FISH AND WILDLIFE IN A WATER PROJECT

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Abstract: This paper briefly reviews important factors in the evolution of fish and wildlife considerations in water resources developments. An application of the related laws and policies is discussed by reviewing the development of the Tehama-Colusa Fish Facilities. The planning process for introducing anadromous fishery mitigation and enhancement facilities into this Sacramento Valley irrigation canal is described. Examples of alternative plans are presented to illustrate the problems and process of plan selection. The configuration, purpose, and operation of the many facilities in the final plan is summarized.

INTRODUCTION

Water projects, in the context that I use the term, are large multipurpose developments. Their characteristics are influenced by many factors, some of which are set forth in laws, policies and guidelines. In order to outline the process of adding the Fish and Wildlife function to a water project, I would first like to discuss some of the pertinent laws and policies and then describe an actual example, the Tehama-Colusa Canal Fish Facilities.

Water resource development, as related to the Bureau of Reclamation began in 1902 when President "Teddy" Roosevelt signed into law the Reclamation Act. Under this law less complex, single-purpose irrigation projects developed. With the growth that the West experienced during the first quarter of this century, the demand for putting water to use for other purposes increased until the first of the major multiple-purpose projects, the Boulder Canyon Project, was authorized in 1928.

In 1934 the growing importance of conserving our fish and wildlife resources was recognized by the enactment of the Fish and Wildlife Coordination Act. This Act provided for consultation with fish and wildlife agencies prior to the construction of a dam with a view toward providing for mitigation of fish and protection of wildlife resources.

In 1946 an amendment of the Fish and Wildlife Coordination Act provided the authority for more than just consultation between related agencies in an attempt to prevent or minimize fish and wildlife losses. It provided the authority to include facilities to mitigate the damages to fish and wildlife that a water project may cause.

In 1958 it was recognized that the 1934 Fish and Wildlife Coordination Act and the 1946 Amendment were steps in the right direction but didn't go far enough. This recognition manifested itself in the form of another amendment to the 1934 Act and provided the authority for the inclusion of fish and wildlife enhancement.

This series of legislative actions was followed in 1962 with a policy statement commonly referred to as "Senate Document 97." This document gives direction to water resource developments by defining planning objectives, policies, and procedures. It states that the well-being of all of the people shall be the overriding determinant in considering the best use of water and related land resources and that when making these decisions all possible significant uses of the resource shall receive equal consideration. This establishes the multiple-purpose concept and requires that equal consideration be given to each purpose in the project formulation process.

There are, of course, numerous other laws--i.e.: The Federal Water Project Recreation Act of 1965 (P.L. 89-72); the Wild and Scenic Rivers Act of 1968 (P.L. 90-542; the National Environmental Policy Act of 1969 (P.L. 91-190); and the Environmental Quality Improvement Act of 1970 (P.L. 91-224)--that also have some bearing on the fish and wildlife functions of water projects. Also, the adoption of new policies being developed by the Water Resources Council will in my opinion eventually supersede Senate Document 97 and provide us with more realistic guides for considering fish and wildlife.

All these laws and directives have been steps in the right direction--toward more effective planning to guard and shape our fish and wildlife resources when they are related to a water development. These steps were taken when the need for them was crystal clear and when the direction for them was undisputable. I am optimistic enough to think that further steps will be taken whenever their need and direction becomes evident.

These laws and policies that I have briefly mentioned only lead up to the real heart of the process of planning fish and wildlife features in a water project. Whether we agree with them or not, they comprise the framework of rules that guide the project formulation process. However, it is the people working within the agencies related to water projects and fish and wildlife resources that in the long run determine the success or failure of these measures. The attitudes of these people working in this relationship will, to a large extent, reflect the quality of the end product.

Experience has shown that when responsible people, all the way from the very first planners to the very last designers, constructors, and operators, approach this task with a cooperative attitude, better and more imaginative solutions to fish and wildlife problems result. That is why I would like to describe the Tehama-Colusa Canal Fish Facilities. This is one of the best examples to date of a new and imaginative solution to a fishery problem arrived at through cooperative effort.

The Setting

The Sacramento River in northern California is one of the finest chinook salmon (*Oncorhynchus tshawytscha*) spawning systems in the nation and contributes heavily to the Pacific Coast salmon fishery. Each year hundreds of thousands of chinook salmon migrate through the Golden Gate, San Francisco Bay, and the Sacramento-San Joaquin River Delta to spawn in the many streams of this river system including the upper Sacramento River. Actual fish counts (not adjusted for periods of ladder outage or night factors) made over the last three years in the fish ladders at the Red Bluff Diversion Dam show that over 110,000 salmon use the Sacramento River above Red Bluff each year.

It was in 1950 that Congress authorized the Sacramento Canals Unit, which includes the Tehama-Colusa Canal and Red Bluff Diversion Dam shown on Figure 1. Initially this canal extending 120 miles southward from Red Bluff was to serve the sole function of diverting and delivering agricultural water to 215,000 acres of agricultural land in the western Sacramento Valley. However, the sale of water to the local farmers was slow and it wasn't until the early 1960's that sufficient water had been contracted to allow construction to begin on the diversion dam and canal.

During the interim period Congress passed the 1958 Fish and Wildlife Coordination Act (P.L. 85-624) that amended the 1934 Act. Until this time, under the 1934 Act, the only fishery facilities the Bureau of Reclamation could include in its projects were those for mitigation (or replacement of damages). However, with the amendment embodied in the 1958 Fish and Wildlife Coordination Act, it became possible to include fishery facilities for the enhancement of fishery resources.

The Tehama-Colusa Canal, closely paralleling the Sacramento River for many miles south of Red Bluff, was identified early as an obvious opportunity to develop such enhancement potentials. This prompted the beginning of one of the closest cooperative efforts ever undertaken by the Fish and Wildlife Service and the Bureau of Reclamation--the introduction of salmon spawning into an irrigation canal.

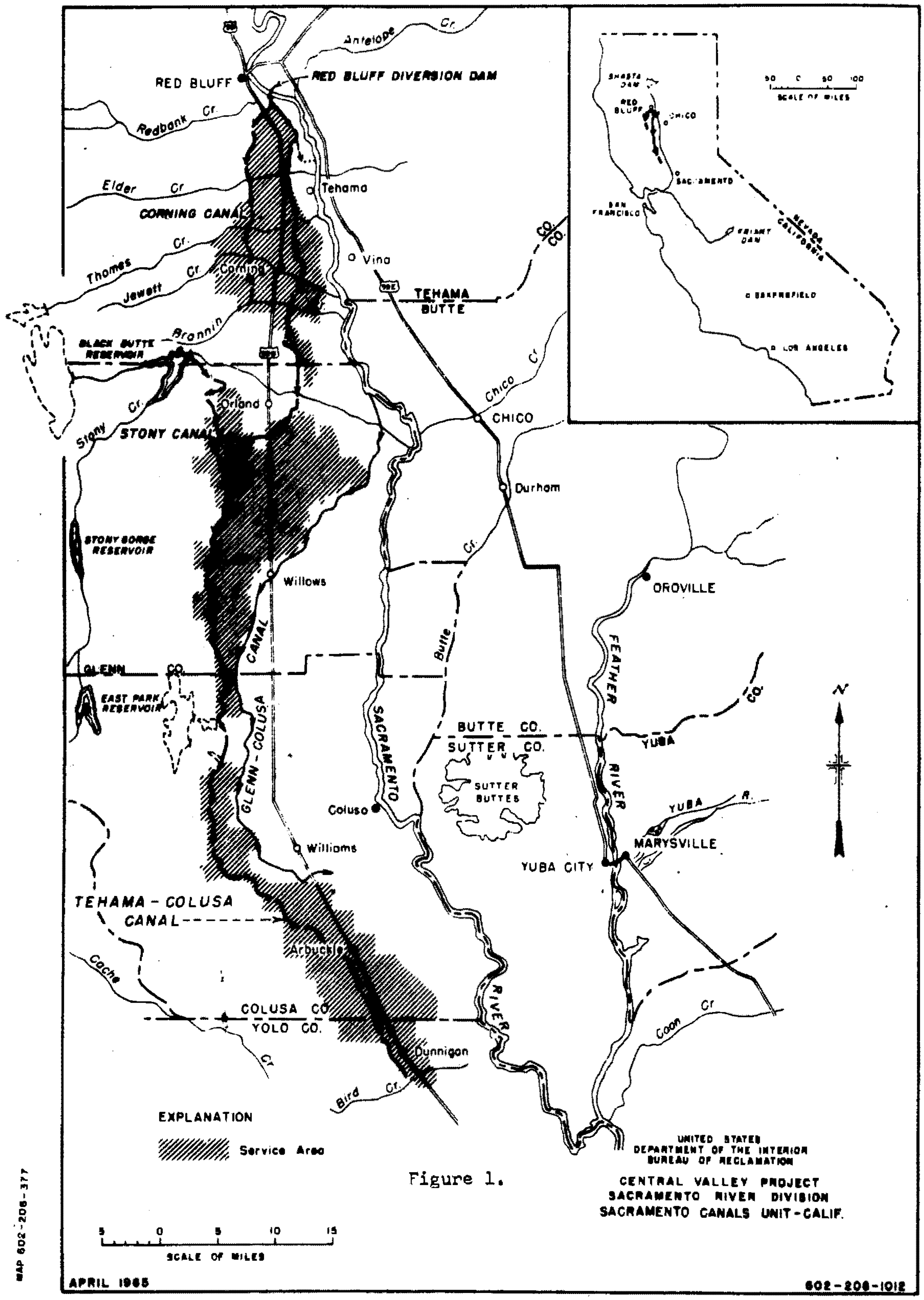

RED BLUFF
RED BLUFF DIVERSION DAM
Antelope Cr.
Redbank Cr.
Elder Cr.
Tehama
CORNING CANAL
Thomes Cr.
Jewett Cr.
Corning
Vina
TEHAMA
BUTTE
BLACK BUTTE RESERVOIR
Brannin
Orland
Stony Cr.
STONY CANAL
Chico Cr.
CHICO
Durham
STONY GORGE RESERVOIR
Willows
OROVILLE
Butte Cr.
GLENN CO.
EAST PARK RESERVOIR
GLENN-COLUSA CANAL
SACRAMENTO
FEATHER
RIVER
BUTTE CO.
SUTTER CO.
YUBA CO.
SUTTER BUTTES
YUBA R.
Colusa
MARYSVILLE
Williams
YUBA CITY
TEHAMA - COLUSA CANAL
Arbuckle
Cache Cr.
COLUSA CO.
YOLO CO.
RIVER
Dunnigan
Coon Cr.
Bird Cr.
N
EXPLANATION
Service Area
UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT
SACRAMENTO RIVER DIVISION
SACRAMENTO CANALS UNIT-CALIF.
5 0 5 10 15
SCALE OF MILES
APRIL 1965
602-206-1012
SHASTA DAM
CHICO
SACRAMENTO
SAN FRANCISCO
FRIANT DAM
NEVADA
CALIFORNIA
BAKERSFIELD
LOS ANGELES
50 0 50 100
SCALE OF MILES
MAP 602-206-377

Figure 1.

Plan Formulation

This idea was unique. Artificial spawning channels had been built but never before had the two purposes, salmon spawning and water conveyance, been joined on a large scale in a single man-made structure.

At first it was envisioned that this dual-purpose canal would simply have a gravel bottom for spawning throughout its first 32 miles from Red Bluff to Stony Creek. Stony Creek was chosen because it is the most southerly major tributary to the Sacramento River that crossed the canal. However, it wasn't long until the biologists and engineers came to grips with biological and hydraulic realities. The spawning environment could not be created by simply dumping spawning gravels onto the bottom of an irrigation canal. Faster flowing water is required for spawning than the standard canal design provides.

Therefore, a series of plans were devised and narrowed down to the five alternatives shown on Figures 2 through 6. The major considerations that shaped these five alternatives are discussed in the following paragraphs.

A hydraulic design that incorporated the biological criteria of a spawning channel and met the economic requirements of a water conveyance canal became a major consideration. It was determined that to meet the primary spawning requirement, a velocity between 1.5 and 2.5 feet per second in the water 0.3 foot above the surface of appropriately sized gravel, a canal slope of 0.00027 is needed. This is an average drop of 0.27 foot for every 1,000 feet of canal. However, this represents an additional loss in elevation over the standard irrigation canal slope of 0.00005, or 0.05 foot for every 1,000 feet of canal, that becomes a pumping cost in the agricultural service area of the 120-mile canal. It was found that the balance between this head loss and the associated pumping costs limited the length of spawning area in the dual-purpose canal to something less than 12 miles. Therefore, none of the five alternatives included spawning in the canal below Thomes Creek.

It appeared that, since the length of the dual-purpose reach is limited, the area of spawning could be maximized by decreasing the depth and widening the canal. Again an economic constraint, this time the cost of bridges, siphons, and other structures across the canal, became prohibitively high when the bottom width of the canal exceeded 50 feet. Therefore, any spawning area wider than 50 feet had to be limited to the first 3.5 miles of the canal where very few structures were required. This formed the basis of alternative plans 4 and 5, shown on Figures 5 and 6.

Comparisons of the cost of spawning area within the canal with separate spawning channels extending from the canal to the river were made. Results of these comparisons showed that in certain areas where terrain and construction conditions were favorable, the cost of spawning area in separate channels was competitive with spawning areas in the main canal. This formed the basis for the separate spawning channels in plans 3 and 5, shown on Figures 4 and 6.

All of the alternative plans include the release of water into Thomes Creek, as shown on Figures 2 through 6, and Stony Creek, not shown on the plates, to provide flows for natural spawning areas in these streams.

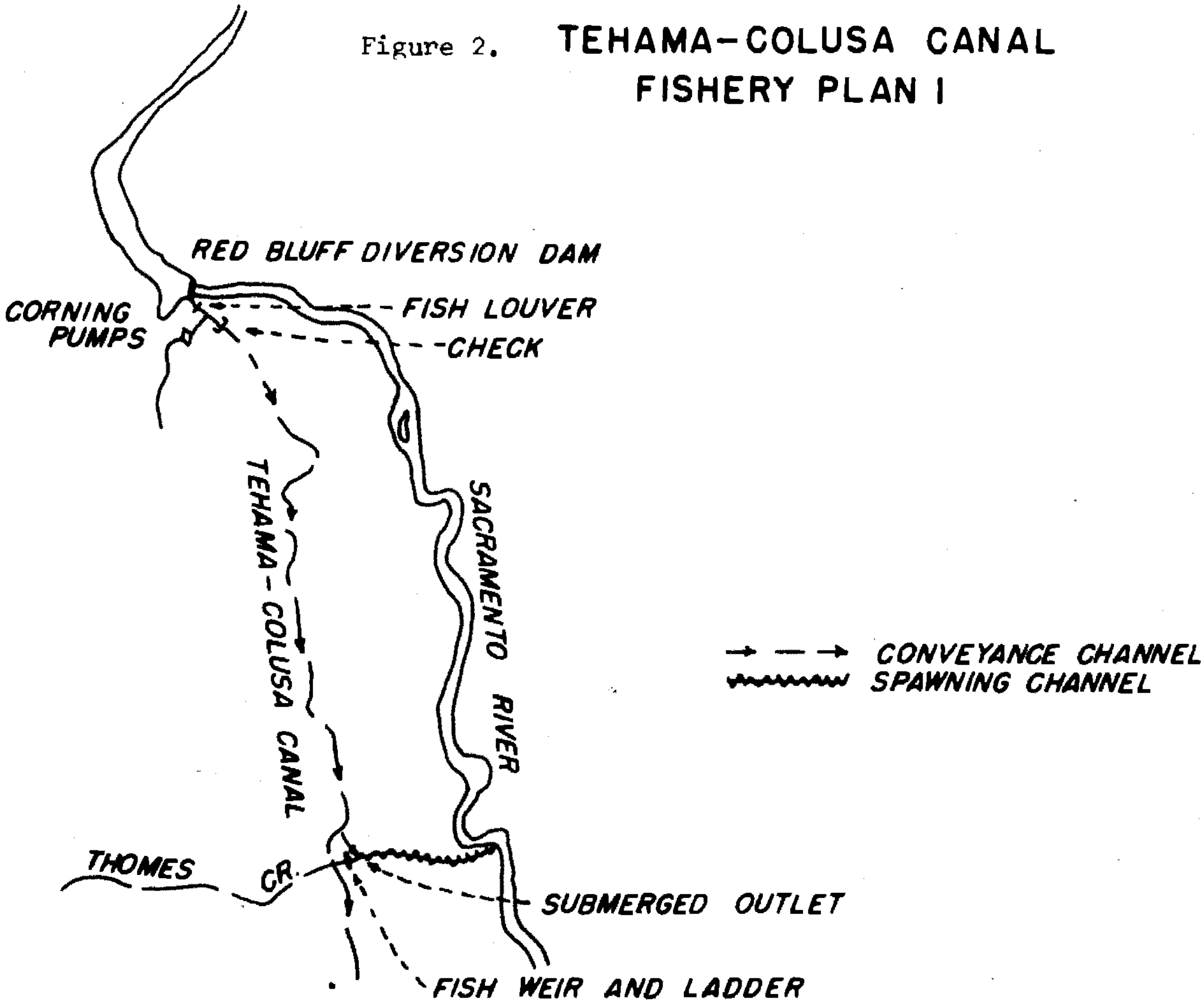
The costs and benefits, based on 1962 cost levels, for these five Alternative Fishery Plans are shown on Table 1.

From this analysis it was decided that plan 5, shown on Figure 6, should be the basic plan for the fish facilities. Plan 5 does not have the highest benefit-cost ratio. However, the judgment evaluation of intangible factors as well as the benefit-cost analysis led to the selection of this plan as the optimum development. Some of these intangibles were:

1. The adverse effect on navigability of returning diverted flows to the river at points farther downstream.

2. The hydrologic characteristics, particularly flooding, of the streams to be used as fishery ingress and egress channels.

Figure 2. TEHAMA-COLUSA CANAL FISHERY PLAN I



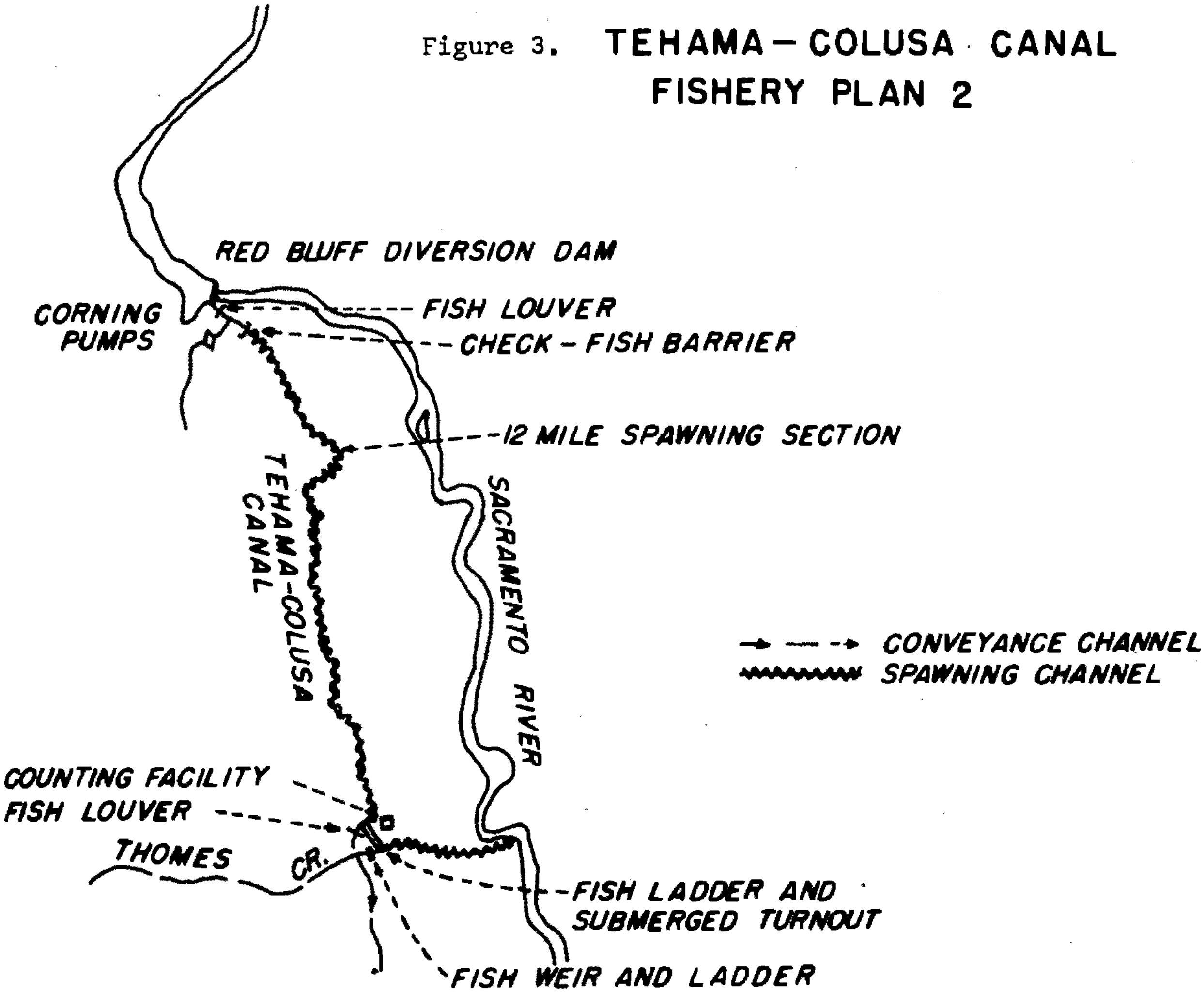
ACCOMPLISHMENTS:

1. Conveyance of irrigation water.
2. Conveyance and turnout for fishery to Thomes Creek and Stony Creek.

FEATURES:

1. Red Bluff Diversion Dam.
2. 2300 cfs - 24' invert - Tehama-Colusa Canal.
3. Fish louver at diversion.
4. Fish weir and by-pass ladder in Thomes Creek at canal crossing.
5. Submerged outlet turnout to Thomes Creek.
6. Submerged outlet turnout to Stony Creek.

Figure 3. TEHAMA – COLUSA CANAL FISHERY PLAN 2



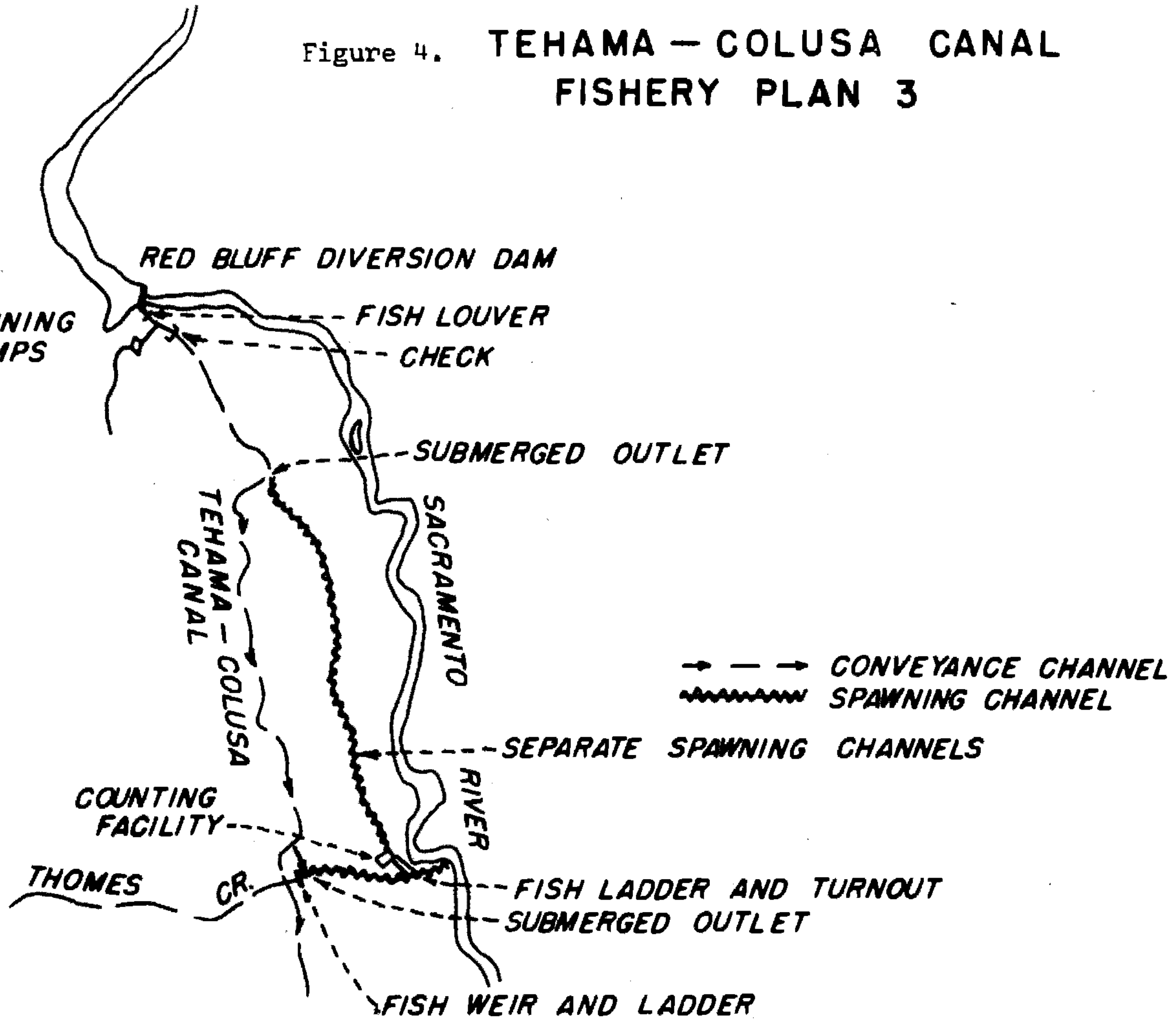
ACCOMPLISHMENTS:

1. Conveyance of irrigation water.
2. 3 million square feet of spawning area in the canal.
3. Conveyance and turnout for fishery to Thomes and Stony Creek.

FEATURES:

1. Red Bluff Diversion Dam.
2. 2300 cfs - 12 miles - 50' gravel invert - Tehama-Colusa Canal
3. Fish louver at diversion.
4. Check-fish barrier between Corning pump intake and spawning section.
5. Fish ladder, turnout, and counting facility at Thomes Creek.
6. Fish louver between fish ladder and Thomes Creek siphon.
7. Fish weir and by-pass ladder in Thomes Creek at canal crossing.
8. Submerged outlet turnout to Stony Creek.

Figure 4. **TEHAMA — COLUSA CANAL FISHERY PLAN 3**



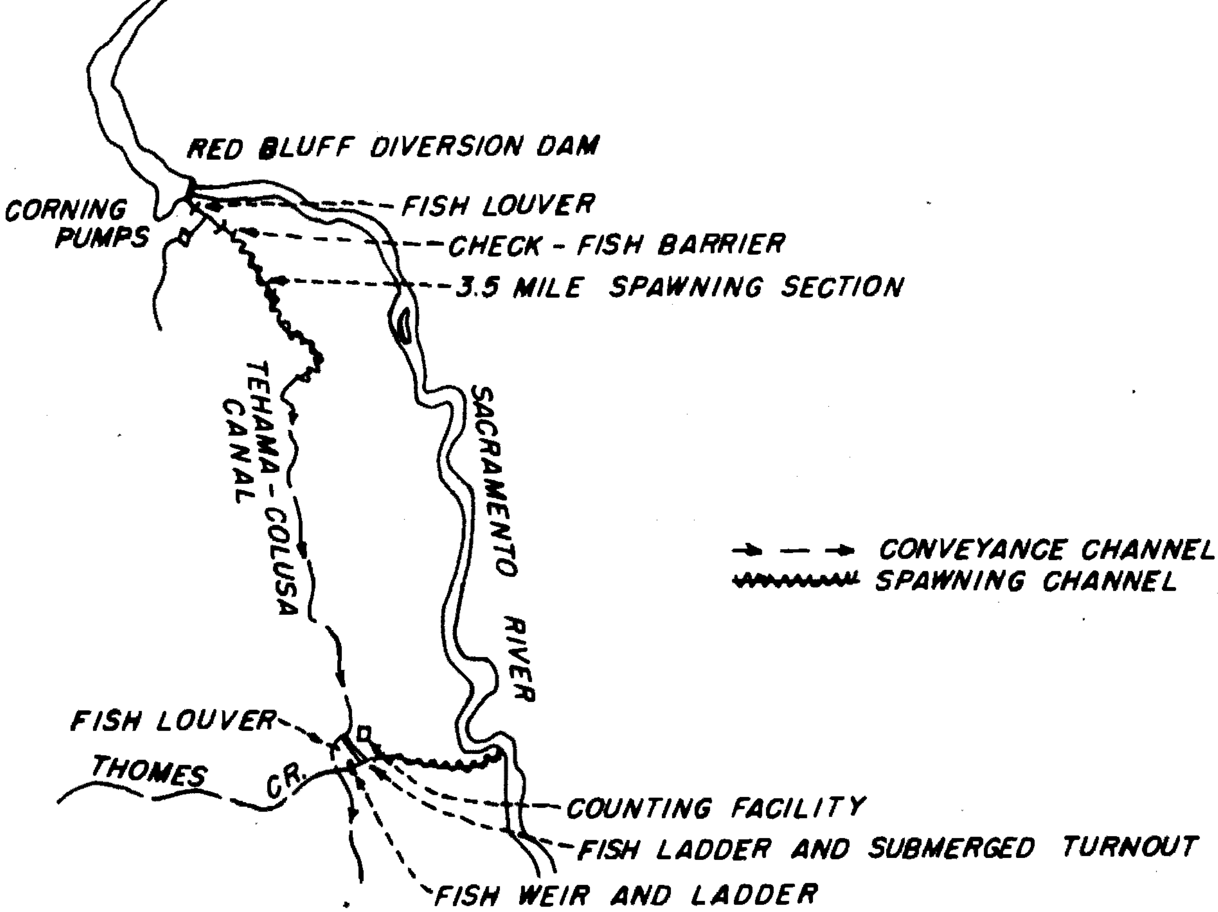
ACCOMPLISHMENTS:

1. Conveyance of irrigation water.
2. 3 million square feet of spawning area in a separate channel.
3. Conveyance and turnouts for fishery to spawning channel, Thomes Creek, and Stony Creek.

FEATURES:

1. Red Bluff Diversion Dam.
2. 230 cfs enlargement of canal for turnout to separate spawning channels.
3. Fish louver at diversion.
4. 230 cfs submerged outlet turnout to separate spawning channels.
5. Separate spawning channels - 2 parallel - 30' gravel invert channels.
6. Counting facility and fish ladder at Thomes Creek.
7. Submerged outlet turnout to Thomes Creek.
8. Fish weir and by-pass ladder in Thomes Creek at canal crossing.
9. Submerged outlet turnout to Stony Creek.

Figure 5. TEHAMA – COLUSA CANAL
FISHERY PLAN 4



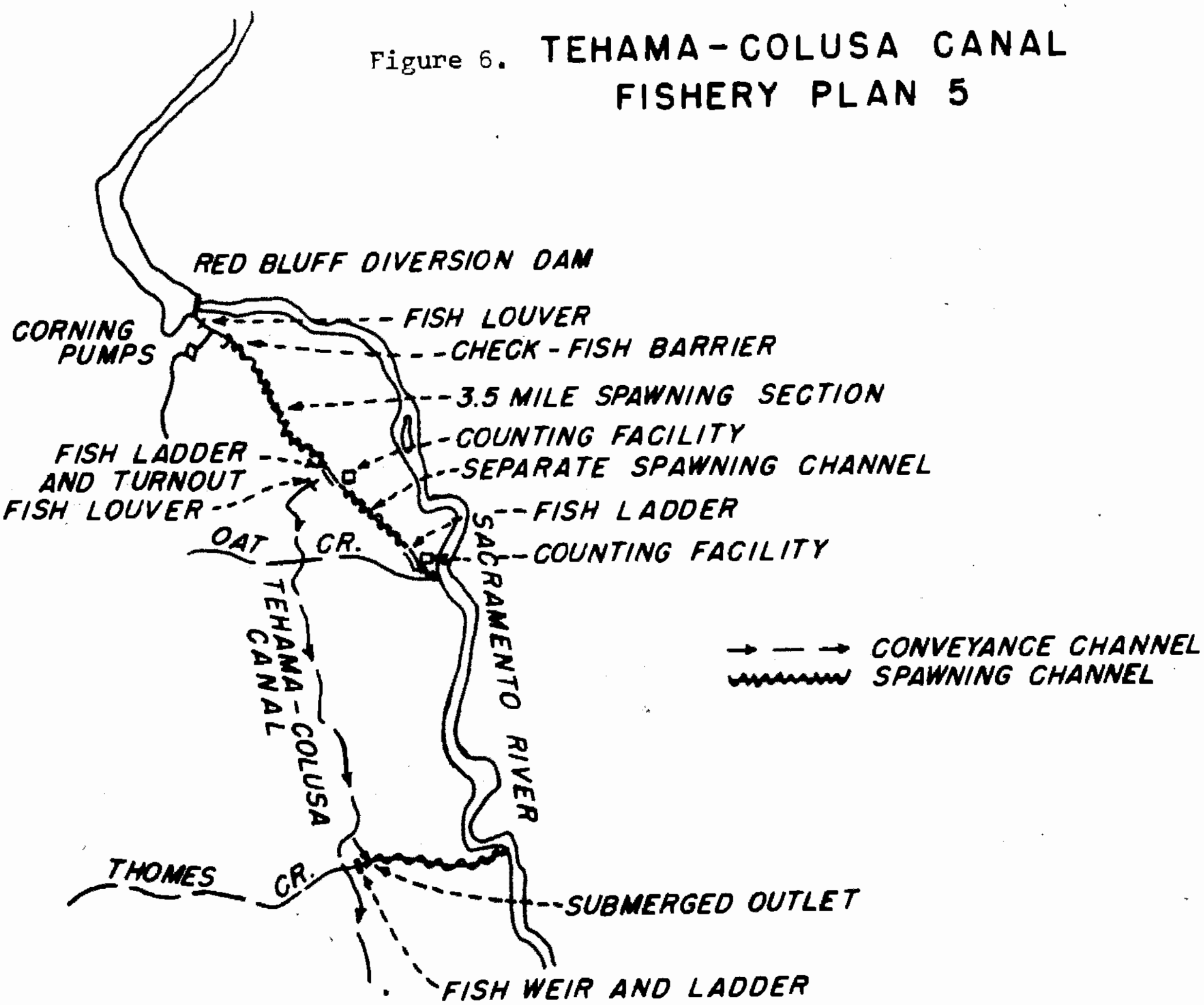
ACCOMPLISHMENTS:

1. Conveyance of irrigation water.
2. 1.8 million square feet of spawning area in the canal.
3. Conveyance and turnouts for fishery to Thomes Creek and Stony Creek.

FEATURES:

1. Red Bluff Diversion Dam.
2. 2300 cfs - 3.5 mile - 100' gravel invert - Tehama-Colusa Canal.
3. Fish louver at diversion.
4. Check-fish barrier between Corning pump intake and spawning section.
5. Fish ladder, turnout, and counting facility at Thomes Creek.
6. Louver between fish ladder and Thomes Creek siphon.
7. Fish weir and by-pass ladder in Thomes Creek at canal crossing.
8. Submerged outlet turnout to Stony Creek.

Figure 6. TEHAMA-COLUSA CANAL
FISHERY PLAN 5



ACCOMPLISHMENTS:

1. Conveyance of irrigation water.
2. 1.8 million square feet of spawning area in the canal plus in the separate channel.
3. Conveyance and turnouts for fishery to Thomes Creek and Stony Creek.

FEATURES:

1. Red Bluff Diversion Dam.
2. Fish louver at diversion.
3. 230 cfs enlargement - 100' gravel invert - 3.5 mile Tehama-Colusa Canal spawning section.
4. Check-fish barrier between Corning pump intake and spawning section.
5. Fish ladder, turnout, and counting facility to separate spawning channel.
6. Fish louver below separate spawning channel turnout.
7. Separate spawning channels - 2 parallel - 30' gravel invert channels of unknown length.
8. Fish ladder and counting facility at Oat Creek.
9. Fish weir and by-pass ladder in Thomes Creek at canal crossing.
10. Submerged outlet turnout to Thomes Creek.
11. Submerged outlet turnout to Stony Creek.

3. The configuration of the facilities and the adaptability of the layout to operational monitoring and performance evaluation.

Since sediment control is an important factor in spawning channels, the sediment carrying characteristics of the Sacramento River at Red Bluff were examined. During the winter the river carries a tremendous sediment load. Complicating the situation is a tributary stream, Red Bank Creek, which enters the Red Bluff Reservoir immediately upstream of the diversion headworks and contributes an unusually high sediment load to the river. It was estimated that in high runoff years as much as 75 acre-feet of sediment could be diverted into the canal. This led to the initiation of a research program that examined the problem of sediment entering the spawning gravels. Eventually this program led to the introduction of a settling basin at the canal headworks, the development of a unique hydraulic gravel cleaning device, and the introduction of embedded biological monitoring equipment for in situ measurements of gravel conditions for spawning and egg incubation.

Also, after the plan was selected, certain occurrences led to the elimination of the natural spawning channel in Stony Creek and the modification of the Thomes Creek spawning to be an artificial channel separated from the natural stream. Primarily this was caused by the 1964 floods which brought unforeseen amounts of sediment down from the foothills and by the development of gravel mining operations which more than quadrupled the stream channel land acquisition costs.

These studies, events, and occurrences brought us to the commencement of construction on the Tehama-Colusa Canal in 1965. The first construction was begun on the irrigation canal reach below Thomes Creek to allow additional time to design the special fishery facilities between the Red Bluff Diversion Dam and Thomes Creek. Next the desilting basin was constructed in 1966. Then the funding of the construction was slowed down by developments on the international scene and it wasn't until June of 1969 that construction of the fish facilities was begun.

Tehama-Colusa Fish Facilities

The Tehama-Colusa Fish Facilities, shown on Figure 7, that are now being constructed comprise a complex of facilities centered primarily around the Red Bluff Diversion Dam and first 3-1/2 miles of the Tehama-Colusa Canal. These facilities are scheduled to be completed in time to be used by the 1971 fall chinook run. These facilities provide 1,858,000 square feet of spawning area and when in full use will accommodate about 37,000 adult spawners.

Additional facilities at Thomes Creek, mile 13 on the Tehama-Colusa Canal, will be constructed during 1975. The Thomes Creek spawning channel will provide another 324,000 square feet of spawning area and will handle about 6,500 more adjult spawners.

The principle physical facilities, shown on Figure 7, that are required to make up the fishery complex indlude:

1. Fish ladders and Counting Stations on both sides of the Red Bluff Diversion Dam.

2. A Fish Trap in conjunction with the left bank Diversion Dam fish ladder to obtain spawners for the channels during initial years.

3. A Louver Fish Screen in the canal headworks to divert fish back to the river.

4. A Settling Basin immediately below the louver fish screen to reduce the sediment load carried into the spawning channels.

5. A Check and Velocity Barrier at the end of the settling basin to keep the spawning channel fish from entering the basin.

6. The Dual Use Spawning Channel which is 3.2 miles long and conveys 2,530 c.f.s. of water over a gravel bed with 1,573,000 square feet of spawning area.

Figure 7. Tehama-Colusa Canal spawning channels and facilities for fishery enhancement

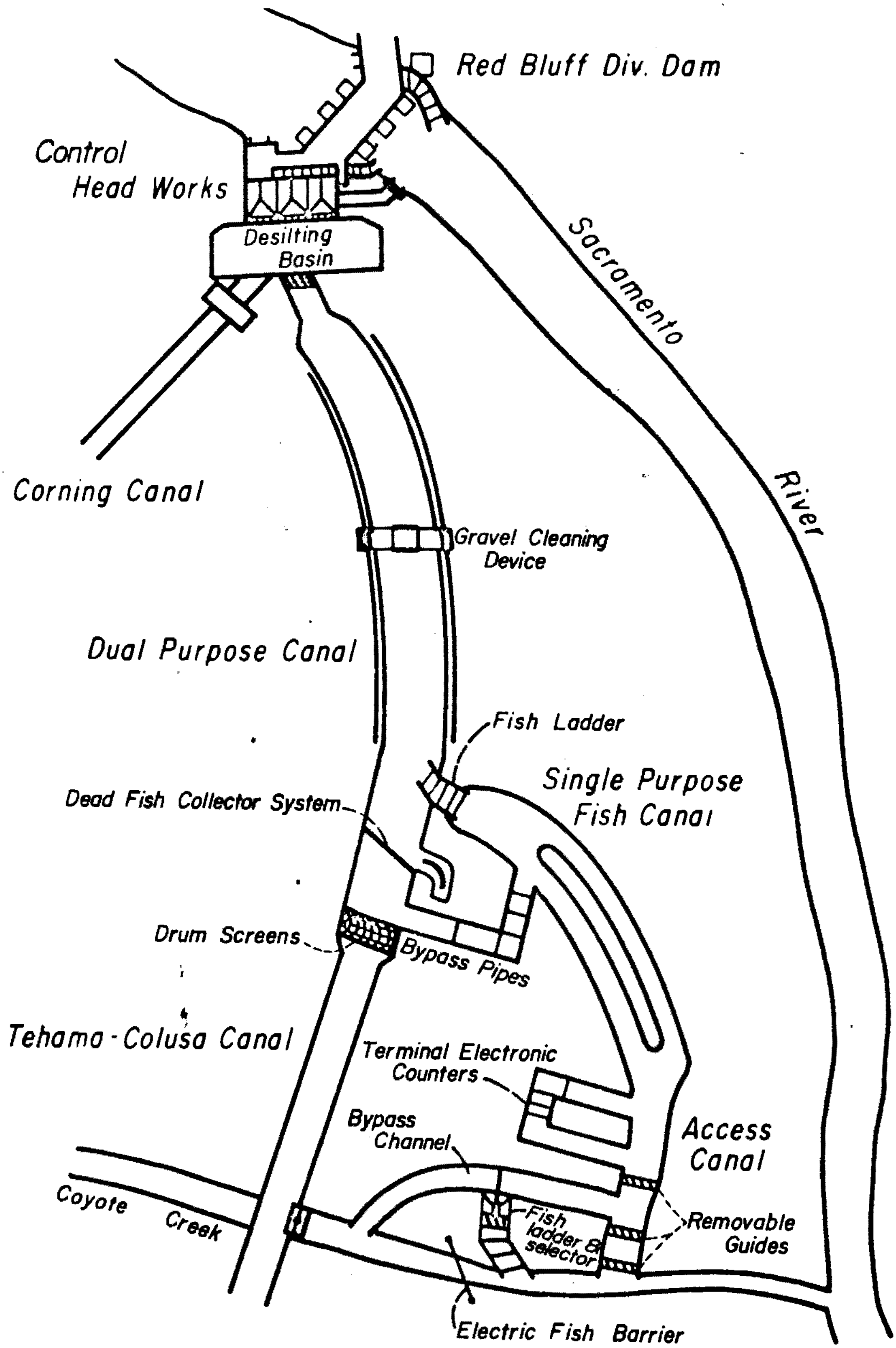
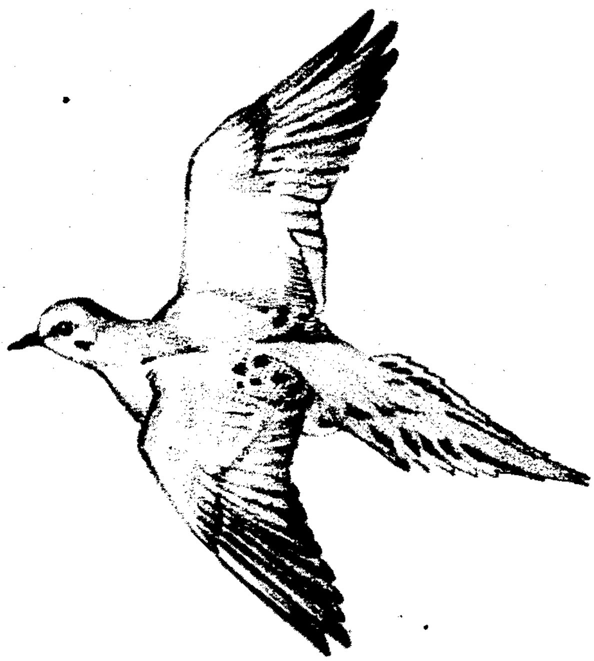


Table 1. Costs and benefits of five alternative fishery development plans

	Plan 1	Plan 2	Plan 3 (1,000)	Plan 4	Plan 5
Capital costs	$14,022	$20,360	$26,835	$17,479	$21,127
Annual costs[1]	508	824	996	702	842
Annual benefits	700	1,860	1,860	1,400	1,660
Benefit-cost ratio	1.38:1	2.26:1	1.87:1	1.99:1	1.97:1

1 Includes amortization of capital costs over 100 years at 3 percent plus the estimated annaul operation, maintenance, replacement, and management costs.



7. A Drum Screen and Turnout at the end of the dual use channel to prevent fish from going down the canal by directing them to and from the single-purpose spawning channel through bypasses, fish ladders and counting facilities.

8. The Single-Purpose Spawning and Access Channels provide an additional 285,000 square feet of spawning area and the ingress and egress route between the canal and Coyote Creek.

9. Coyote Creek will carry 1,000 c.f.s. of attraction flow in addition to providing the migration route to and from the river.

10. The Spawning Gravel will have a uniform size range of 3/4 inch to 6 inches and will form a 2-1/2 foot layer along the bottom of these spawning channels.

11. Monitoring Stations to determine when gravels must be cleaned through allowing for testing of water samples for dissolved oxygen levels and determining percolation velocities are installed at various locations throughout the spawning areas.

12. A Gravel Cleaner that will operate on the principle of scour, caused by high velocity water flowing under a moveable baffle, will be provided for the dual-use spawning channel.

13. The Thomes Creek Channel (not shown on Figure 7) will be just over 1 mile in length and will provide 324,000 square feet of spawning area.

The total estimated cost of the Tehama-Colusa Fish Facilities now stands at $20,323,000.

Summary

The Fish and Wildlife Service and the Bureau of Reclamation have jointly developed a plan for enhancing the Sacramento River anadromous fishery. The introduction of fish spawning areas into the upper 3-1/2 miles of the Tehama-Colusa Canal and the development of a spawning channel at Thomes Creek is expected to increase the chinook salmon population by 43,500 fish.

During initial years adult salmon would be trapped and planted in the spawning channels each fall. After a run has been established, the salmon returning in the fall would migrate up Coyote Creek from the Sacramento River to an electric barrier that guides them to a selection station. Selected adult spawners are to be put into the single-purpose access channel to migrate upstream into the single-purpose spawning channels and the dual-use spawning channel.

Fingerlings migrating out in the spring would be counted electronically as they moved, or were forced to move, out of the dual-use spawning channel into the single-purpose spawning channel. They would be counted again, along with the additional out migrants, as moved out of the single-purpose channels to travel down Coyote Creek to the Sacramento River.

Research related to this project has already added to our knowledge for designing hydraulic structures to meet biological needs and the treatment of sediment in large scale spawning gravels. It is our sincere hope that the unprecedented biological research opportunities that these facilities provide will be utilized by many of you.

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