. Salamunovich, T. D. Hofstra

Timber Harvesting and Runoff in Redwood Creek Basin, California
V. M. King

Redwood Creek Estuary Flood History, Sedimentation and Implications for Aquatic Habitat
C. Ricks

Determining the Economic Value of Aquatic Resources Within the Impact Area of Proposed Highway Construction
R. Wood, California Department of Fish and Game, Eureka, California
T. Hofstra, Redwood National Park, Arcata, California
D. McLeod, California Department of Fish and Game, Eureka, California

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Magnitude and Causes of Gully Erosion in the Lower Redwood Creek Drainage Basin
W. E. Weaver and D. K. Hagans

Role of Fluvial Hillslope Erosion and Road Construction in the Sediment Budget of Garrett Creek, Humboldt County, California
D. K. Hagans, H. Kelsey, D. Best, and M. Alpert

Sediment Routing in Tributaries of the Redwood Creek Basin: Northwestern California
J. Pitlick

Recent Changes in Channel Stored Sediment in Redwood Creek Basin
M. A. Madej

Geomorphic Analysis of Streamside Landslides in the Redwood Creek Basin
M. Kelsey, M. Coghlan, J. Pitlick and D. Best

Summer Cool Pools in Redwood Creek Near Orick, California
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Appendix A

Hydrologic Records Available at
Redwood National Park

I. Precipitation

National Weather Service:

Station	Period of Record	Type of Data
Eureka Weather Service Office	1891 to Present	Daily Totals

Redwood National Park:

Station	Period of Record	Type of Data
Little Lost Man Creek @ Site #2 (RNP 1)	10-01-74 to Present	Monthly Totals
Lost Man Creek @ 18.5 (RNP 2)	10-08-73 to Present	Monthly Totals
Lost Man Creek Near Orick (RNP 3)	10-06-73 to 3-82	Monthly Totals
Freshwater Lagoon (RNP 4)	10-01-74 to 4-82	Monthly Totals
McArthur & Elam Divide (RNP 5)	10-01-77 to Present	Monthly Totals
Hayes Creek (RNP 6)	11-01-73 to Present	Monthly Totals
Upper Little Lost Man Creek (RNP 7)	10-08-73 to Present	Monthly Totals
Holter Ridge (RNP 8)	10-13-73 to Present	Monthly Totals
Bald Hills Road and C-Line (RNP 9)	10-01-74 to Present	Monthly Totals

Appendix A (Continued)

Station	Period of Record	Type of Data
Bond & 44 Creek Divide (A-Line)	10-16-73 to Present	Monthly Totals
Upper Miller & C-Line (RNP 11)	11-01-73 to Present	Monthly Totals
C-50 (Upper Harry) Weir (RNP 12)	10-28-74 to Present	Monthly Totals
Head of Tom McDonald Creek (RNP 13)	10-01-74 to Present	Monthly Totals
M-Line and G-Line Intersection (RNP 14)	10-16-73 to Present	Monthly Totals
M-7-5 Road (RNP 15)	10-01-74 to Present	Monthly Totals
Shotgun Pass (RNP 16) 16	10-16-73 to Present	Monthly Totals
Copper Creek (RNP 17)	10-13-73 to Present	Monthly Totals
Little River - Redwood Creek Divide (RNP 18)	11-19-74 to 10-01-181	Monthly Totals
Kerr Prairie (Stiglich Farm) Farm)	1982 to Present	Daily rainfall, snowfall, and temperature.
Elk Camp	10-16-73 to Present	Continuous Recording (15-minute intervals)
Klamath & Korbel Road	10-16-74 to 10-01-82	"

Appendix A (Continued)

Station	Period of Record	Type of Data
Orick Operations (RNP)	01/81 to Present	Daily Totals
Bridge Creek #1 Slope Plots	10/79 to 05/81	Monthly Totals
Bridge Creek #2 Crossing #7	01/80 to 5/81 (Partial)	Monthly Totals
Bond Creek #1 Upper	10/79 to 05/81	Monthly Totals
Bond Creek #2 Lower	10/79 to 05/81	Monthly Totals
Copper Creek	10/80 to 05/81	Monthly Totals
Manezes Creek	10/80 to 05/81	Monthly Totals
Emerald Creek - C-90 Road Near Slide	10/81 to 10/82	Monthly Totals
Emerald Creek - Site 81-6	10/81 to 10/82	Monthly Totals
West Side Access Road	10/81 to 10/82	Monthly Totals
M-6 West Side (Near Site 80-3)	10/81 to 10/82	Monthly Totals
Bridge Creek Site 80-3	11/80 to 04/81	Monthly Totals
Bridge Creek (near M-6 and M-line intersection)	10/82 to present	Continuous recording (15-minute intervals)
A-9 deck	10/82 to present	Continuous recording (15-minute intervals)

California Department of Water Resources Stations:

Station	Period of Record	Type of Data
Big Lagoon	10/47 to 12/71 10/77 to 09/79	Monthly Totals
Blue Lake	01/50 to 07/71	Monthly Totals
Fieldbrook 4D Ranch	01/55 to 12/79	Monthly Totals
Honor Camp #42	01/56 to 09/71	Monthly Totals
Long Prairie Ranch	07/52 to 09/62	Monthly Totals
Orick 5 SSW	07/51 to 06/56	Monthly Totals
Orick (Arcata Redwood Co.)	07/54 to Present	Monthly Totals
Orick 3 NNE Davidson Ranch	07/50 to Present	Monthly Totals
Patrick Point State Park	07/47 to 04/72	Monthly Totals

Other:

Station	Period of Record	Type of Data
Prairie Creek Fish Hatchery (Humboldt State Redwoods Park)	07/72 to 02/82	Daily Totals
Minor Creek (U.S.G.S.)	10-26-74 to Present	Continuous recording (15-minute intervals

Appendix A

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Station	Period of Record	Type of Data
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Lost Man Creek Near Orick (RNP 3)	10-06-73 to 3-82	Monthly Totals
Freshwater Lagoon (RNP 4)	10-01-74 to 4-82	Monthly Totals
McArthur & Elam Divide (RNP 5)	10-01-77 to Present	Monthly Totals
Hayes Creek (RNP 6)	11-01-73 to Present	Monthly Totals
Upper Little Lost Man Creek (RNP 7)	10-08-73 to Present	Monthly Totals
Holter Ridge (RNP 8)	10-13-73 to Present	Monthly Totals
Bald Hills Road and C-Line (RNP 9)	10-01-74 to Present	Monthly Totals

* Since 1982, daily sediment measurements are only taken from Oct. 1 through April 30.