RN Park 1986

ESTUARINE MANAGEMENT AND RESEARCH ACTIVITIES
MOUTH OF REDWOOD CREEK
1985

Redwood National Park
Crescent City, California
February 1986

INTRODUCTION

Background

During late spring and early summer months, as water discharge in Redwood Creek decreases, ocean waves often build a sand berm at the mouth of the creek, forming an embayment east of the beach. By providing habitat for optimal growth and marine acclimation, the embayment is a critical element in the life history of anadromous salmonids, particularly chinook salmon. However, the morphology and productivity of the embayment were adversely altered by the construction of a flood control project on the lower 3.2 miles of Redwood Creek in 1968. In addition, as the embayment forms and water level exceeds 5.0 feet above mean sea level, adjacent private farm lands are flooded. Draining of the embayment to prevent flooding removes fish habitat and can prematurely wash fish into the ocean. A detailed discussion of the problem and alternatives are discussed in Management Alternatives for the Redwood Creek Estuary, March 1983, Redwood National Park.

The park has actively managed the remnant Redwood Creek embayment since 1982. Management actions were designed to maintain what little rearing habitat remained and to prevent flooding of private property resulting from natural embayment formation.

Summary Evaluation for 1985

The overall objective of activities undertaken in 1985 was to maintain summertime estuarine habitat for rearing juvenile salmonids while preventing flooding of adjacent private property. Management and research activities included topographic and bathymetric surveys, embayment water level control, water quality monitoring, and numbers and growth monitoring of juvenile salmonids utilizing the embayment.

Flooding of private property was prevented. Water levels fluctuated greatly and were generally marginal as far as fish habitat was concerned. However, tolerable embayment conditions were maintained so that some habitat was available for juvenile salmonids. Invertebrate production in the embayment and its value as salmonid rearing habitat was limited by unstable substrate. Bottom instability resulting from tidally influenced water level fluctuations was further aggravated by park water level control activities. Nevertheless, juvenile chinook salmon, steelhead, and cutthroat trout did spend an extended period in the embayment. During this period, rearing salmon and steelhead grew substantially. Such growth enhances their chances of survival during the ocean stage of their life cycle.

Slough necks excavated in 1983 to restore embayment volume and to improve fish access to the sloughs were resurveyed. The resurvey shows that sand deposition has occurred in the areas of excavation although the channel bottoms of the slough necks remain considerably below pre-excavation levels.

Proposed Activities for 1986

1. It is proposed as a short term solution that embayment water levels be regulated by the NPS by controlled breaching.

   Under certain summertime, low flow conditions, embayment water levels can be controlled to prevent flooding of private property while maintaining some juvenile fish habitat. Embayment water level control is an expensive and time consuming method of dealing with the flooding/fish habitat issue. However, as long as adjacent private property can not be permitted to flood by natural embayment formation, water levels must be controlled in a manner which also protects fish habitat as much as possible.

   Water levels will be maintained as close to 5.0 feet above mean sea level as possible. This is the elevation which maximizes fish habitat without flooding adjacent pasturelands. If necessary for construction purposes (See number 6. below) water levels may be maintained below 5.0 feet above mean sea level.

2. It is proposed that the north and south slough necks be resurveyed.

   A resurvey of the slough necks would identify the degree of winter sediment accumulation in excavated areas. An evaluation could then be made of fish accessibility to the sloughs during 1986.

3. It is proposed that the park continue to evaluate alternatives to improve circulation patterns in the north slough.

   Poor summertime water quality in the north slough will limit fish habitat until circulation patterns are improved. Alternatives to improve water quality, such as installation of gated culvert(s) in the levee, should be pursued.

4. It is proposed that estuarine water quality, and embayment fish numbers and growth rates be monitored.

5. It is proposed the park increase interpretation and public dissemination of information regarding park management activities at the estuary.

6. It is proposed that a controlled floodgate be installed through the south levee to allow Redwood Creek flows to enter the south slough.

   Improving water circulation and quality in the south slough would improve this area as summer rearing habitat for juvenile salmonids. The project would be funded by the California Department of Transportation as mitigation for fisheries losses from construction of the U.S. Highway 101 Bypass project.

MANAGEMENT, RESEARCH AND MONITORING ACTIVITIES IMPLEMENTED IN 1985

South and North Slough Resurvey

Accumulated sand was excavated from the slough necks to restore embayment volume and improve access for juvenile salmonids to the main slough areas in 1983. The area excavated is shown in Figure 1. Profiles were surveyed across the neck areas before and after excavations to document the amount of material removed and to determine final channel configuration. Profile locations are shown in Figure 2.

The resurvey shows the excavated channels have undergone some readjustment and filling with sand. Sand deposition was greatest near the mouths of both sloughs, however, channel bottom elevations are still lower at these sites than farther up each neck. Therefore, sediment accumulation at the slough mouths is not yet a problem and is likely to fluctuate both higher and lower in future years.

Circulation between each slough and the mouth of Redwood Creek is controlled by the highest channel-bottom elevation in the connecting neck. This "limiting elevation" prevents circulation and fish movement when the backwater of Redwood Creek falls near or below that level. Limiting elevations remain considerably below pre-excavation levels:

Limiting Elevations (above mean sea level)

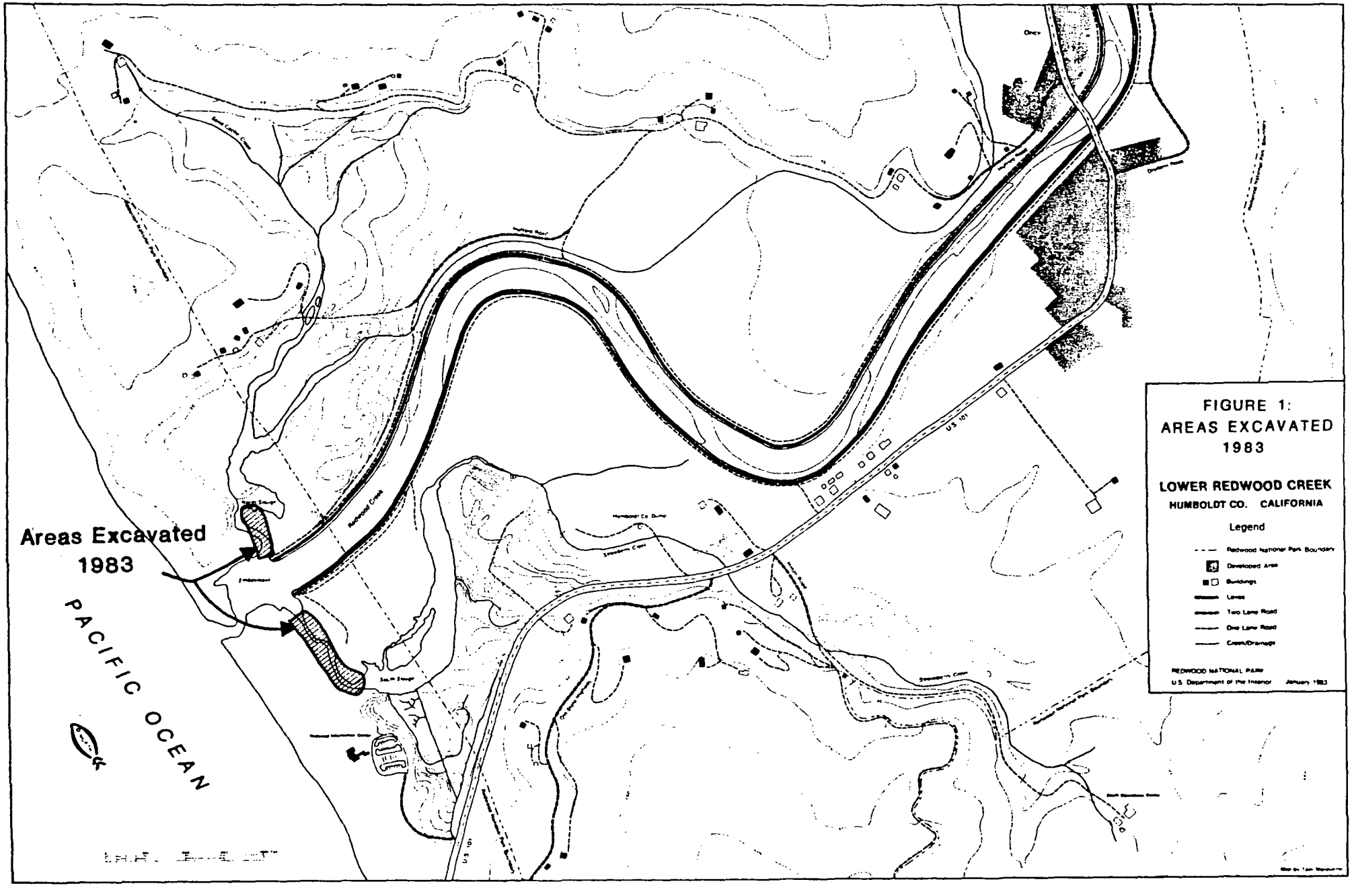
	May, 1983 (Before Excavation)	July, 1983 (After Excavation)	July, 1984 (After First Winter)	September, 1985 (After Second Winter)
South Slough	2.9	0.1	1.2	1.2
North Slough	6.6	3.1	2.2	2.4

Embayment Water Level Control

The objective was to maintain embayment water levels to protect adjacent private lands from flooding while retaining sufficient water to provide habitat for juvenile salmonids. Water levels were to be maintained as high as possible without exceeding 5.0 feet above mean sea level, when pastures begin to flood. An operations plan was developed by Resources Management Division outlining objectives, methods, and responsiblities.

Water levels were manipulated by controlled breaching a total of 6 times from June 29 through September 16.

In conjunction with embayment water level control, a record of water levels and other observations was maintained by Resources Management. Entries


Areas Excavated
1983
PACIFIC OCEAN
FIGURE 1:
AREAS EXCAVATED
1983
LOWER REDWOOD CREEK
HUMBOLDT CO. CALIFORNIA
Legend
REDWOOD NATIONAL PARK
U.S. Department of the Interior

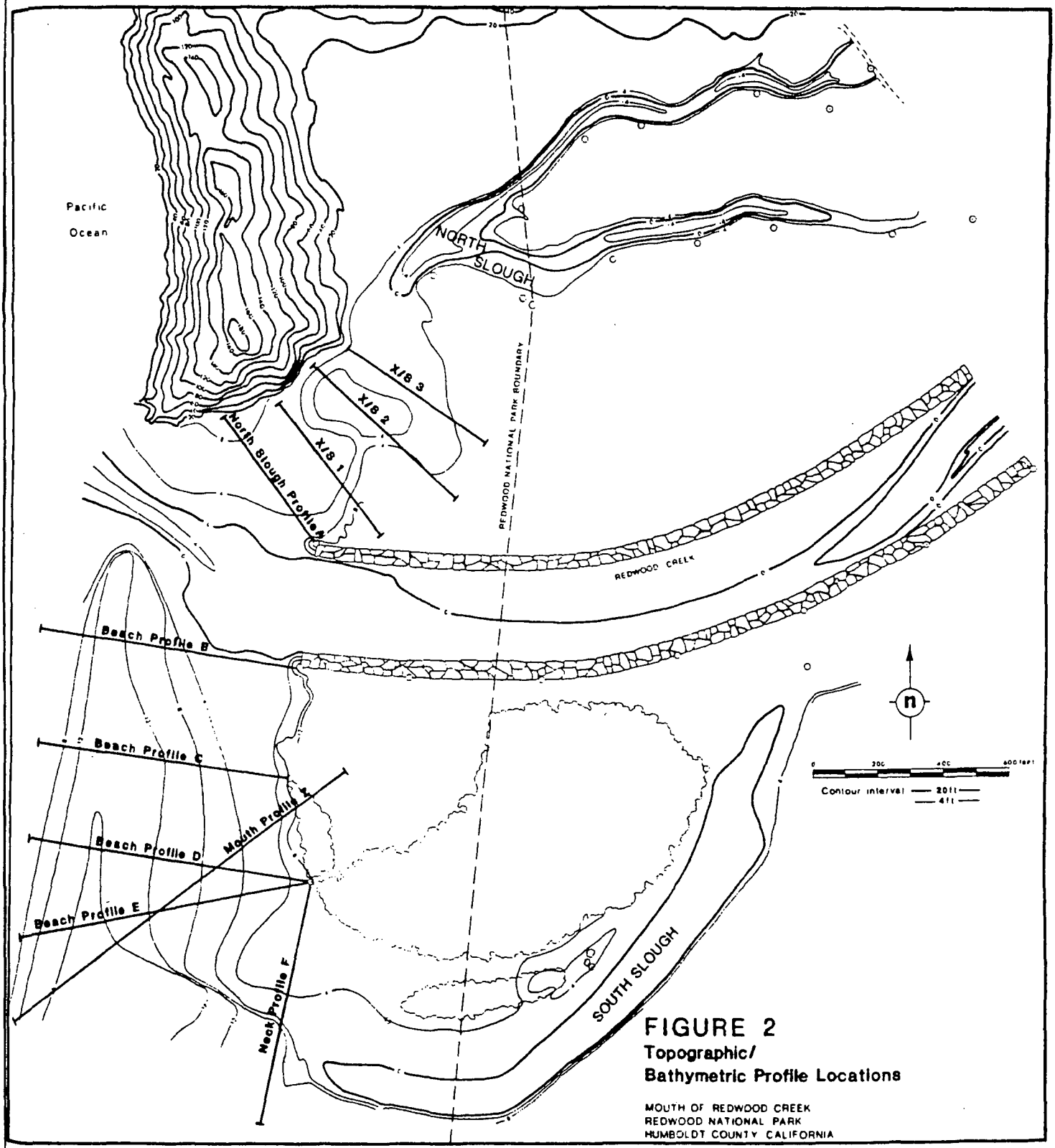


FIGURE 2

Topographic/
Bathymetric Profile Locations

MOUTH OF REDWOOD CREEK
REDWOOD NATIONAL PARK
HUMBOLDT COUNTY CALIFORNIA

included water levels, outflow configuration, wind and sea conditions, time spent, and other comments. A total of 457 observations were recorded from June 1 to November 15.

Water Quality Studies

Monitoring was conducted to determine if and when estuarine (embayment and sloughs) water quality was a limiting factor for juvenile salmonids. Parameters measured at twelve sites in the north and south sloughs and the embayment included conductivity, temperature, salinity, and dissolved oxygen. A vertical profile from surface to bottom was determined for each parameter, at each station, 9 different times from June 26 through October 17. Poorest water quality was observed in the sloughs, where temperatures reached levels that were limiting to salmonids. In the embayment, water temperature was never limiting. Dissolved oxygen was generally adequate at all sites throughout the summer. Levels in the north slough, however, became limiting in late summer below about 4 feet in depth. Dissolved oxygen levels also became limiting near the bottom of the south slough during this same period.

The embayment alternated between a fresh and brackish water system. High tides and ocean overwash caused short periods when brackish conditions prevailed. A dense salt water layer remained on the slough bottoms throughout the summer. A salt water layer also existed on the embayment bottom, but its depth varied with tide, ocean conditions, and mouth configuration.

Fish Migration and Estuary Utilization

This program was directed at determining numbers and growth of juvenile salmonids utilizing the embayment.

Embayment fish populations were estimated by seining and marking captured fish. The ratio of marked versus unmarked fish captured two days later was utilized in calculating population estimates. Four estimates were made from July 8 to September 16. Growth was monitored 7 times by seining and measuring each fish captured from June 27 to October 9. On each of these sampling days approximately 20 fish (10 steelhead and 10 salmon) were sacrificed for stomach analyses and for determination of food habits. Scales were collected from 30 individuals of each species.

The major area utilized by juvenile salmonids was the embayment. Fish avoided the saltwater layer on the embayment bottom and area adjacent to the ocean berm during periods of overwash, preferring water of lower salinity. Few fish utilized the sloughs. Population estimates and growth for juvenile chinook salmon and steelhead trout are shown in Figures 3 and 4. These figures show downstream migrating salmonids found favorable habitat in the estuary as soon as an embayment began to form.

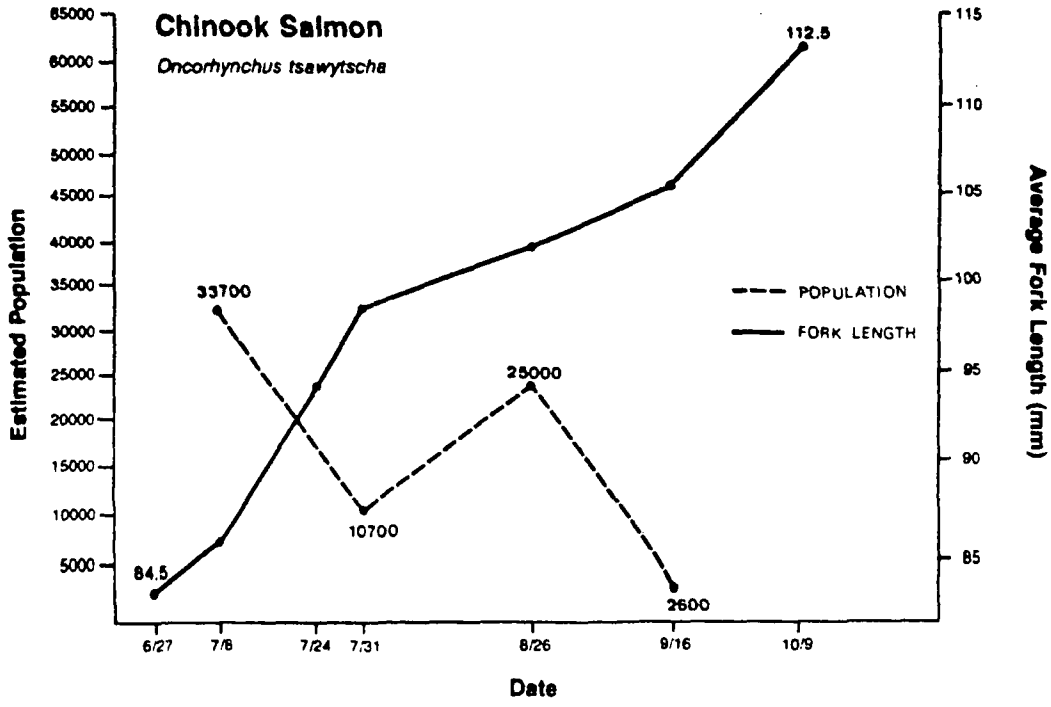


FIGURE 3: Population estimates and growth of chinook salmon, Summer 1985

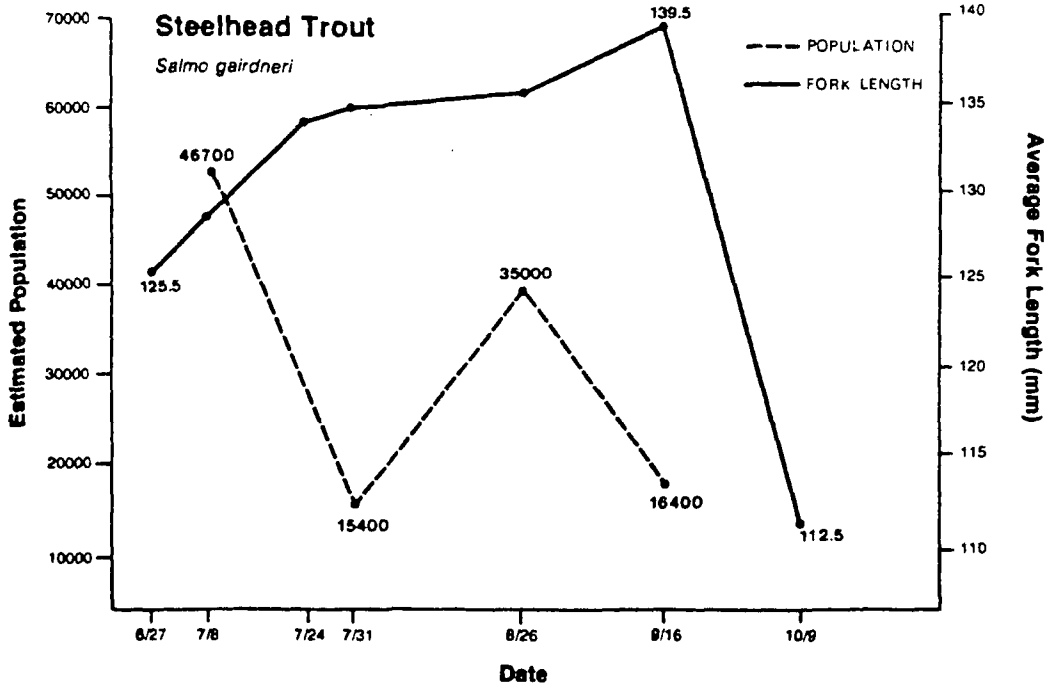


FIGURE 4: Population estimates and growth of steelhead trout, Summer 1985

Juvenile salmon growth in the estuary during the summer was significant (see Figure 3). Fork length averaged 84.5 mm on June 27 and 112.5 mm on October 9.

Patterns of estuarine use by juvenile steelhead trout (Figure 4) were similar to that of salmon. That is, when habitat was available, steelhead spent an extended period in the estuary.

1985 Cost Summary

Management Activities

Water Level Control and Monitoring	13,900
Total	$13,900

Research and Monitoring

Resurvey of Excavated Areas	$ 800
Water Quality Monitoring	1,300
Aquatic Invertebrate (Analysis of 1984 samples)	2,000
Fish Population and Growth Monitoring	4,600
Total	$8,700

SOUTH SLOUGH INTAKE STRUCTURE
PROJECT DESCRIPTION

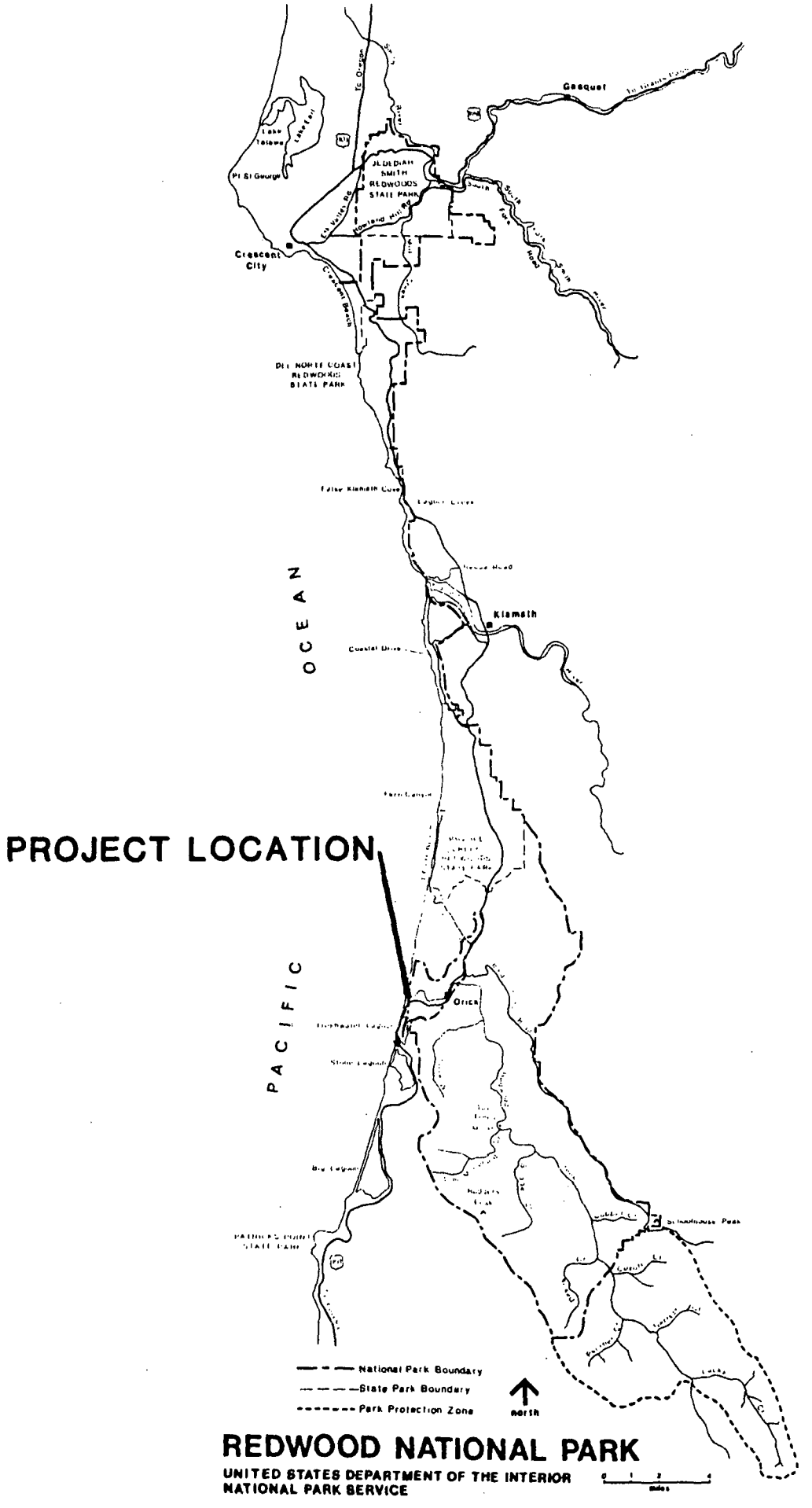
The proposed culverts are intended to partially offset the fisheries losses resulting from construction of the U.S. 101 Bypass project. By diverting a portion of Redwood Creek's flow through the former main channel of the creek (now the South Slough), summer rearing habitat for juvenile steelhead and chinook salmon will be improved (see attached drawings).

Through an agreement with the National Park Service, the culverts will be designed and constructed by the Corps of Engineers. The National Park Service is responsible for obtaining necessary permits and the Service will also own and operate the culverts when construction is complete. The California Department of Transportation is obtaining the right-of-way and is funding the project.

The culverts will consist of three, eight-foot by nine-foot concrete boxes with manually operated gates on each culvert. The culverts will be approximately 120 feet long, with a trash screen on the upper end to match the existing levee bank and an apron on the downstream end to direct discharge. The culverts will require approximately 2.2 acres while temporary storage of equipment and material will require an additional 3.8 acres.

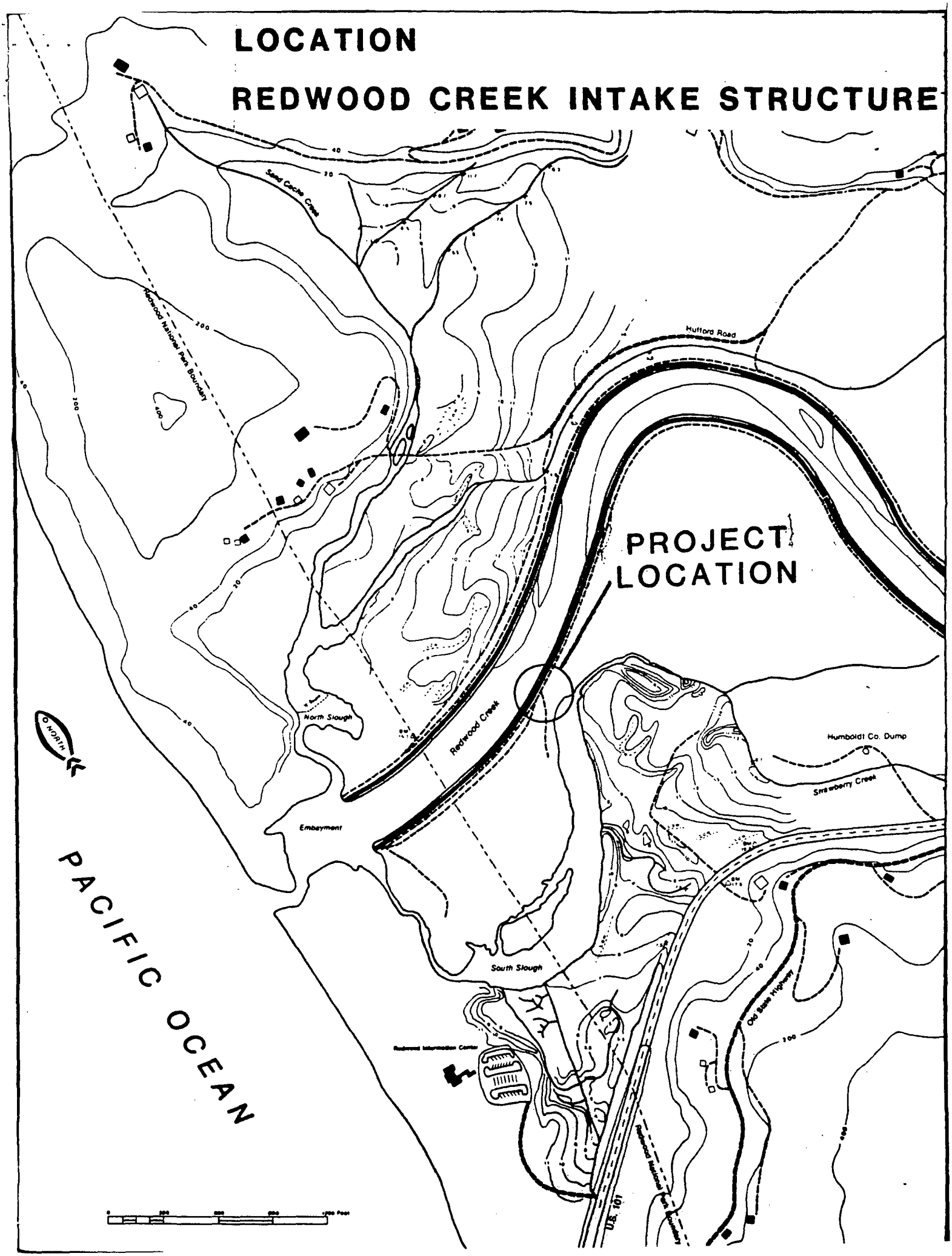
Construction of the culverts will require removal of a portion of the existing levee at the upper end of the South Slough. The existing levee material, which consists of rock and soil, will be stored on-site and partially reused during construction. Cofferdams may be constructed in Redwood Creek and the South Slough to prevent backwater flooding from interfering with construction. Alternately, the National Park Service may manage water levels as it has in the past four summers to prevent flooding. The culverts will be built in place and the levee material will be placed on the sides and over the top of the boxes. At the conclusion of the work, the overall levee configuration will remain the same as it appears today.

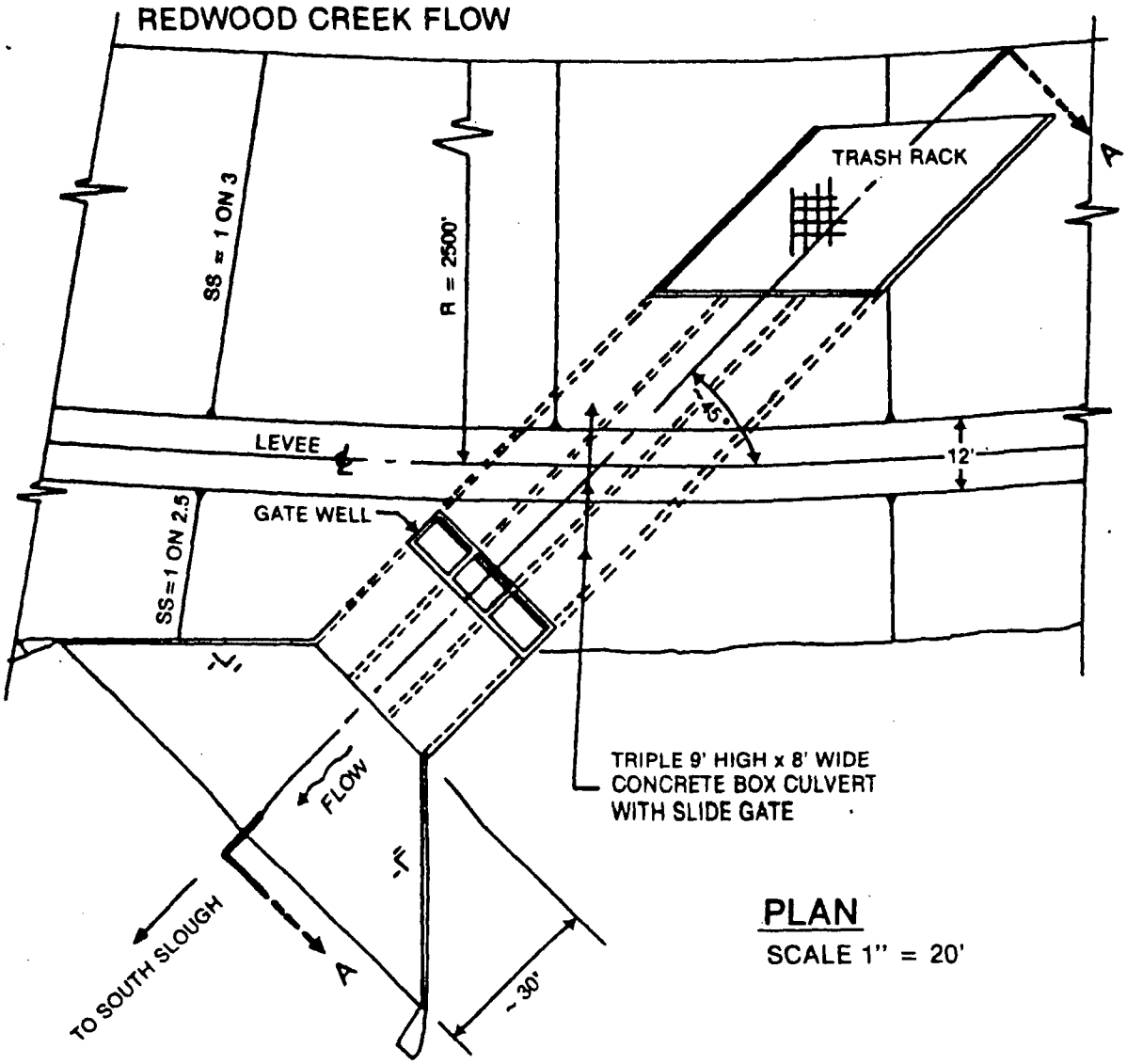
The Corps has provided the park with a rating curve for the culverts, however it will take several months of winter and summer flows to calibrate the culverts and their gates. During the summer months, water level management activities will continue at the mouth of Redwood Creek to maintain rearing habitat for juvenile salmonids while preventing flooding of adjacent private property. If necessary, a small (2 - 3-foot high), seasonal gravel berm will be created in Redwood Creek to divert the low summer flow into the South Slough. The berm would be pushed up using heavy equipment in early summer and allowed to wash away with winter rains.


PROJECT LOCATION
OCEAN
PACIFIC
Crescent City
Klamath
Orick
Gasquet
Lake Talawa
Pt St George
JEDEDIAH SMITH REDWOODS STATE PARK
DEL NORTE COAST REDWOODS STATE PARK
Coastal Drive
National Park Boundary
State Park Boundary
Park Protection Zone
north
REDWOOD NATIONAL PARK
UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

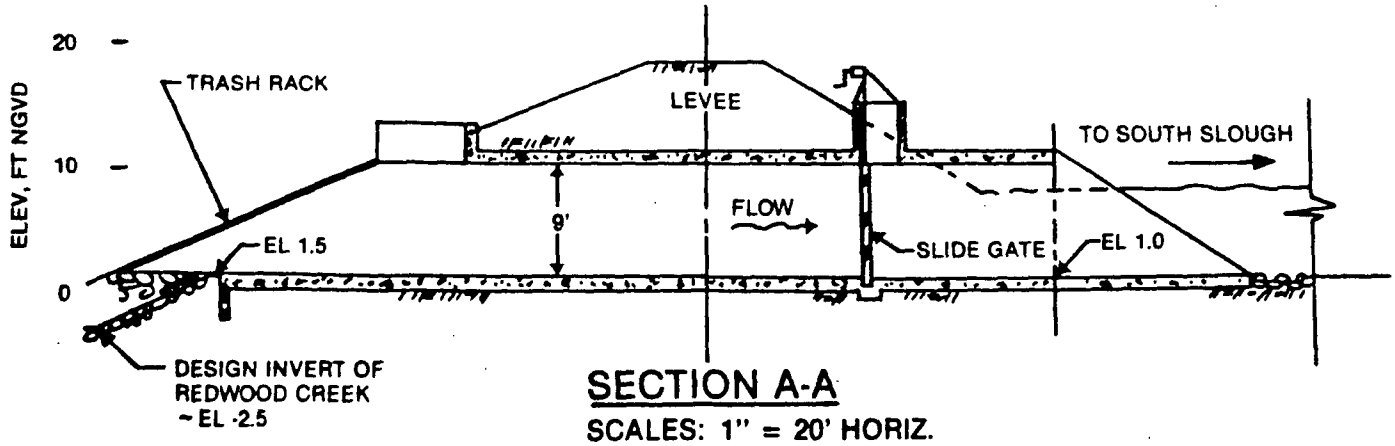
LOCATION

REDWOOD CREEK INTAKE STRUCTURE





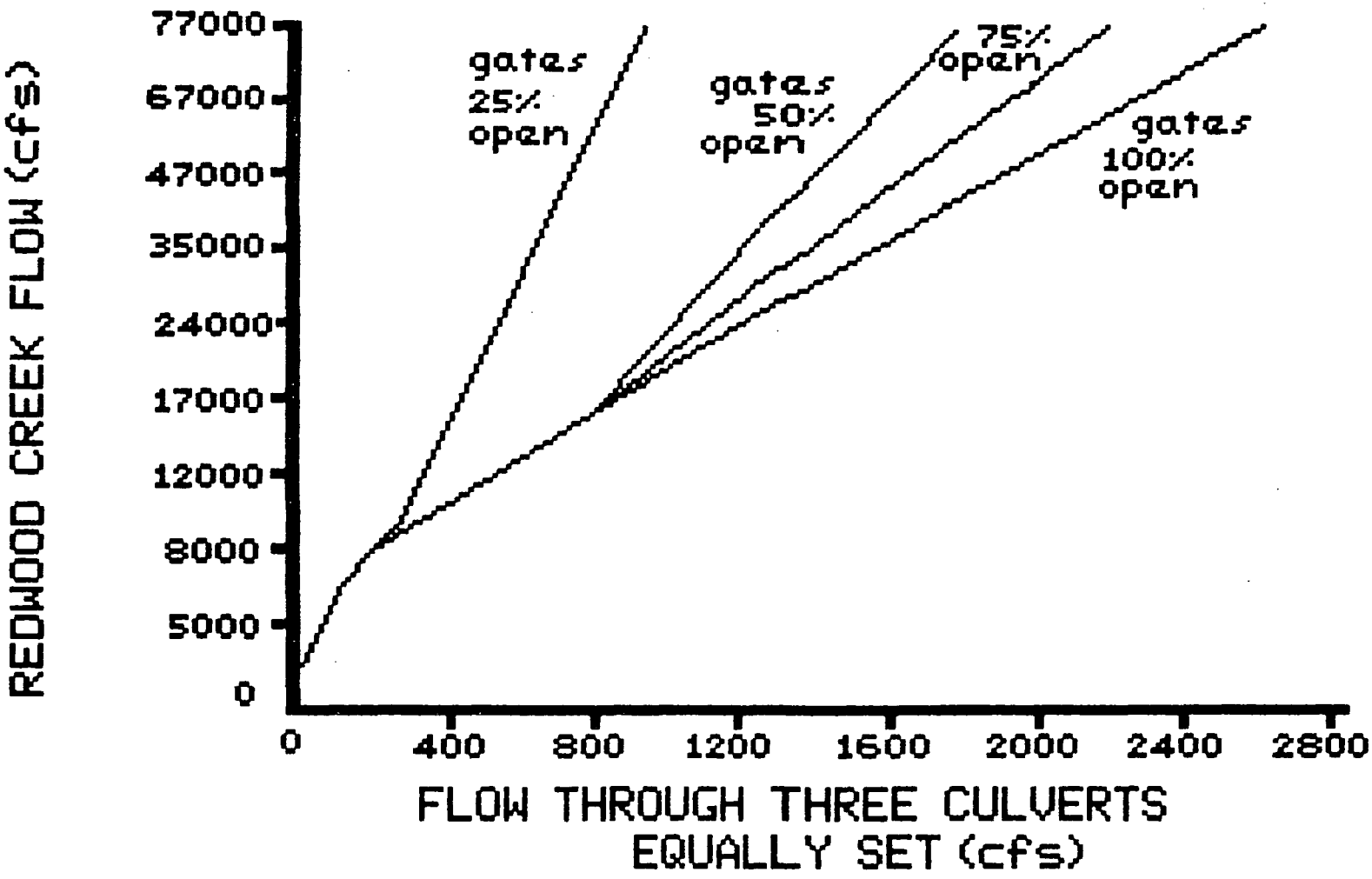
PLAN
SCALE 1" = 20'



SECTION A-A
SCALES: 1" = 20' HORIZ.
1" = 10' VERT.

SOUTH SLOUGH INTAKE STRUCTURE ON REDWOOD CREEK, ORICK, CA.

Redwood Creek Rating Curve



ESTUARINE MANAGEMENT AND RESEARCH ACTIVITIES
MOUTH OF REDWOOD CREEK
1985

CONTAINS POP'N ESTIMATES

Redwood National Park
Crescent City, California
February 1986

INTRODUCTION

Background

During late spring and early summer months, as water discharge in Redwood Creek decreases, ocean waves often build a sand berm at the mouth of the creek, forming an embayment east of the beach. By providing habitat for optimal growth and marine acclimation, the embayment is a critical element in the life history of anadromous salmonids, particularly chinook salmon. However, the morphology and productivity of the embayment were adversely altered by the construction of a flood control project on the lower 3.2 miles of Redwood Creek in 1968. In addition, as the embayment forms and water level exceeds 5.0 feet above mean sea level, adjacent private farm lands are flooded. Draining of the embayment to prevent flooding removes fish habitat and can prematurely wash fish into the ocean. A detailed discussion of the problem and alternatives are discussed in Management Alternatives for the Redwood Creek Estuary, March 1983, Redwood National Park.

The park has actively managed the remnant Redwood Creek embayment since 1982. Management actions were designed to maintain what little rearing habitat remained and to prevent flooding of private property resulting from natural embayment formation.

Summary Evaluation for 1985

The overall objective of activities undertaken in 1985 was to maintain summertime estuarine habitat for rearing juvenile salmonids while preventing flooding of adjacent private property. Management and research activities included topographic and bathymetric surveys, embayment water level control, water quality monitoring, and numbers and growth monitoring of juvenile salmonids utilizing the embayment.

Flooding of private property was prevented. Water levels fluctuated greatly and were generally marginal as far as fish habitat was concerned. However, tolerable embayment conditions were maintained so that some habitat was available for juvenile salmonids. Invertebrate production in the embayment and its value as salmonid rearing habitat was limited by unstable substrate. Bottom instability resulting from tidally influenced water level fluctuations was further aggravated by park water level control activities. Nevertheless, juvenile chinook salmon, steelhead, and cutthroat trout did spend an extended period in the embayment. During this period, rearing salmon and steelhead grew substantially. Such growth enhances their chances of survival during the ocean stage of their life cycle.

Slough necks excavated in 1983 to restore embayment volume and to improve fish access to the sloughs were resurveyed. The resurvey shows that sand deposition has occurred in the areas of excavation although the channel bottoms of the slough necks remain considerably below pre-excavation levels.

Proposed Activities for 1986

1. It is proposed as a short term solution that embayment water levels be regulated by the NPS by controlled breaching.

   Under certain summertime, low flow conditions, embayment water levels can be controlled to prevent flooding of private property while maintaining some juvenile fish habitat. Embayment water level control is an expensive and time consuming method of dealing with the flooding/fish habitat issue. However, as long as adjacent private property can not be permitted to flood by natural embayment formation, water levels must be controlled in a manner which also protects fish habitat as much as possible.

   Water levels will be maintained as close to 5.0 feet above mean sea level as possible. This is the elevation which maximizes fish habitat without flooding adjacent pasturelands. If necessary for construction purposes (See number 6. below) water levels may be maintained below 5.0 feet above mean sea level.

2. It is proposed that the north and south slough necks be resurveyed.

   A resurvey of the slough necks would identify the degree of winter sediment accumulation in excavated areas. An evaluation could then be made of fish accessibility to the sloughs during 1986.

3. It is proposed that the park continue to evaluate alternatives to improve circulation patterns in the north slough.

   Poor summertime water quality in the north slough will limit fish habitat until circulation patterns are improved. Alternatives to improve water quality, such as installation of gated culvert(s) in the levee, should be pursued.

4. It is proposed that estuarine water quality, and embayment fish numbers and growth rates be monitored.

5. It is proposed the park increase interpretation and public dissemination of information regarding park management activities at the estuary.

6. It is proposed that a controlled floodgate be installed through the south levee to allow Redwood Creek flows to enter the south slough.

   Improving water circulation and quality in the south slough would improve this area as summer rearing habitat for juvenile salmonids. The project would be funded by the California Department of Transportation as mitigation for fisheries losses from construction of the U.S. Highway 101 Bypass project.

MANAGEMENT, RESEARCH AND MONITORING ACTIVITIES IMPLEMENTED IN 1985

South and North Slough Resurvey

Accumulated sand was excavated from the slough necks to restore embayment volume and improve access for juvenile salmonids to the main slough areas in 1983. The area excavated is shown in Figure 1. Profiles were surveyed across the neck areas before and after excavations to document the amount of material removed and to determine final channel configuration. Profile locations are shown in Figure 2.

The resurvey shows the excavated channels have undergone some readjustment and filling with sand. Sand deposition was greatest near the mouths of both sloughs, however, channel bottom elevations are still lower at these sites than farther up each neck. Therefore, sediment accumulation at the slough mouths is not yet a problem and is likely to fluctuate both higher and lower in future years.

Circulation between each slough and the mouth of Redwood Creek is controlled by the highest channel-bottom elevation in the connecting neck. This "limiting elevation" prevents circulation and fish movement when the backwater of Redwood Creek falls near or below that level. Limiting elevations remain considerably below pre-excavation levels:

Limiting Elevations (above mean sea level)

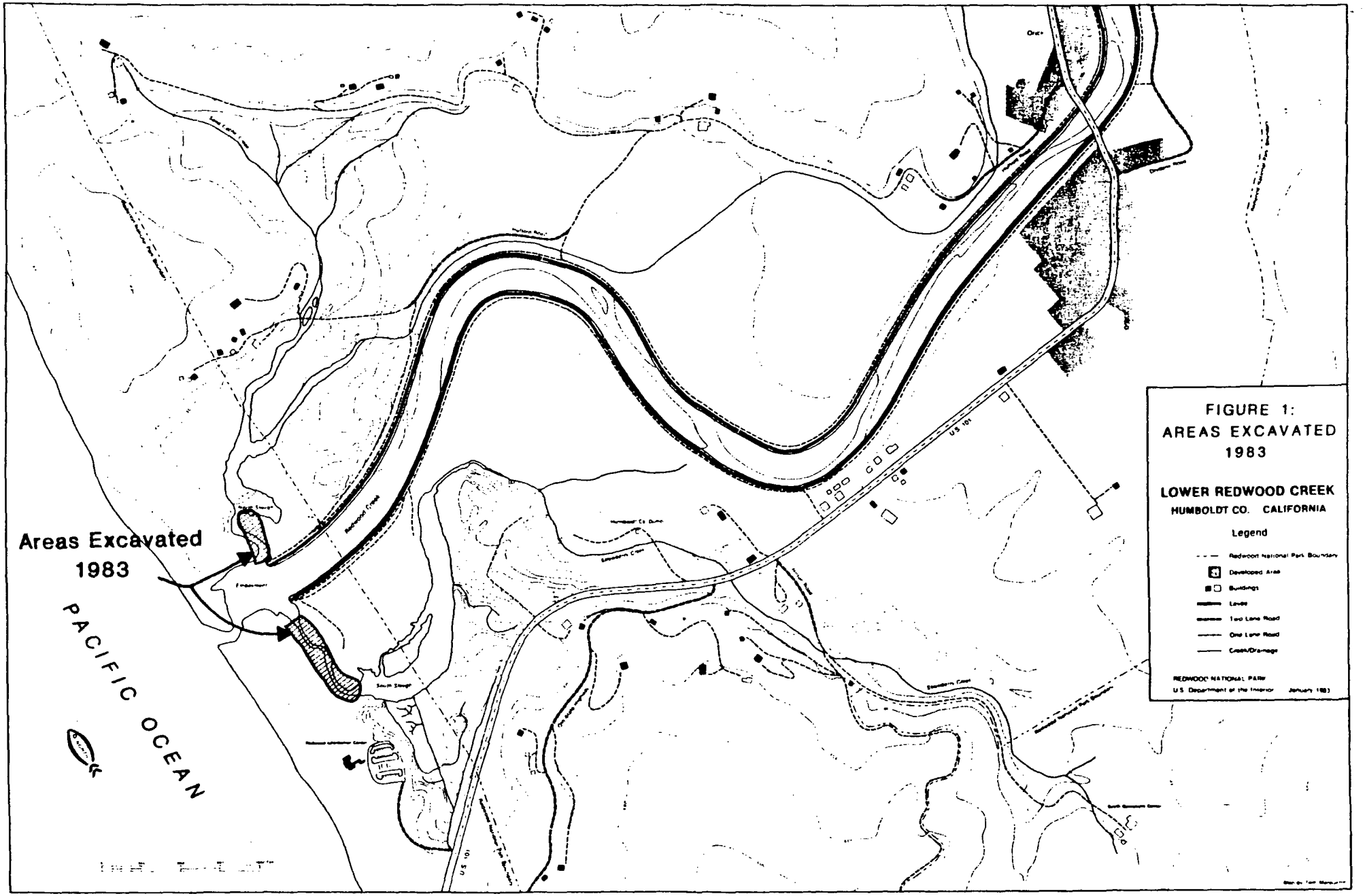
	May, 1983 (Before Excavation)	July, 1983 (After Excavation)	July, 1984 (After First Winter)	September, 1985 (After Second Winter)
South Slough	2.9	0.1	1.2	1.2
North Slough	6.6	3.1	2.2	2.4

Embayment Water Level Control

The objective was to maintain embayment water levels to protect adjacent private lands from flooding while retaining sufficient water to provide habitat for juvenile salmonids. Water levels were to be maintained as high as possible without exceeding 5.0 feet above mean sea level, when pastures begin to flood. An operations plan was developed by Resources Management Division outlining objectives, methods, and responsiblities.

Water levels were manipulated by controlled breaching a total of 6 times from June 29 through September 16.

In conjunction with embayment water level control, a record of water levels and other observations was maintained by Resources Management. Entries


Areas Excavated
1983
PACIFIC OCEAN
FIGURE 1:
AREAS EXCAVATED
1983
LOWER REDWOOD CREEK
HUMBOLDT CO. CALIFORNIA
Legend
REDWOOD NATIONAL PARK
U.S. Department of the Interior

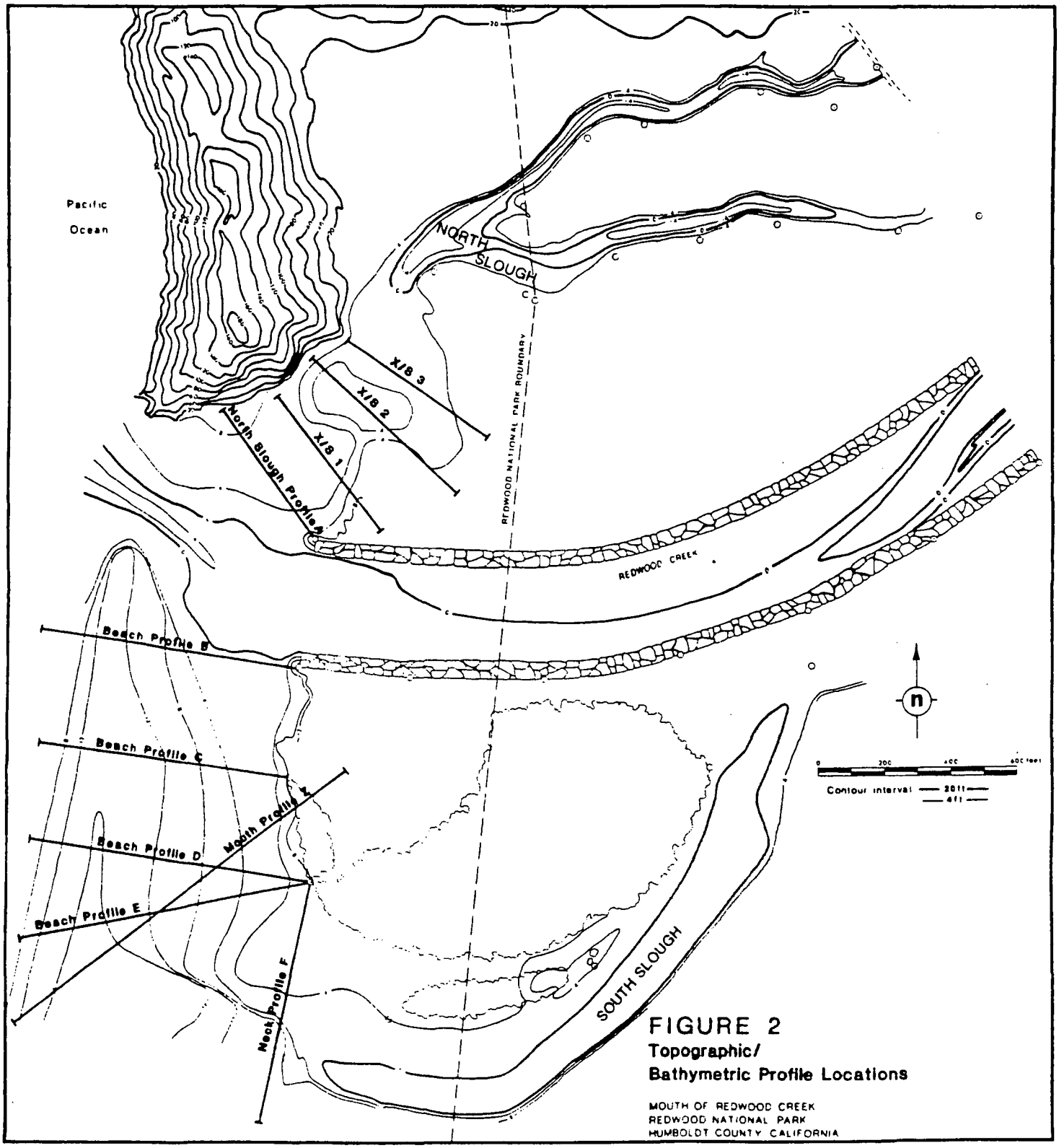


FIGURE 2
Topographic/
Bathymetric Profile Locations

MOUTH OF REDWOOD CREEK
REDWOOD NATIONAL PARK
HUMBOLDT COUNTY CALIFORNIA

included water levels, outflow configuration, wind and sea conditions, time spent, and other comments. A total of 457 observations were recorded from June 1 to November 15.

Water Quality Studies

Monitoring was conducted to determine if and when estuarine (embayment and sloughs) water quality was a limiting factor for juvenile salmonids. Parameters measured at twelve sites in the north and south sloughs and the embayment included conductivity, temperature, salinity, and dissolved oxygen. A vertical profile from surface to bottom was determined for each parameter, at each station, 9 different times from June 26 through October 17. Poorest water quality was observed in the sloughs, where temperatures reached levels that were limiting to salmonids. In the embayment, water temperature was never limiting. Dissolved oxygen was generally adequate at all sites throughout the summer. Levels in the north slough, however, became limiting in late summer below about 4 feet in depth. Dissolved oxygen levels also became limiting near the bottom of the south slough during this same period.

The embayment alternated between a fresh and brackish water system. High tides and ocean overwash caused short periods when brackish conditions prevailed. A dense salt water layer remained on the slough bottoms throughout the summer. A salt water layer also existed on the embayment bottom, but its depth varied with tide, ocean conditions, and mouth configuration.

Fish Migration and Estuary Utilization

This program was directed at determining numbers and growth of juvenile salmonids utilizing the embayment.

Embayment fish populations were estimated by seining and marking captured fish. The ratio of marked versus unmarked fish captured two days later was utilized in calculating population estimates. Four estimates were made from July 8 to September 16. Growth was monitored 7 times by seining and measuring each fish captured from June 27 to October 9. On each of these sampling days approximately 20 fish (10 steelhead and 10 salmon) were sacrificed for stomach analyses and for determination of food habits. Scales were collected from 30 individuals of each species.

The major area utilized by juvenile salmonids was the embayment. Fish avoided the saltwater layer on the embayment bottom and area adjacent to the ocean berm during periods of overwash, preferring water of lower salinity. Few fish utilized the sloughs. Population estimates and growth for juvenile chinook salmon and steelhead trout are shown in Figures 3 and 4. These figures show downstream migrating salmonids found favorable habitat in the estuary as soon as an embayment began to form.

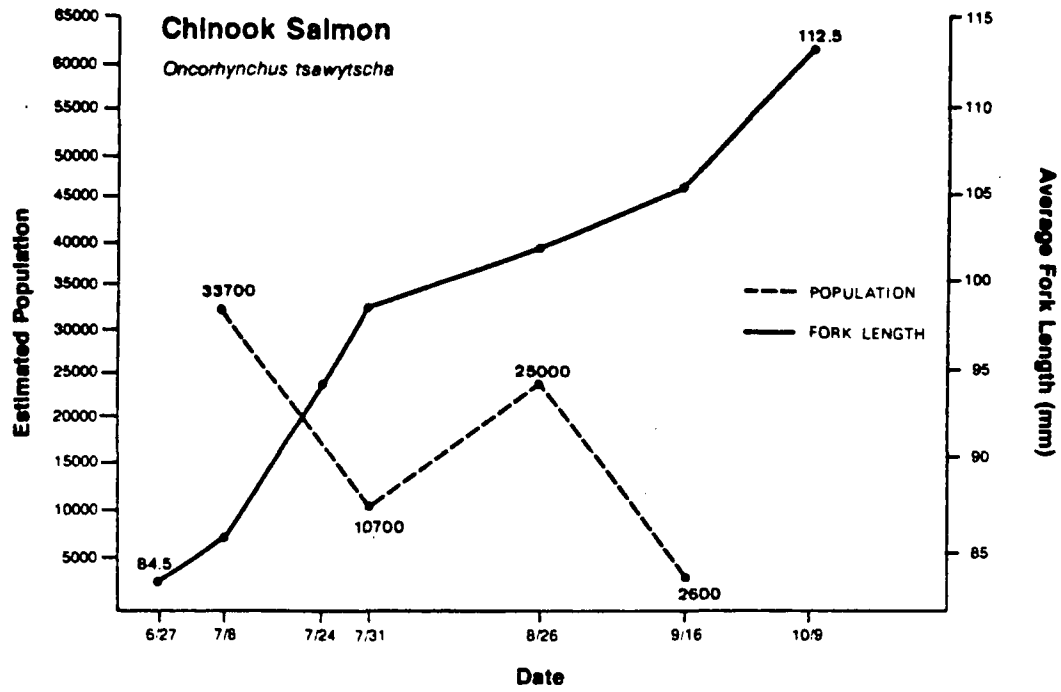


FIGURE 3: Population estimates and growth of chinook salmon, Summer 1985

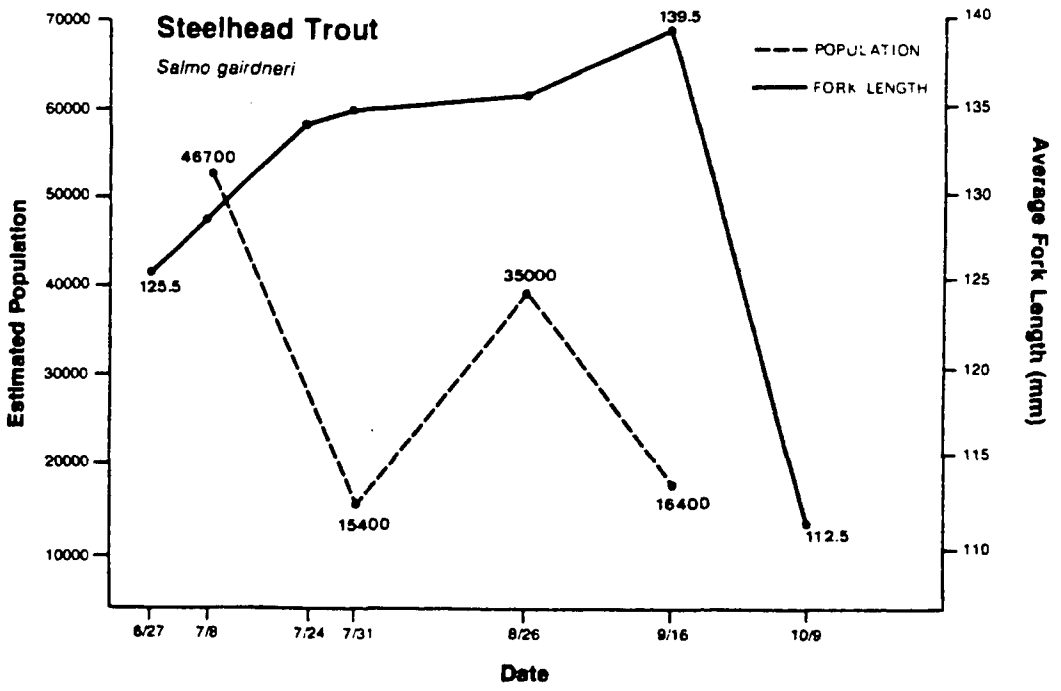


FIGURE 4: Population estimates and growth of steelhead trout, Summer 1985

Juvenile salmon growth in the estuary during the summer was significant (see Figure 3). Fork length averaged 84.5 mm on June 27 and 112.5 mm on October 9.

Patterns of estuarine use by juvenile steelhead trout (Figure 4) were similar to that of salmon. That is, when habitat was available, steelhead spent an extended period in the estuary.

1985 Cost Summary

Management Activities

Water Level Control and Monitoring	13,900
Total	$13,900

Research and Monitoring

Resurvey of Excavated Areas	$ 800
Water Quality Monitoring	1,300
Aquatic Invertebrate (Analysis of 1984 samples)	2,000
Fish Population and Growth Monitoring	4,600
Total	$8,700

SOUTH SLOUGH INTAKE STRUCTURE
PROJECT DESCRIPTION

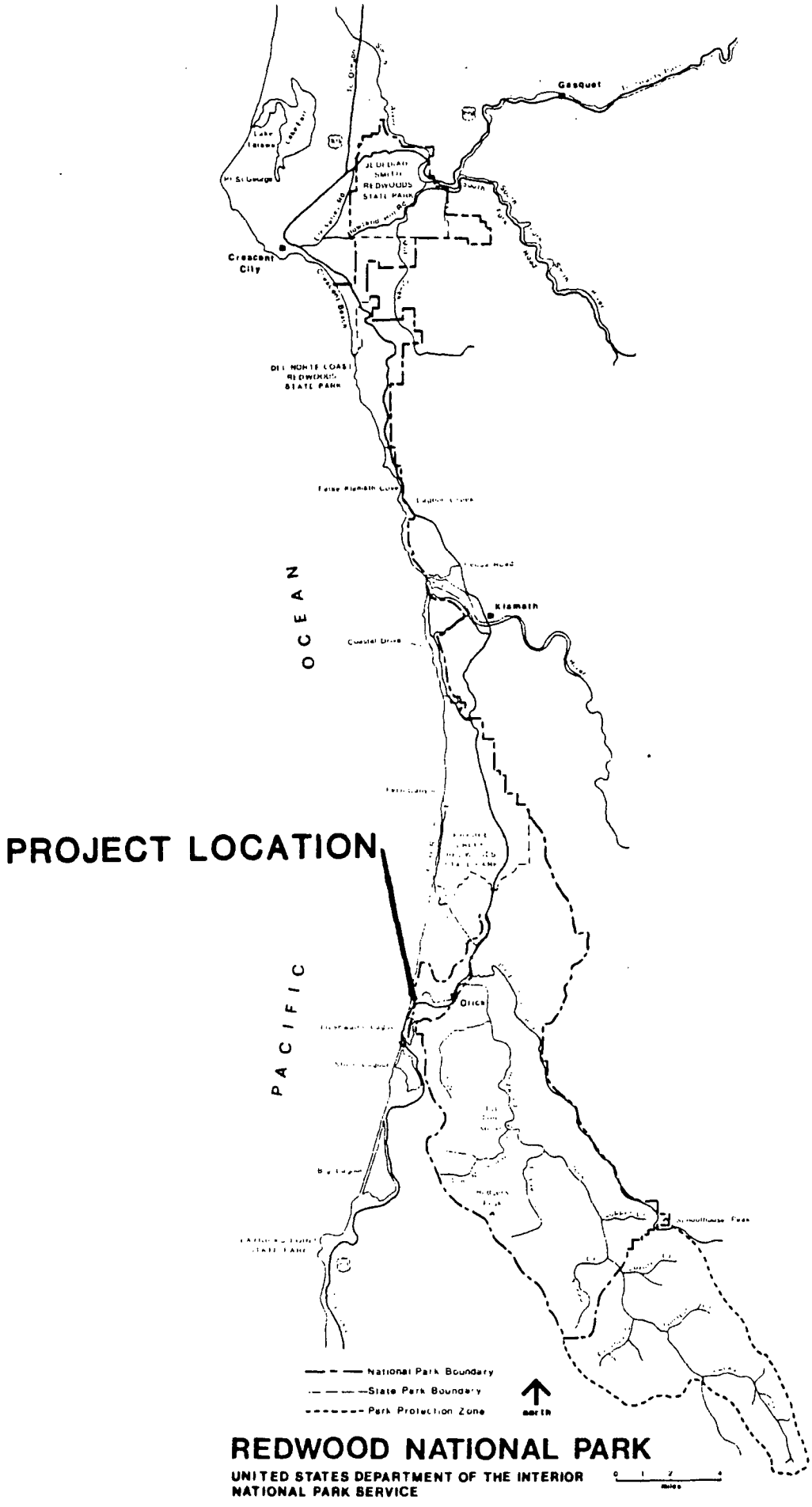
The proposed culverts are intended to partially offset the fisheries losses resulting from construction of the U.S. 101 Bypass project. By diverting a portion of Redwood Creek's flow through the former main channel of the creek (now the South Slough), summer rearing habitat for juvenile steelhead and chinook salmon will be improved (see attached drawings).

Through an agreement with the National Park Service, the culverts will be designed and constructed by the Corps of Engineers. The National Park Service is responsible for obtaining necessary permits and the Service will also own and operate the culverts when construction is complete. The California Department of Transportation is obtaining the right-of-way and is funding the project.

The culverts will consist of three, eight-foot by nine-foot concrete boxes with manually operated gates on each culvert. The culverts will be approximately 120 feet long, with a trash screen on the upper end to match the existing levee bank and an apron on the downstream end to direct discharge. The culverts will require approximately 2.2 acres while temporary storage of equipment and material will require an additional 3.8 acres.

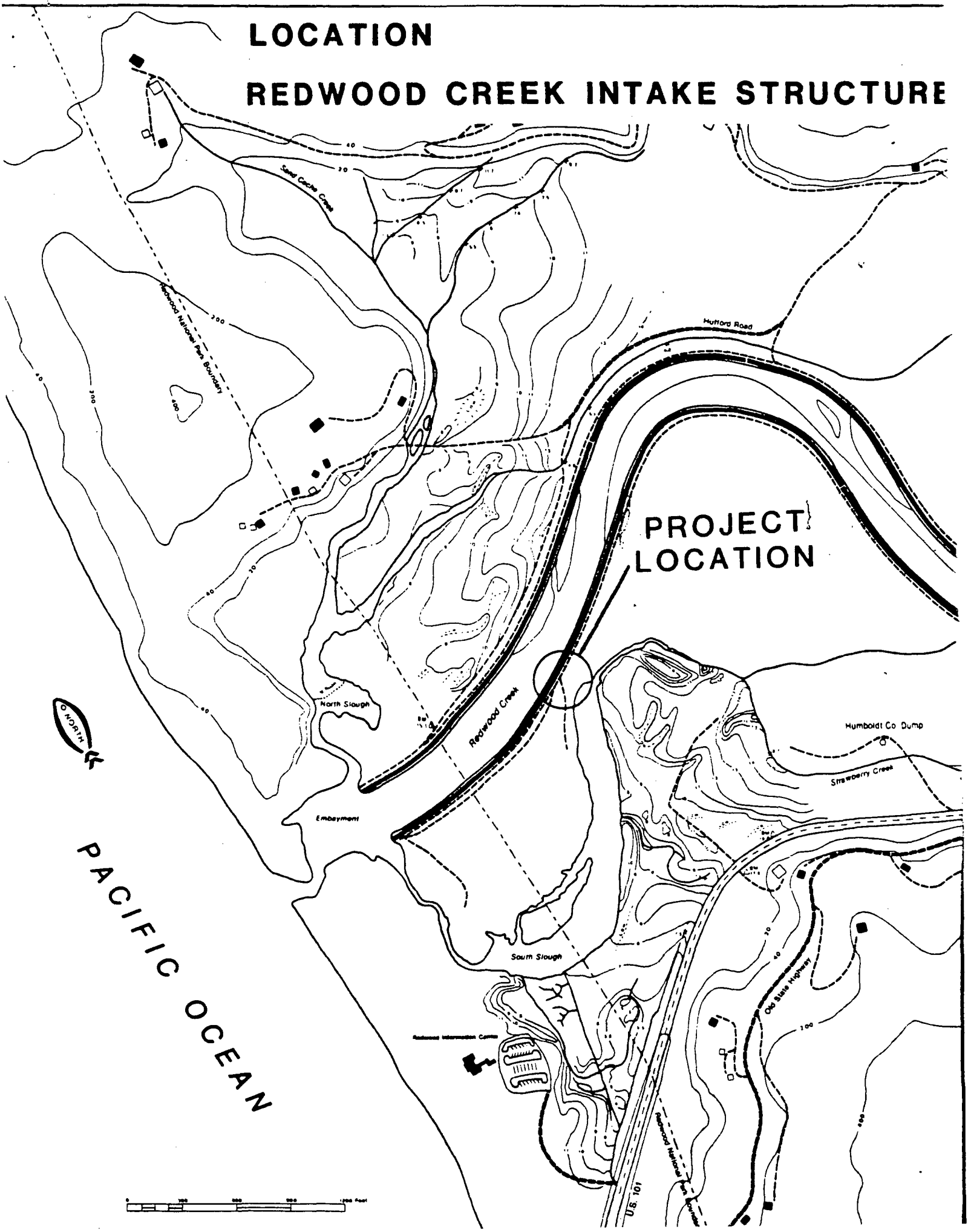
Construction of the culverts will require removal of a portion of the existing levee at the upper end of the South Slough. The existing levee material, which consists of rock and soil, will be stored on-site and partially reused during construction. Cofferdams may be constructed in Redwood Creek and the South Slough to prevent backwater flooding from interfering with construction. Alternately, the National Park Service may manage water levels as it has in the past four summers to prevent flooding. The culverts will be built in place and the levee material will be placed on the sides and over the top of the boxes. At the conclusion of the work, the overall levee configuration will remain the same as it appears today.

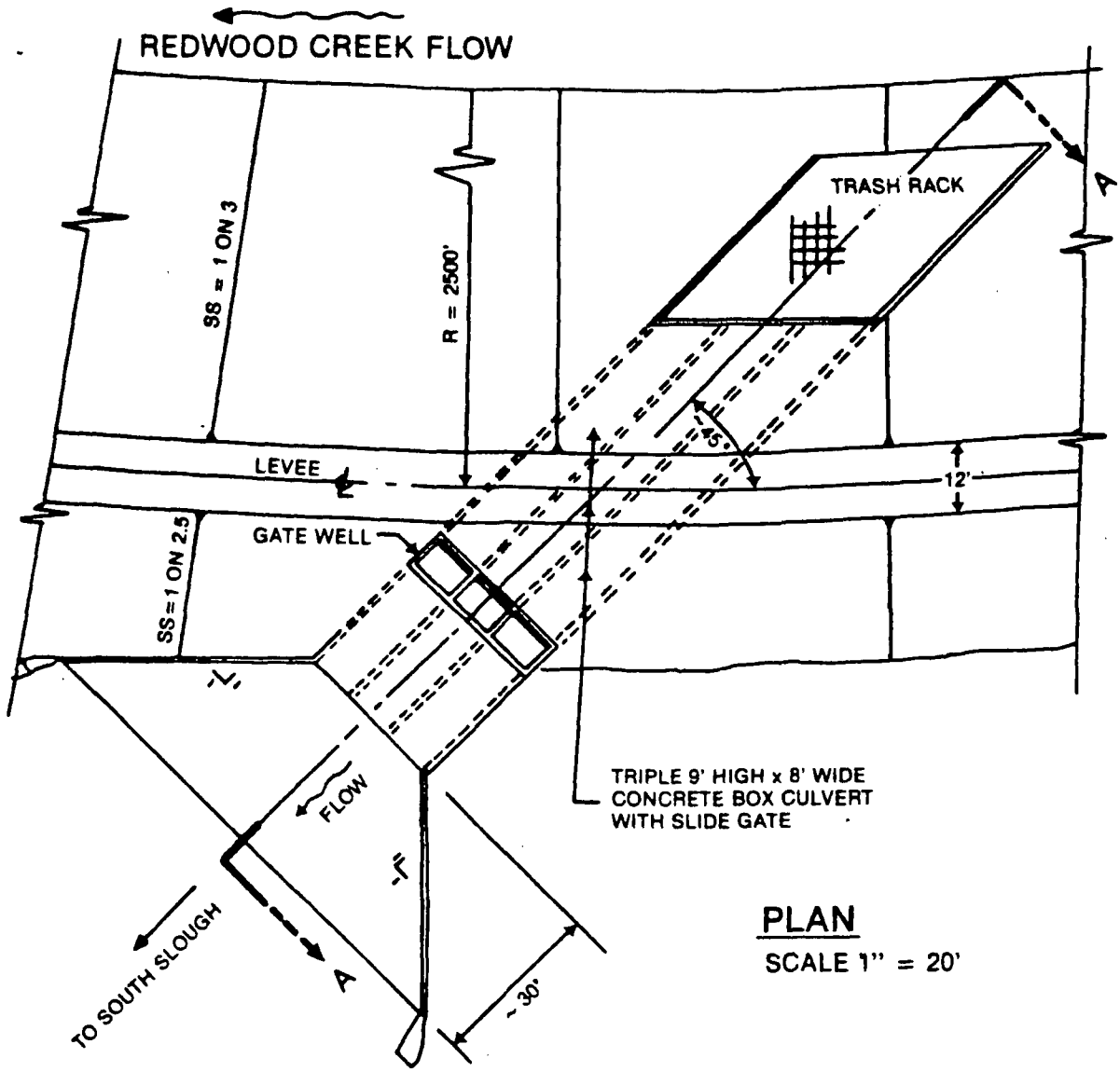
The Corps has provided the park with a rating curve for the culverts, however it will take several months of winter and summer flows to calibrate the culverts and their gates. During the summer months, water level management activities will continue at the mouth of Redwood Creek to maintain rearing habitat for juvenile salmonids while preventing flooding of adjacent private property. If necessary, a small (2 - 3-foot high), seasonal gravel berm will be created in Redwood Creek to divert the low summer flow into the South Slough. The berm would be pushed up using heavy equipment in early summer and allowed to wash away with winter rains.


PROJECT LOCATION
OCEAN
PACIFIC
Gasquet
Crescent City
Klamath
Orick
National Park Boundary
State Park Boundary
Park Protection Zone
north
REDWOOD NATIONAL PARK
UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

LOCATION

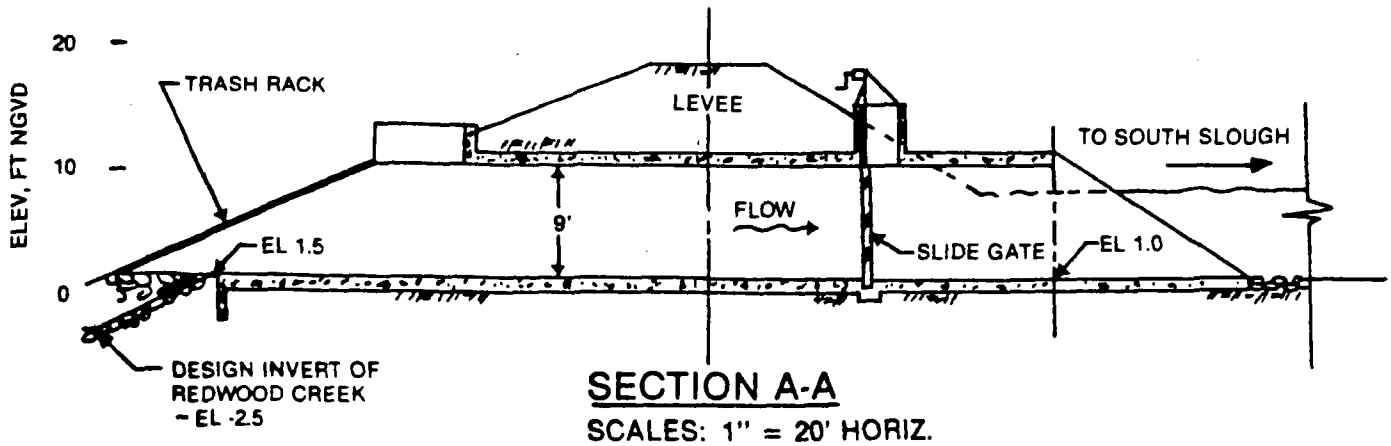
REDWOOD CREEK INTAKE STRUCTURE





PLAN

SCALE 1" = 20'



SECTION A-A

SCALES: 1" = 20' HORIZ.
1" = 10' VERT.

SOUTH SLOUGH INTAKE STRUCTURE ON REDWOOD CREEK, ORICK, CA.

Redwood Creek Rating Curve