STUDY OF UPSTREAM AND DOWNSTREAM MIGRANT STEEHEAD PASSAGE FACILITIES FOR THE LOS PADRES PROJECT AND NEW SAN CLEMENTE PROJECT

Charles H. Wagner

October, 1983

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October 31, 1983

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Attention: Bruce Buel
General Manager

Subject: Study of Upstream and Downstream Migrating Steelhead Passage Facilities at Los Padres and Proposed New San Clemente Projects.

Gentlemen:

I am pleased to submit this report representing the results of my study for the requirements to pass upstream and downstream migrating steelhead over Los Padres and the proposed New San Clemente Dams. This study was authorized by the agreement with the Monterey Peninsula Water Management District dated September 14, 1983.

The purpose of this study is to functionally develop means to improve acceptance and safe downstream passage over the spillway at Los Padres Dam; evaluate the adult upstream passage facilities and recommend improvements and/or new facilities at Los Padres Dam and develop upstream and downstream facilities for the proposed New San Clemente Dam with 18,000 acre-feet of usable storage.

The modification proposed for the Los Padres spillway is to lower a section of the spillway crest to provide a deeper and more concentrated flow from the reservoir during the lower river discharges. This flow would be confined to a narrow channel down the existing chute by a training wall. At the downstream end the design would assure free fall into tailwater. An alternate solution is suggested due to dam safety concerns. This proposal provides the lower river flows to be discharged through an opening in the right upstream wingwall and into a conduit laid adjacent to the spillway chute.

The primary suggestion to improve the existing adult facilities at Los Padres Dam is to improve the fish barrier dam by increasing its height, apron length and crest length. However, it is recommended that an entirely new facility of a barrier dam, fish ladder, holding pool and fish transfer and truck loading system be provided. A fish ladder was found feasible should it be found economical to replace the trucking operations.

With the New San Clemente project, a Green Peter type of downstream migrant collection and passage facility is recommended for the downstream migrating steelhead. Its means of application to the 18,000 acre-feet project is developed. In addition to this facility, it was found there would be sufficient occurrences of spill to warrant special design considerations for safe fish passage for the lower spill flows. A similar solution to that for Los Padres project of concentrating the lower discharges into a specially designed chute or conduit to convey the fish safely to tailwater is proposed.

The upstream adult migrant facilities would be essentially as described in Converse Consultants, Inc., October 28, 1982 letter report.

The proposals shown in this report are based on my experience and the experience of others. The addendum includes references in the form of abstracts and conclusions from evaluation reports for numerous projects passing fish runs.

Prior to beginning the detail designs of the project, I suggest the State of California Fish and Game Department be given the opportunity to review the proposals in this report and solicit their concurrence and/or any considerations they feel need to be included to assure facilities that will meet with their approval.

I sincerely appreciated the opportunity to provide this study and my services are available for reviewing this work with you and personnel of California Fish and Game Department, as well as for any additional work that may be needed for this project.

Sincerely,

Charles H. Wagner

Charles Wagner

CHW:bjw

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INTRODUCTION

SCOPE

With the desire to maintain the steelhead, salmo gairdneri, run in the Carmel River and with the increasing demand for water supply for the people in the area, this study is to determine upstream and downstream fish passage requirements at Los Padres Dam and the proposed New San Clemente Dam, as investigated and reported in D.W. Kelley & Associates' Report, June 13, 1982, and their letter reports of November 2, 1982 and June 21, 1983. More specifically, this report proposes:

1. Modifications to the Los Padres Dam spillway to improve downstream migration passage in both acceptance and survival.
2. An evaluation of the existing adult upstream fish passage facilities at Los Padres Dam as well as provide recommended improved or new facilities including a fish ladder over the dam as an alternate to fish trapping and hauling.
3. Develops functional design for upstream and downstream fish passage facilities with 18,000 acre-feet and 27,000 acre-feet alternate New San Clemente projects.

GENERAL PROJECT DESCRIPTION

Los Padres Dam

Los Padres Dam, located on the Carmel River approximately one mile upstream from the confluence of the Carmel River and Cacagua Creek, is an earth fill dam with about 125 feet of head at full reservoir. A chute type spillway is provided over the right abutment. The spillway crest length is 110 feet with the chute extending downstream some 600 feet. A regulating outlet is provided through the left side of the dam. Since construction of the project in 1948, the right bank downstream of the chute has eroded and the river degraded to where there is now estimated a vertical drop of about 30 feet at the end of the concrete chute structure. The reservoir capacity is approximately 2,000 acre-feet and has a surface area of 67 acres. (Kelley, page 122.)

PROPOSED NEW SAN CLEMENTE DAM

The site for the New San Clemente Dam proposed for a 27,000 acre-feet reservoir project would be located on the Carmel River approximately 1,200 feet downstream of the existing San Clemente Dam. For an 18,000 acre-feet reservoir project, the dam would be located about 3,600 feet downstream of the existing dam. Project data for the two alternate proposals are as follows and were obtained from Converse Consultants' Reports of August 1982 and June 1983.

27,000 ACRE-FOOT PROJECT

Reservoir

Active Storage	27,000 Acre-Feet
Area at (El. 692)	337 Acres

Dam

Height of Dam	300 Feet
Length of Crest	1,200 Feet
Crest Elev. of Dam	El. 726
Type of Dam	Concrete Faced Rockfill

Spillway

Type of Spillway Crest	Ungated Overflow
Length of Crest	125 feet
Maximum Flood Level (PMF)	El. 723
Spillway Crest Elevation	El. 692
Capacity at El. 723	77,000 CFS

Outlet Works

Discharge at Full Reservoir El. 692	924 CFS

18,000 ACRE-FEET PROJECT

Reservoir

Active	18,000 Acre-Feet
Area at (El. 642)	260 Acres

Dam

Height of Dam	250 Feet
Length of Crest	840 Feet
Crest Elevation of Dam	El. 662
Type of Dam	Roller Compacted Concrete Dam

Spillway

Type of Spillway Crest	Ungated Overflow
Length of Crest	148 Feet
Spillway Crest Elevation	El. 642
Capacity at El. 658.5	38,500 cfs
Capacity at El. 662	51,400 cfs

Outlet Works

Approximate Discharge at Full Reservoir El. 642	620 cfs

LOS PADRES DAM

The time of year the juvenile steelhead migrate downstream past Los Padres Dam should be similar to that at San Clemente Dam where they begin moving past the dam about the first of December and continue well into May (Kelley, page 198), the major smolt migration being in the spring months of March, April, and May.

A review was made of the 76 years of recorded monthly historical flows published in the New San Clemente Project Report (Converse Consultants). Assuming 75 percent of the flow at New San Clemente Dam site passes through Los Padres Reservoir (Kelley, June 1982, page 122) and storage begins in October, the Los Padres Reservoir should have been filled almost every year by the middle of January. Continuous spill should occur during the entire downstream migrant period. Exceptions would be the extreme dry water years such as the 1977 water year.

When the reservoir has not filled, any emigration of fish from the reservoir would have had to have been through the regulating outlet and/or the water supply pipe to the adult fish trapping facility. Injury and mortality of fish passing through this outlet system is expected to be very high, possibly approaching 100 percent at times.

Presently downstream migrating steelhead pass over the spillway. From personal observation, the spillway at Los Padres Dam is rough, particularly the ogee section, and fish probably suffer extensive abrasion at low flows. At low spill flows the depth of flow over the ogee and chute will be extremely shallow and much of the flow will fall on the rocks below. Abrasion has been shown to cause delayed mortality in salmonids. Particularly when water depth is not adequate for fish to avoid contact with the spillway surface, internal as well as external injuries are expected as they pass over this spillway.

In addition to the likely injuries caused by fish passing over this spillway, predation is expected to occur on the chute as well as on disoriented fish downstream of the project during the low spill periods.

With proper modifications to the spillway, survival rates could be as high as 98 to 100 percent. One reference on survival of fish passing through spillway is the North Pacific Division, U.S. Corps of Engineers 1972, A Compendium on Survival of Fish Passing Through Spillways and Conduits.

PROPOSED SPILLWAY MODIFICATION

"The Department of Fish and Game has suggested that either the spillway structure be smoothed in some manner, or reconstructed so that low flows pass down a narrow channel at one edge, and a 'ski jump' be installed at the end so the fish fall into a pool." (Kelley, June 13, 1982 page 125.)

The recommended solution follows the second suggested method by the Department of Fish and Game in providing a narrow channel for the lower spill flows. To accomplish this proposal will require concentrating the low spill flows over one end of the spillway crest and providing a training wall the length of the chute. One means to concentrate the low flows is to lower a section of the spillway crests to pass this low flow. Training walls were installed at Pelton Dam (OR) and North Fork Dam (OR) in order that adequate depth in the spillway for fish could be achieved and at these projects a free fall to a pool also was provided.

Review of the flow records indicate extended periods of spill of less than 150 cfs (75% of 10,850 AF/MO flow at Robles del Rio Gage) did occur nearly 50 percent of the 76 years in March, and over 75 percent of the years in April. Extended periods of spills less than 50 cfs were also not uncommon during March, April and May.

The capacity of the lowered section of the spillway crest is suggested to be designed to pass about 150 cfs before spill commences over the remainder of the spillway. This lowered spillway crest section would be gated. The proposed modification is illustrated in Fig. 1. The lowered section of the spillway crest, with the gate wide open, should compensate for the discharge lost over the spillway crest caused by the need of a pier required to support the gate.

To pass 150 cfs at crest full reservoir will require about 5 feet of the right end of the spillway crest be lowered 4.5 feet. From the lowered crest a training wall is required down the full length of the chute to contain this spill in a channel. The channel width would be approximately 3 feet wide. Fillets would be provided along the bottom of the walls to further narrow the channel width at very low flows. At the downstream end of the concrete channel, the channel would be extended sufficiently and so designed to assure the flow from it to plunge into the pool below.

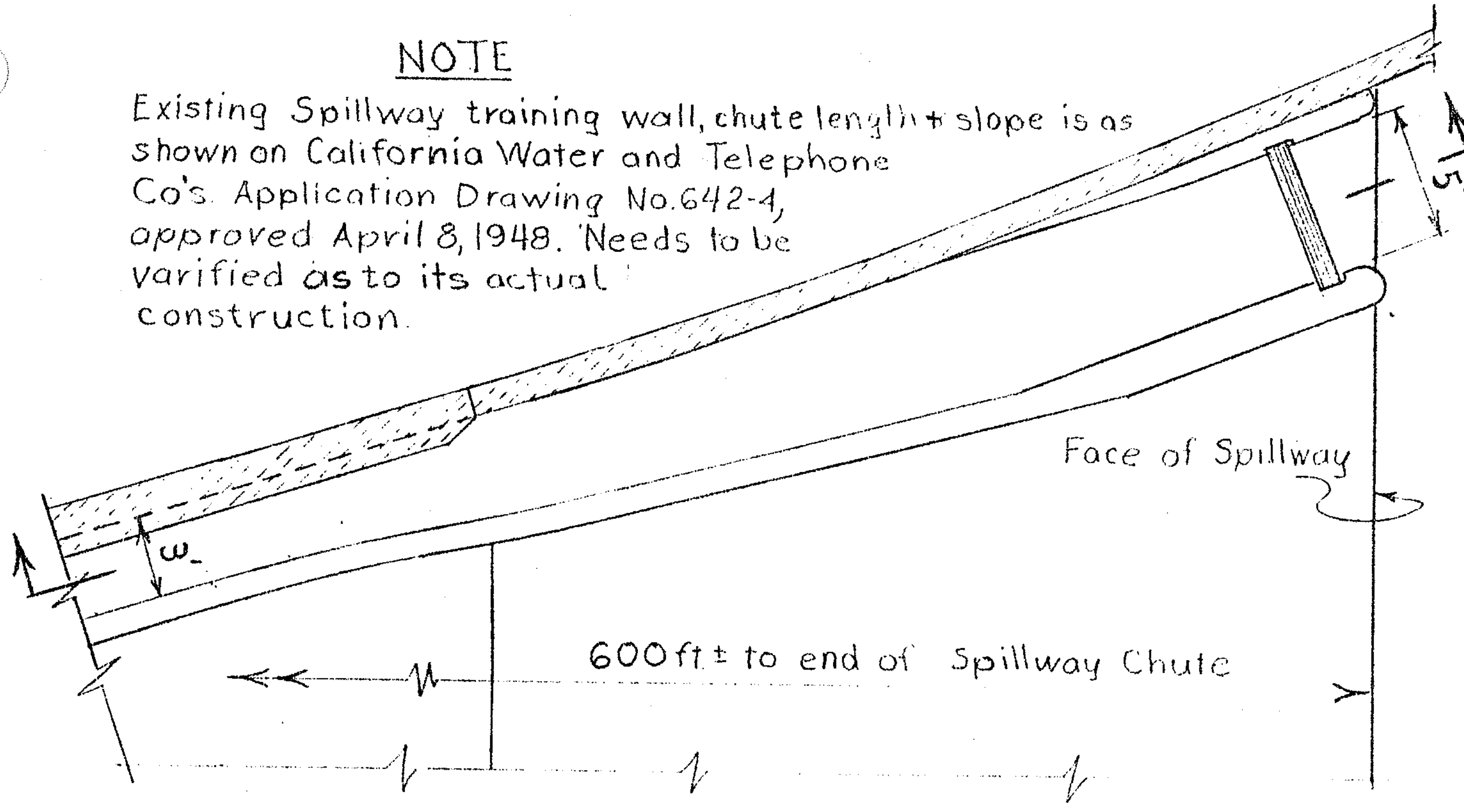
The gate would be automatically operated to maintain a crest full reservoir, but would open wide once spill began over the rest of the spillway.

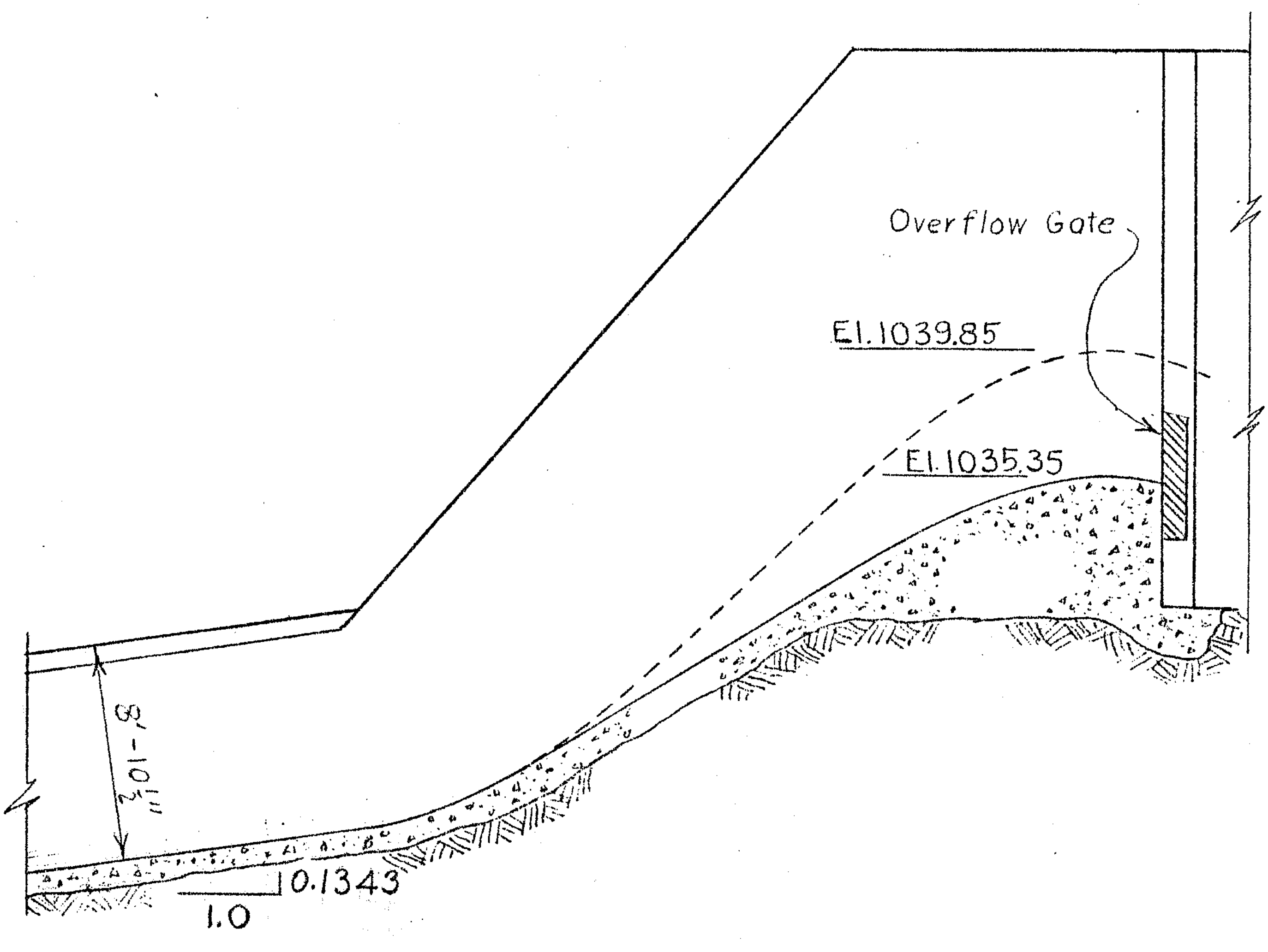
Not only would this modification provide improved fish passage conditions over the spillway, but it should also reduce delay of fish leaving the reservoir. Downstream migrants have an increasing reluctance to pass over a sill as the depth becomes less than one foot. This

PROPOSED SPILLWAY MODIFICATION
for
DOWNSTREAM MIGRATING FISH

NOTE

Existing Spillway training wall, chute length + slope is as shown on California Water and Telephone Co's. Application Drawing No. 642-4, approved April 8, 1948. Needs to be varified as to its actual construction.





design would provide more depth at low flows over the sill as well as concentrate the flow in a smaller area for better fish attraction.

The proposed spillway gate could also be operated to permit increased spills during the time of day to coincide with the major diurnal downstream migration periods. At some projects, the major downstream movement was found to occur in the evening at dusk and shortly after dusk. The increased flows during these periods would provide added attraction.

During spill flows exceeding 150 cfs it is expected the majority of the fish would still pass through this lowered section of the spillway. This is due largely to the depth and volume the lowered section would discharge. For example, when the total spillway flow is 300 cfs, about 190 cfs would pass through the lowered section with 110 cfs over the rest of the spillway at a depth of about 6 inches.

CALIFORNIA WATER & TELEPHONE COMPANY
Monterey Peninsula Division

LOS PADRES DAM
SPILLWAY DISCHARGE – RATING TABLE

REC
DEC 2
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CALIFORNIA WATER & TELEPHONE COMPANY
Monterey Peninsula Division

LOS PADRES DAM
SPILLWAY DISCHARGE

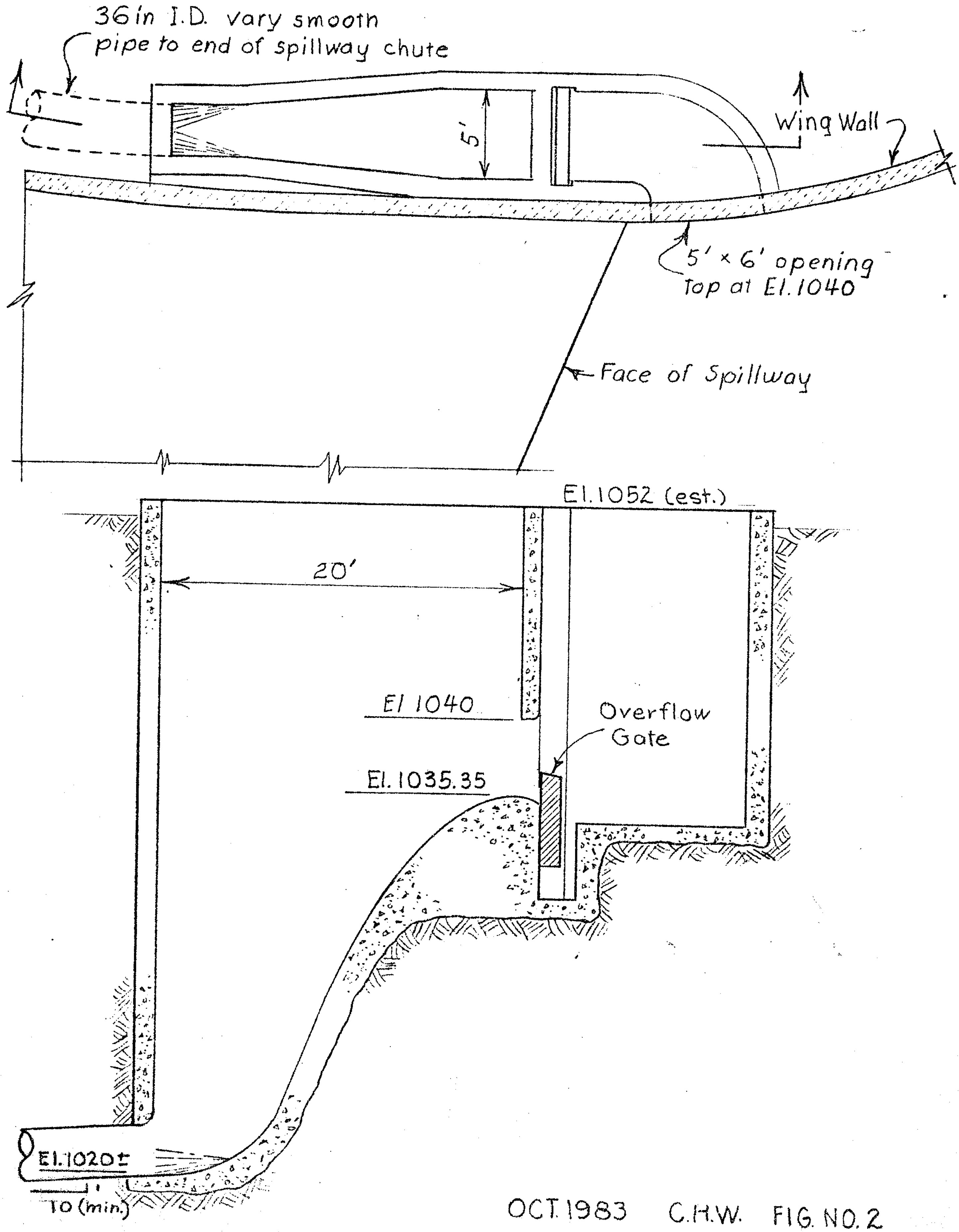
ELEVATION (FT)	FLOW (CFS)	ELEVATION (FT)	FLOW (CFS)	ELEVATION (FT)	FLOW (CFS)	ELEVATION (FT)	FLOW (CFS)
1039.85	-0-	1040.25	62.54	1040.65	197.05	1041.05	386.68
.86	.08	.26	65.22	.66	201.28	.06	392.05
.87	.16	.27	67.90	.67	205.50	.07	397.42
.88	.24	.28	70.58	.68	209.73	.08	402.78
.89	.32	.29	73.26	.69	213.95	.09	408.15
1039.90	.41	1040.30	75.96	1040.70	218.18	1041.10	413.52
.91	1.58	.31	78.82	.71	222.52	.11	419.12
.92	2.75	.32	81.67	.72	226.66	.12	424.72
.93	3.92	.33	84.53	.73	231.21	.13	430.31
.94	5.09	.34	87.38	.74	235.55	.14	435.91
1039.95	6.28	1040.35	90.24	1040.75	239.89	1041.15	441.51
.96	7.48	.36	93.38	.76	244.34	.16	447.22
.97	8.68	.37	96.52	.77	248.80	.17	452.93
.98	9.88	.38	99.67	.78	253.25	.18	458.61
.99	11.08	.39	102.81	.79	257.71	.19	464.35
1040.00	12.26	1040.40	105.95	1040.80	262.16	1041.20	470.03
.01	13.75	.41	109.21	.81	266.84	.21	475.89
.02	15.24	.42	112.46	.82	271.53	.22	481.71
.03	16.73	.43	115.72	.83	276.21	.23	487.54
.04	18.22	.44	118.97	.84	280.90	.24	493.36
1040.05	19.71	1040.45	122.23	1040.85	285.58	1041.25	499.19
.06	21.48	.46	125.71	.86	290.38	.26	505.13
.07	23.25	.47	129.20	.87	295.18	.27	511.07
.08	25.02	.48	132.68	.88	299.97	.28	517.01
.09	26.79	.49	136.17	.89	304.77	.29	522.95
1040.10	28.56	1040.50	139.65	1040.90	309.57	1041.30	528.89
.11	30.62	.51	143.31	.91	314.60	.31	535.00
.12	32.68	.52	146.96	.92	319.62	.32	541.11
.13	34.74	.53	150.62	.93	324.65	.33	547.23
.14	36.80	.54	154.27	.94	329.67	.34	553.34
1040.15	38.84	1040.55	157.93	1040.95	334.70	1041.35	559.45
.16	41.07	.56	161.76	.96	339.78	.36	565.79
.17	43.30	.57	165.58	.97	344.87	.37	572.13
.18	45.53	.58	169.41	.98	349.95	.38	578.47
.19	47.76	.59	173.24	.99	355.04	.39	584.81
1040.20	49.98	1040.60	177.06	1041.00	360.12	1041.40	591.15
.21	52.49	.61	181.06	.01	365.43	.41	597.55
.22	55.00	.62	185.06	.02	370.74	.42	603.95
.23	57.52	.63	189.05	.03	376.06	.43	610.34
.24	60.03	.64	193.05	.04	381.37	.44	616.74

PROPOSED ALTERNATE SPILLWAY MODIFICATION

There has been concern expressed about the dam's safety with an altered spillway crest and construction of the training wall down the spillway chute. In order to assure the spillway capacity will not be decreased and the dam structure not endangered, may require hydraulic model studies.

An alternate proposal for the safe passage of fish at low flows would be to provide an opening through the wing wall upstream of the spillway crest. From this opening the low flows would flow into a smooth pipe laid adjacent to the spillway chute and discharge freely into the pool downstream. The system would be designed so that at full pipe flow and at full reservoir, El. 1040, its capacity would be 150 cfs. The alternate proposal is shown on Fig. 2.

ALTERNATE
PROPOSED SPILLWAY MODIFICATION
for
DOWNSTREAM MIGRATING FISH



OCT. 1983 C.H.W. FIG. NO. 2

UPSTREAM MIGRANT FACILITIES

EXISTING FACILITY

The existing upstream adult facilities consist of a low flow fish barrier, a Denil type fish ladder on the right bank that leads to a trapping facility from which fish are dipped and placed into a tank on a truck for transportation over the dam. The facilities are located approximately 275 feet downstream from the downstream end of the Los Padres Dam spillway chute.

The low flow fish barrier is constructed of "gabions" and extends across the main river channel but does not cross what appears to be the dam's outlet channel along the left bank. It was reported that at high river flows fish can and do pass over and around the left end of the barrier dam.

The upstream adult migration period begins sometime in December and continues into April with 95 percent of the steelhead counted over San Clemente Dam during January, February and March. A much higher river flow will occur when fish are present than the approximately 5 cfs observed on September 7, 1983 (Kelley, June 1982, page 19). A minimum flow of 40 cfs in the stream is recommended in Kelley's report of June 1982.

Observation of the high water marks led to the conclusion that at least part of the dam also becomes submerged at higher river flows and evidence of stream bed degradation downstream of the barrier dam was noted. Concern was expressed by persons at the site over the possible short life of the wire of the gabion's mesh and the gabion's ultimate collapse.

At the low river flow observed on September 7, 1983, the flow from the Denil fish ladder did produce good attraction flow into the river. It is not known whether this attractive flow condition continues at higher river flows, particularly when there is spill over the gabion dam.

A few feet upstream from the ladder exit is an underwater swing-gate fish trap. Fish exit this type of fishway at a fairly good speed and could swim right through the gate. However, it is likely that many fish will hesitate passing through the swing-gate and with the gate being so close to the ladder exit, will drop back down the ladder where they can be injured from the sharp metal edges of the baffles.

Operation of the facilities as described to me, is that after the fish pass through the swing-gate trap into the holding pool, they are crowded to one of two small pens. From these pens the fish are dipped with a dip net into the tank mounted on a truck.

The water supply for operating the trap and ladder is brought to the facilities through a pipe line from the dam.

A short distance upstream were the remains of a previously constructed ladder and trap which appeared to have been severely damaged by high water.

Few fish are reported to be trapped at this facility. In the winter and spring of 1982 only 13 males and 37 females were passed over Los Padres Dam (Kelley, 1982, page 70). Of those passed over the dam it is most likely not known whether these fish were progenies of fish spawned above or downstream of the dam.

Suggested Improvements

1. Without major reconstruction, improvements that can be made to the present facilities are to heighten and extend the gabion

fish barrier across the flood channel. The overflow sill of the dam should be raised to provide a minimum of a 3.5 to 4 foot drop onto the gabion apron. The apron, which is also made of gabions, may have to be widened to extend 8 to 10 feet downstream of the sill. Review of river flows indicate a fish barrier is required for river flows of about 2,000 cfs.

2. Protection against damage from floods should be provided to the fish ladder with the construction of an abutment wall.

3. Replace the submerged swing-gate trap with a tunnel trap and relocate it around the corner of the holding pool to provide a longer distance between the exit of the ladder and the tunnel trap.

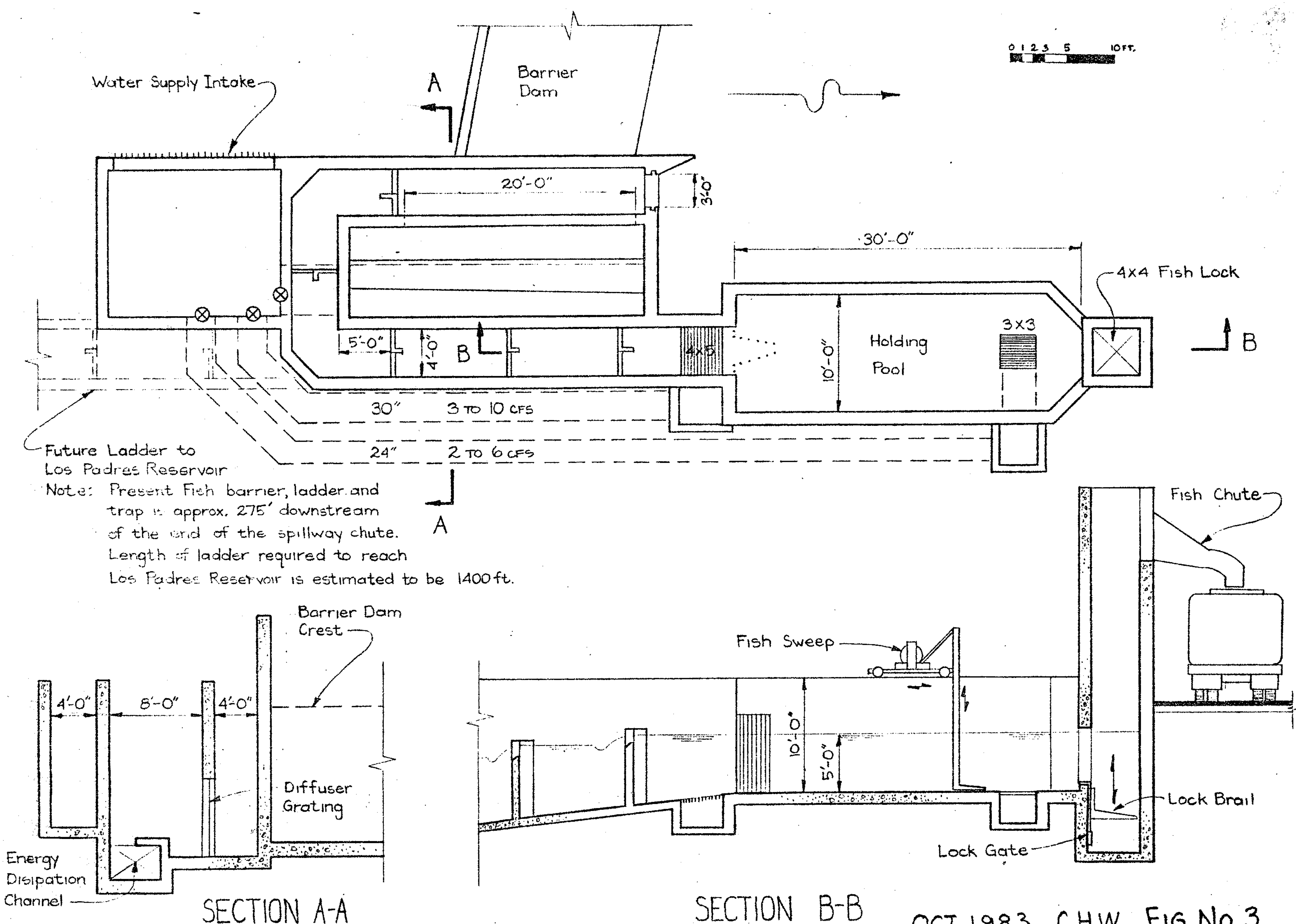
4. Provide a shallow hopper in the two small holding areas and a jib hoist so that fish can be lifted and placed into the tank on the truck without hand dipping.

RECOMMENDED UPSTREAM ADULT MIGRANT FACILITIES

The proposed upstream adult migrant facilities for Los Padres Dam consist of a new fish barrier dam, fish ladder, holding pool and truck loading facilities. The proposed facilities are illustrated on Fig. 3.

FISH BARRIER DAM

Construct a new fish barrier dam. Of the two types of barrier dams most commonly used, one design maintains a sufficient drop to stop fish at all stream flows and the other creates a fish block by providing a limited depth with a high velocity on a flat apron with a change in direction of flow at the upper end of the apron. The two are referred to as a minimum drop fish barrier and velocity-apron barrier.



OCT. 1983 C.H.W. FIG. No. 3

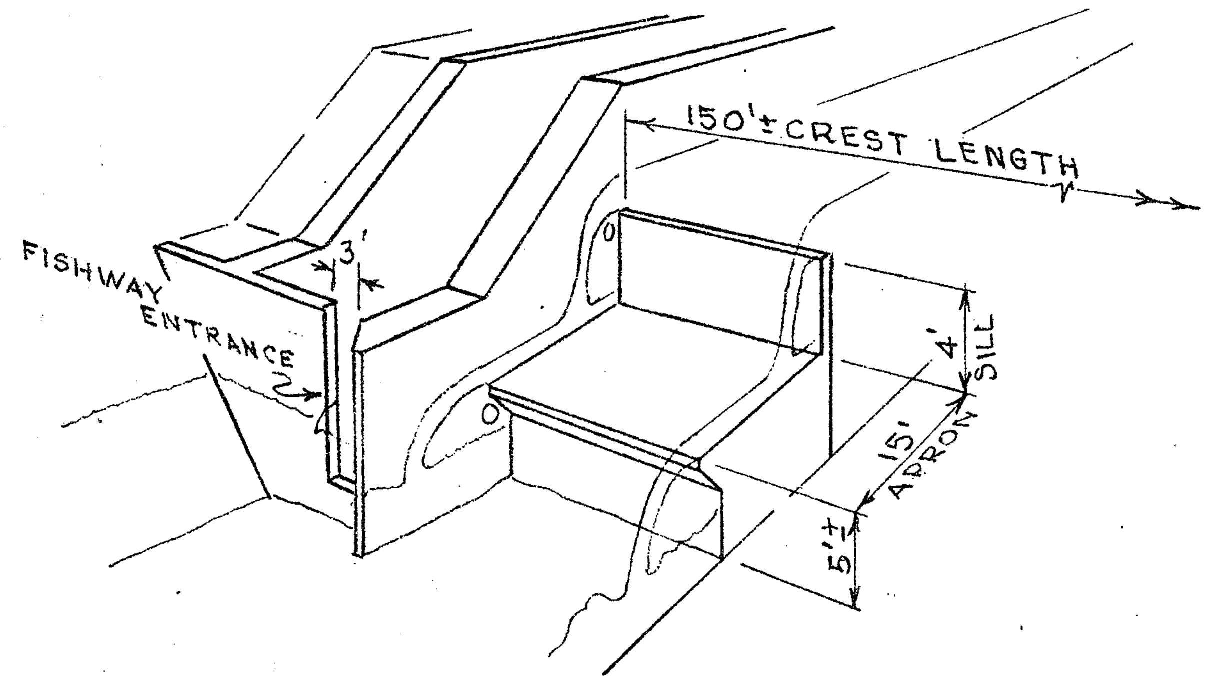
For this initial study, the type of fish barrier dam recommended is the velocity apron type fish barrier as illustrated in Fig. 4. Its design was first developed in California, and is now incorporated in numerous presently operating facilities, including Colema Hatchery, CA, Fall Creek Dam, OR, Applegate Dam, OR, White Salmon Hatchery, WA, Carmen Smith Dam, OR, and has been tested at the Fishery Laboratory at Bonneville Dam. Hydraulics of such a barrier were model tested at the Corps of Engineers Hydraulic Laboratory at Vicksburg, Mississippi.

The range in river flows and river stage should be established through which a barrier has to be effective. Good attraction needs also to be maintained to the fishway entrance through this range of river flows.

A guideline often used in the northwestern states to avoid extensive overdesign and still provide good conditions for fish is that optimum fishway flow conditions be provided for all river flows up to those that do not last more than 3 days once in 10 years. The facilities will continue to operate at higher flows but under less than desirable conditions. Often upstream fish movement ceases during the very high flood flows.

The maximum instantaneous flows recorded since August 1957 are 7,100 cfs on April 2, 1958 and 7,030 cfs on January 16, 1978. The daily average flows for those days were respectively 4,800 cfs and 2,780 cfs. Flows not exceeded for more than 3 days are less yet. It is therefore estimated the daily average flow one could design for the fish barrier, using 75 percent of the flow at the Robles del Rio Gage, is 2,000 cfs.

For this site it appears the design river flow would be about 2,000 cfs. The rise in river for river flows, 50 cfs to 2,000 cfs, is



FISH BARRIER

OCT. 1983 C.H.W FIG. NO. 4

estimated will be about 4 feet. (U.S.G.S. Robles del Rio Gage, 1958 rating table, Table 1.)

The barrier should be constructed diagonally across the river to form a guide or lead fish to the fishway entrance on the right bank. The barrier crest length would be 150 feet long. With proper alignment and fishway entrance location attempts by fish to pass the barrier are reduced, if not eliminated.

The entrance design is probably the most important part of the fishway. The fishway entrance, located at the right end of the barrier dam, should be placed in a manner that fish will not bypass it and will be attracted into it by its flow.

The width, depth, discharge and velocity are all factors to be considered in providing good attraction to fish throughout the range in river flows. The discharge is usually the designer's foremost concern.

It is recommended that the first 50 cfs released past Los Padres Dam be diverted at the first barrier dam into the fishway entrance pool to be discharged from the fishway entrance. At this flow the drop from the entrance pool to the river should be one foot.

As releases are increased from Los Padres Dam, additional water should be added to the entrance pool until approximately 150 cfs is added.

ENTRANCE DESIGN CONSIDERATIONS

River flow range for optimum passage conditions	40 cfs to 2,000 cfs
Tailwater range	4 feet (to be verified in field)
Discharge	Vary 40 cfs to 150 cfs; first 50 cfs in river to discharge from entrance before any spill over barrier
Head	Maintain 1 foot for entrance discharges above 50 cfs
Width of opening	3 feet minimum
Depth	3 feet minimum (adjustable with stop logs)

The added water to the entrance pool would be provided through a diffusion chamber. Fish entering the pool are in a confined condition differing from that which they just left in the river and some fish passage delay can be expected here before they proceed up the fishway. A good flow through the pool will lessen fall out back through the entrance.

ENTRANCE POOL DESIGN CONSIDERATIONS

Minimum depth	5 feet
Auxiliary water Introduction through side diffuser, diffuser velocity	Horizontal velocity over gross area--1.0 f.p.s. for side diffuser
Bar spacing	1 inch clear

The fish ladder begins at the upstream end of the entrance pool. The most common fish ladder is the pool type with overflow weirs containing submerged orifices and the pool type with vertical slots in the dividing partitions. The other type somewhat common is the Denil or counterflow design first developed by MacDonald in 1879 then refined by Denil in 1909. The Alaska steeppass uses one of Denil's baffle designs.

Denil type ladders are usually limited to about 50 feet in length before a resting pool needs to be provided. The usual recommended maximum length for salmon is 36 feet. Although fish going upstream in a Denil ladder very seldom strike a baffle, should they drop back downstream they are thrown against the baffles by the turbulent flow on their way down.

An advantage of a pool type ladder is that resting space is provided in each pool and fish will pace themselves through the ladder as they migrate upstream. This was well demonstrated at the National Marine Fisheries Laboratory at Bonneville Dam. (Corps of Engineers Progress Report, 1960, on Fisheries Engineering Research Program.)

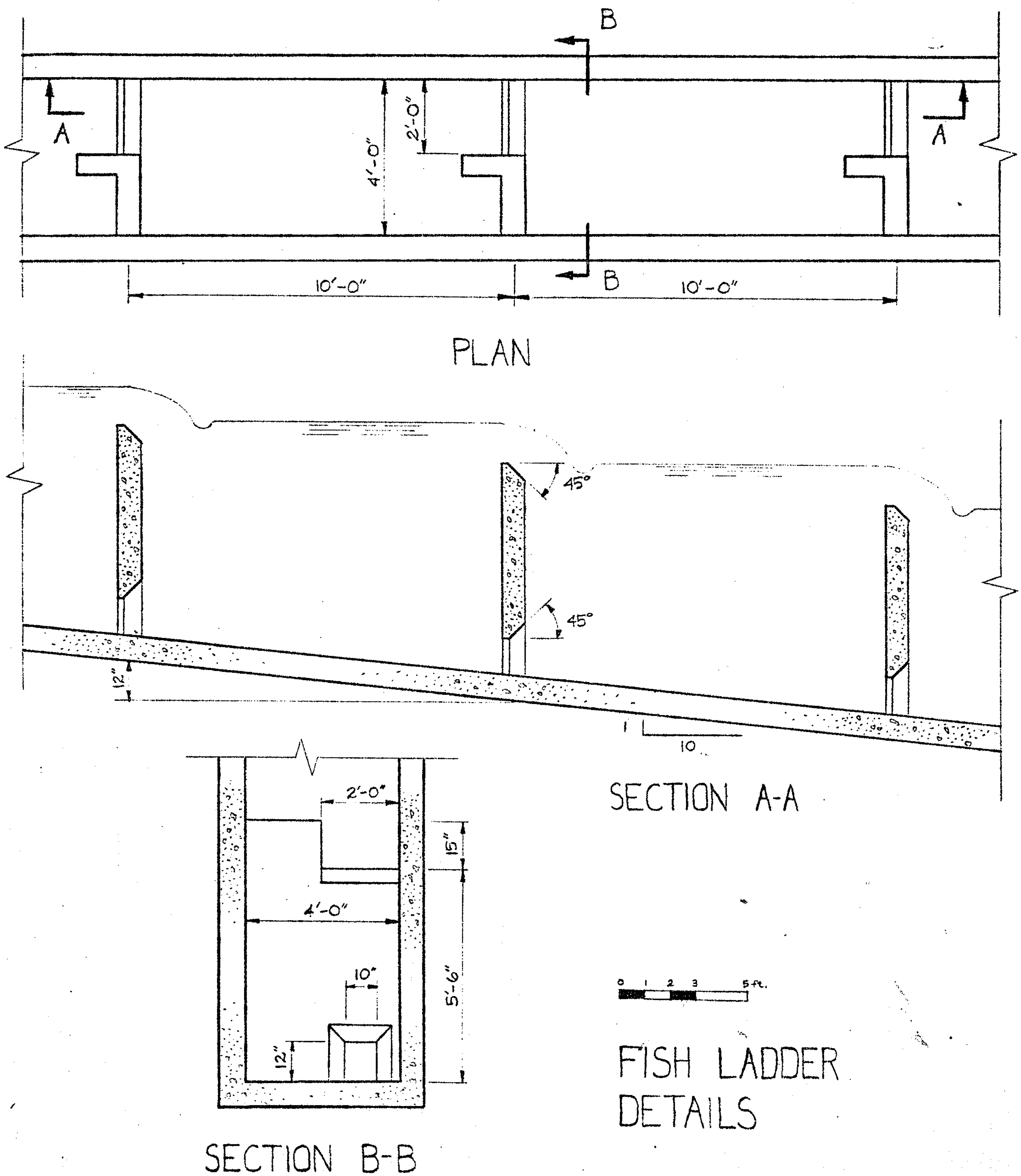
A submerged orifice with the overflow weir is considered desirable for steelhead. Steelhead, as with salmon, prefer swimming at a deeper depth and it has been observed on fishways in the Columbia River system that most salmon and steelhead will pass through the orifices where both the overflow and orifice are provided. Even at the Lewiston Dam on the Clearwater River where an orifice of only 10 inches wide by 12 inches high was provided under an overflow weir width of 3 feet, the majority of the steelhead passed through the orifice.

FISH LADDER DESIGN CONSIDERATIONS

Pool sizes and shapes	Minimum pool size for salmon and steelhead-- 4 feet wide, 10 feet long and preferably 6 feet deep
Ladder discharge	12 cfs
Weir design	Ice Harbor design with 2 feet overflow
Orifice--number and size	1 per pool--10 inches x 12 inches located under the overflow weir
Drop between pools	12 inches

The design for a pool type ladder recommended for this project is as shown on the following sketch. (Fig. 5.)

The three most common types of devices to keep fish in a holding pool are the finger trap attached to the top of an overflow weir crest, a picketed tunnel trap and a false weir trap. Any of these designs



FISH LADDER
DETAILS

OCT. 1983 C.H.W. FIG. No. 5

is acceptable for this project.

The holding pool needs to be designed to accommodate the expected peak number of fish to be held at one time. Approximately 15 percent of the total run can be expected in one day. For a run of 2,000 steelhead this is 300 fish. Assuming that during the peak of the run, the holding pool will be emptied at least twice, the pool should be able to accommodate at least 150 fish.

A crowder should be provided in the holding pool to urge the fish into the transfer facilities to transfer the fish to the truck.

HOLDING POOL DESIGN CONSIDERATIONS

Required space in trap holding pool	1.0 cu. feet per pound of fish
Average weight per steelhead	Est. 9 lbs.
Depth of pool	5 feet (minimum)
Water exchange	2.5 times per hour (minimum) water introduced in bottom diffuser
Crowder speed	Variable 0 - 20 f.p.m.

To minimize handling and stress of the fish, the fish transfer is often accomplished by use of a hopper into which the fish are crowded from the holding pool. Another method is by the fish lock method developed by the Oregon Fish and Wildlife Service. One such installation is at Applegate Dam (OR). One advantage of the lock system is a sizeable crane hoist is not required.

FUTURE EXTENSION OF LADDER OVER LOS PADRES DAM

In the future it is possible to extend the fish ladder from where it enters the holding pool to the forebay of Los Padres Dam. The reservoir should be filled during the upstream migration period for the adult steelhead which begins sometime in December and continues into April with most passage to occur in January, February and March (Kelley, June 1982, page 19). The ladder would draw its water from the surface of the reservoir and water quality should not be a factor in deterring fish to migrate up the ladder this time of the year. The total rise of about 130 feet of the fish ladder will not be a factor in limiting its success.

The logical route for the fish ladder from the barrier dam would be to traverse along the right wall of the spillway chute to the forebay.

To control the flow down the fish ladder for a fluctuating forebay level and still permit uninterrupted fish passage can be accomplished in a number of different manners at the upstream end of the ladder. The control necessary is usually within 10 percent plus or minus of the optimum level. The following is a list of different methods that have been used:

a) Stoplogs

b) Vertical adjustable weirs

c) Vertical adjustable weirs plus weir removal

d) Tilting weirs

e) Submerged orifices with controlled make-up below orifice section

f) Vertical slot with make-up below control section

g) Vertical slot with bleed off system from each control pool

Pool designs must be considered individually for each method.

The submerged orifice flow control with a controlled make-up flow below the orifice section is recommended.

The submerged orifice control section is composed of a series of pools with only submerged orifices in the partitions to pass the ladder flow. (Figure 6.)

Since less flow will occur at the lower reservoir levels, the orifices are designed to pass the ladder flow at the design upper reservoir level and as the pool drops, water is added to the fish ladder pool below the orifice flow control section.

This type of ladder flow control is used on may fish ladders including those at Rock Island, Rocky Reach, Priest Rapids, Wanapum and Wells Dams on the Columbia River.

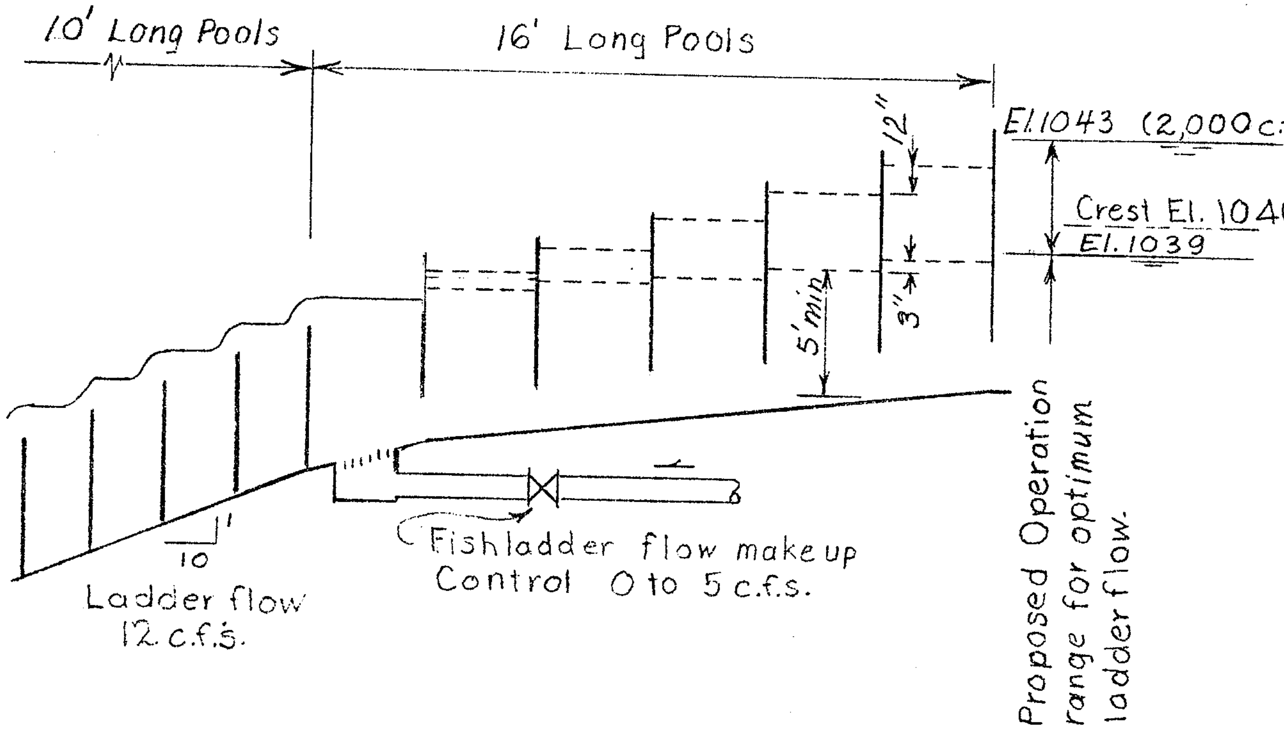
FISH LADDER FLOW CONTROL DESIGN CONSIDERATIONS

Reservoir level	Spill flows that do not last longer than 3 days once in 10 years (est. 2,000 cfs)
Pool length	16 feet minimum

FISH COUNTING FACILITIES

Often it is desirable to include fish counting facilities with a fish ladder. The two most common counting methods involve one with a horizontal submerged board over which the fish swims and is identified from above the water surface and the other a vertically submerged board which the fish swims by and is seen through a window in the fishway wall. The latter is preferred, primarily due to better fish identification and usually less delay. An example is the one located at the Tehama-Colusa spawning channel. Because of the short delay caused by the counting station, the pool downstream needs to be of adequate size to accommodate the build up of fish during the peak of the daily hourly fish movement.

WEIR TYPE FISHWAY WITH ORIFICE FLOW CONTROL



OCT. 1983 C.H.W. FIG. N(

Fish counting stations have been located at the exit of the fish ladder or down in the fish ladder itself. When located at the exit, its design must accommodate the forebay fluctuation and if placed in the fish ladder, additional length must be added to the fish ladder to accommodate the station.

NEW SAN CLEMENTE DAM

REVIEW OF WATER STORAGE PROJECTS WITH FISH PASSAGE

Table A provides a list of projects where fish runs were passed over the dam. Projects where the passage has been discontinued are designated by an asterisk.

REASONS FOR DISCONTINUING FISH PASSAGE

AT THE FOLLOWING PROJECTS

BROWNLEE DAM

The downstream migrant facilities consisted of a floating collection net across the reservoir just upstream of the dam. The fish were collected in three floating traps placed along the net. Attraction flow into the traps was accomplished by pumps. The net itself was over 2,000 feet long and 120 feet deep.

Passage of fish was discontinued when it was found that many of the juveniles did not migrate downstream the 60 miles of reservoir, survival in the reservoir was low, and maintenance of the downstream facilities, particularly the net, was extremely difficult. (Fourth Progress Report, Fisheries Engineering Program, May 1976, U.S.C.E. Report No. 48.)

COUGAR DAM

The downstream facilities consisted of five, vertically spaced, specially designed fixed outlets (fish horns) built into the regulating outlet tower just upstream of the dam. The adult trapping facility was at a fish barrier constructed in the regulating outlet tailrace channel.

Collection of adult and juvenile salmon and survival of juveniles was determined unsatisfactory and fish passage was discontinued with the run transferred to a hatchery. (Fourth Progress Report; Fisheries Engineering Program, May 1976, U.S.C.E. Report No. 35.)

Table A

PROJECT	HEAD (feet)	RESERVOIR Capacity (Acre-feet)	Length (Miles)	PRIMARY SPECIES
Baker (upper)(WA)	285			Sockeye, coho
Baker (lower)(WA)	262	70,000		Sockeye, coho
Brownlee (ID-OR)*	375	1,470,000	60	Chinook (steelhead transplanted)
Cougar (OR)*	320	208,000	6.5	Chinook
Fall Creek (OR)	166	125,000	6.8	Chinook, steelhead
Foster (OR)	115	61,000	3.5	Chinook, sockeye, steelhead
Green Peter (OR)	322	430,000	8.5	Chinook, sockeye, steelhead
Mayfield (WA)	182	127,000	21.5	Chinook, coho, steelhead
Merwin (WA)*	313	650,200		Coho
Mossyrock (WA)*	350	1,371,860		Chinook, coho, steelhead
Mud Mountain (WA)	Flood control	106,000		Chinook
North Fork (OR)*	135			Chinook, steelhead
Pelton (OR)*	208	80,000 (est)	7.5	Chinook, steelhead
Round Butte (OR)*	365	520,000	10	Chinook, steelhead
Wynoochee (WA)	155	64,000	4	Chinook, steelhead

*Fish runs are no longer passed at these projects.

MERWIN DAM

Coho rearing was attempted in the reservoir. Modifications to a spillway bay and use of a floating trap were tested here to collect and transfer the downstream migrants over the dam. It was concluded conditions, principally predation, precluded the use of Lake Merwin as a rearing area for coho salmon. (Fourth Progress Report, Fisheries Engineering Program, May 1976, U.S.C.E. Report No. 43.)

MOSSYROCK DAM

The downstream migrant facilities consisted of a series of floating traps located along the shoreline of the reservoir. From these traps the juveniles would be collected and trucked to below the dam. The traps proved ineffective in collecting sufficient numbers of juveniles and the runs of salmon and steelhead have been transferred to a hatchery.

PELTON DAM

Downstream migrant facilities consisted of an artificial surface outlet at the right abutment of the dam. Water drawn into the outlet for fish attraction was returned deep into the reservoir. Fish passage was stopped after Round Butte Dam was constructed and adequate downstream migrant passage failed at Round Butte. Tests conducted at Pelton Dam after Round Butte Dam was constructed showed efficiency of collection of juveniles ranged from poor to fair. (Fourth Progress Report, Fisheries Engineering Program, May 1976, U.S.C.E. Report No. 41.)

ROUND BUTTE DAM

Two types of downstream migrant fish collectors were used at Round Butte. One was an artificial outlet that operated near the reservoir surface for the first 21 feet of reservoir operation and the other a floating fish trap identical to the Baker Dam "gulper." The "gulper" operated for reservoir levels below 21 feet from full capacity. In 1965, small numbers of chinook and steelhead juveniles were collected for passage. The passage of fish runs has been discontinued and has been transferred to a hatchery. (Fourth Progress Report, Fisheries Engineering Program, May 1976, U.S.C.E., Report No. 41.)

MEANS OF DOWNSTREAM PASSAGE
OF THOSE PROJECTS PASSING FISH RUNS

UPPER AND LOWER BAKER DAMS

Downstream juvenile migrants are collected in the reservoirs near each dam in a floating "gulper." From this facility they are transported by pipe to below the dam. Attraction flow is provided into the "gulper" by a low head pump. At these projects this method has been successful in maintaining the sockeye salmon runs. It is worth noting that artificial spawning beaches are provided above the upper reservoir to offset lost spawning habitat.

FALL CREEK DAM

Three sets of outlets, called "fish horns," were constructed on the upstream slope of the rock filled dam. In addition, the regulating outlet of the dam is used to pass downstream migrating fish. Each set of outlets consists of three outlets of various sizes, the smallest being of 30 cfs capacity. When all three are in operation about 200 cfs is discharged. Each size outlet has a separate pipe through the dam and is either on or off. The intake of the outlet structure is about 40 feet from the face of the dam. The "fish horns" did not prove to be as effective as desired in collection of downstream migrants. One possible reason for reduced effectiveness is the intake location in respect to the face of the dam and depth in reservoir. Present reservoir operation empties the reservoir completely sometime during the winter months and most migrants emigrate out through the regulating outlet. (Oregon Fish Commission, Final Report, 1970, Evaluation of Fish Facilities and Passage at Fall Creek Dam on Big Fall Creek in Oregon.)

FOSTER DAM

No special facilities were provided at this project, with downstream passage to be through the spillway and powerhouse. The turbines were designed and operation controlled to minimize mortality for any fish passing through the powerhouse.

Steelhead proved to be reluctant to pass under the 50-feet deep spillway gates and into the powerhouse intakes.

Recent work showed steelhead juvenile migrants were very surface oriented at the project and modification of a spillway bay to provide surface spill has greatly improved their passage. 90 percent of the reservoir releases at Foster, and 82 percent of the Green Peter Reservoir releases, which had to pass Foster Dam, were recaptured about 130 miles downstream at Willamette Falls. (Oregon Department of Fish and Wildlife, Progress Report 1982, Restoration of the Native Winter Steelhead Run on the South Santiam Above Foster Dam.)

GREEN PETER DAM

Green Peter Dam very seldom has any surface spill during the early spring months. Passage of downstream migrants is entirely through the downstream facilities. The downstream facilities consist of a "fish horn" constructed on the vertical face of the dam that is adjustable both with the rise and fall of the reservoir and with the reservoir water surface itself. Attraction flow into the horn is pumped back deep into the reservoir. Juveniles are screened from this flow and transported to below the project by pipe. (Oregon Department of Fish and Wildlife, Progress Report 1982, Restoration of the Native Winter Steelhead Run on the South Santiam Above Foster Dam.)

WYNOOCHEE DAM

Wynoochee Dam has four outlets provided for downstream migrants at the face of the dam located at various elevations. Each outlet has a separate conduit to tailrace and is operated either on or off. One or all can be operated at one time. Successful collection and passage of juveniles from the reservoir appears to improve with more than one outlet in operation. Species studies were primarily the coho salmon. (Washington State Department of Fisheries, Progress Report No. 45, 1978, Evaluation of Downstream Fish Passage at Wynoochee Dam.)

RESERVOIR OPERATION OF PROJECTS PASSING FISH RUNS

Of those projects presently passing runs of fish, most are Corps of Engineers projects. Flood control is a primary consideration in these projects' reservoir design and operation.

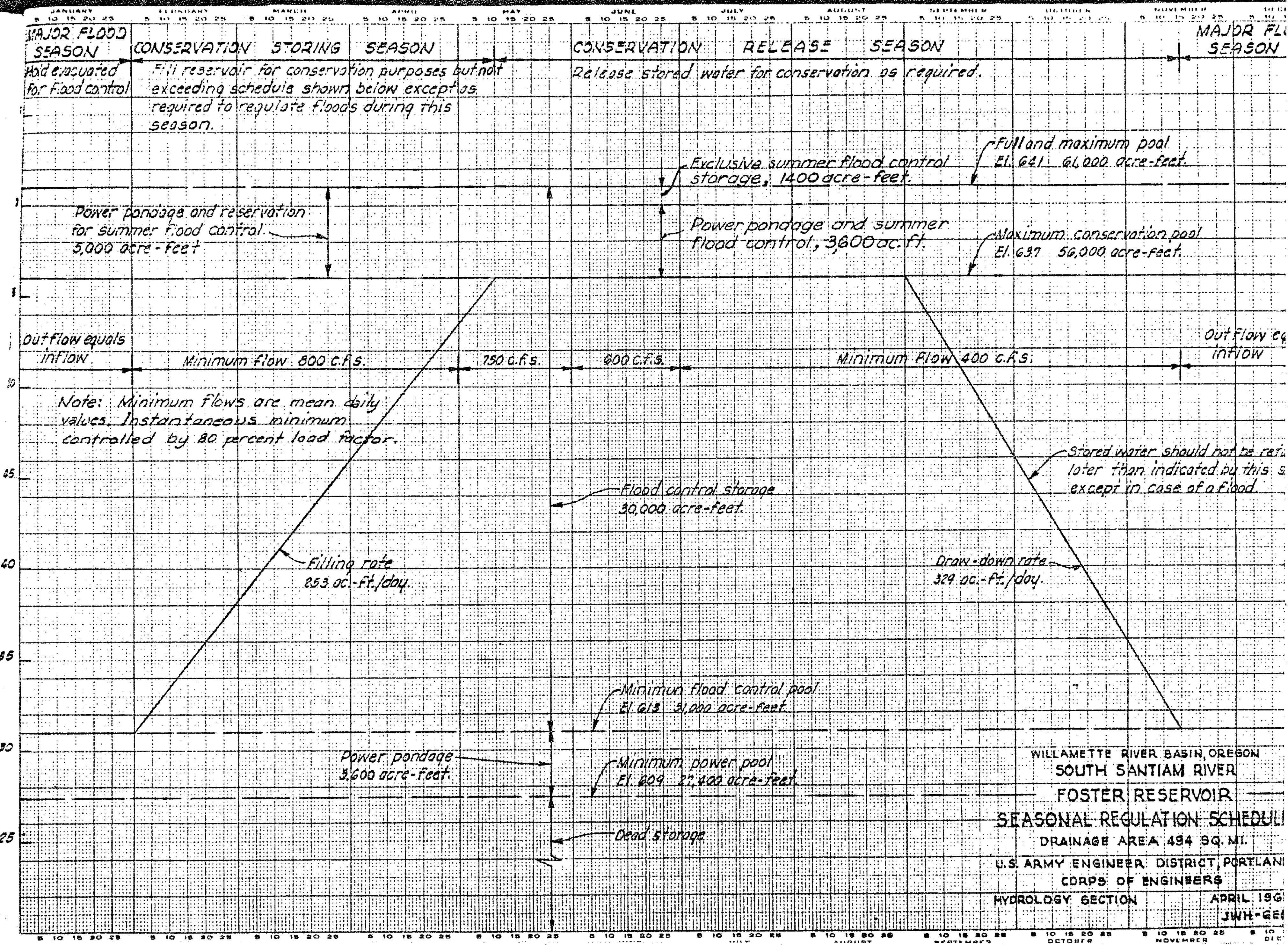
Reservoir operation is similar for Foster, Cougar, Green Peter, Fall Creek and Wynoochee. The reservoirs are drawn down in the fall to flood control levels for short-term flood storage during the winter months. The reservoirs usually begin filling on February 1 and reach full pool around May 10. Releases vary with each project but can be as low as 30 cfs as at Fall Creek Dam and 50 cfs at Green Peter Dam. This occurs particularly when there is a low runoff during the filling period.

Mayfield flows reflect storage at Mossyrock. Space is also set aside in Mossyrock Reservoir for flood control and this space is filled during February, March and April.

Operating rule curves for Foster, Cougar and Green Peter Dams are on the following pages, Fig. 7, 8 and 9.

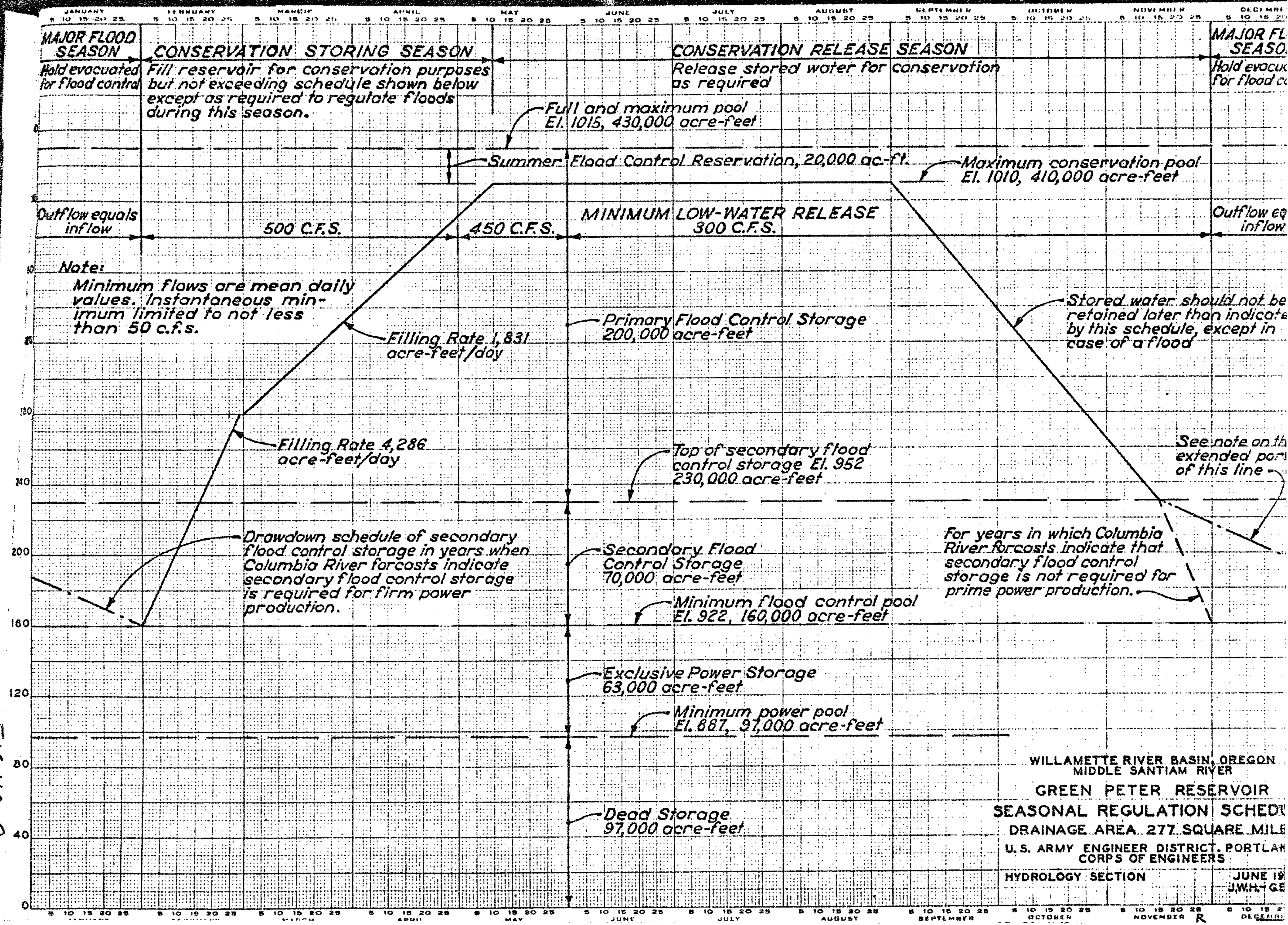
Mud Mountain Dam is operated entirely for flood control and the reservoir is drawn down after every major storm runoff has been regulated. Downstream migrants pass through the bottom outlets of the dam.

The flow through these reservoirs can be dramatically reduced during February, March and April, particularly when the runoff is low during these months.



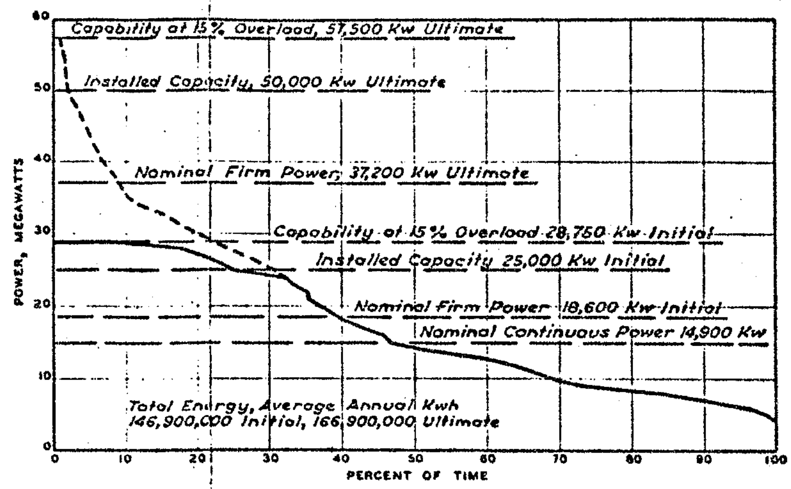
MAJOR FLOOD SEASON
CONSERVATION STORING SEASON
CONSERVATION RELEASE SEASON
MAJOR FL[…] SEASON
Hold evacuated for flood control
Fill reservoir for conservation purposes but not exceeding schedule shown below except as required to regulate floods during this season.
Release stored water for conservation as required.
Full and maximum pool El. 641 61,000 acre-feet.
Exclusive summer flood control storage, 1400 acre-feet.
Power pondage and reservation for summer flood control. 5,000 acre-feet
Power pondage and summer flood control, 3,600 ac. ft.
Maximum conservation pool El. 637 56,000 acre-feet.
Outflow equals inflow
Minimum flow 800 c.f.s.
750 c.f.s.
600 c.f.s.
Minimum flow 400 c.f.s.
Note: Minimum flows are mean daily values. Instantaneous minimum controlled by 80 percent load factor.
Stored water should not be re[…] later than indicated by this […] except in case of a flood.
Flood control storage 30,000 acre-feet.
Filling rate 253 ac.-ft./day.
Draw-down rate 329 ac.-ft./day.
Minimum flood control pool El. 613 31,000 acre-feet
Power pondage 3,600 acre-feet.
Minimum power pool El. 609 27,400 acre-feet
Dead storage
45
40
35
30
25
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
WILLAMETTE RIVER BASIN, OREGON
SOUTH SANTIAM RIVER
FOSTER RESERVOIR
SEASONAL REGULATION SCHEDU[…]
DRAINAGE AREA 494 SQ. MI.
U.S. ARMY ENGINEER DISTRICT, PORTLAN[…]
CORPS OF ENGINEERS
HYDROLOGY SECTION
APRIL 196[…]
JWH-GE[…]

FIG. NO. 7



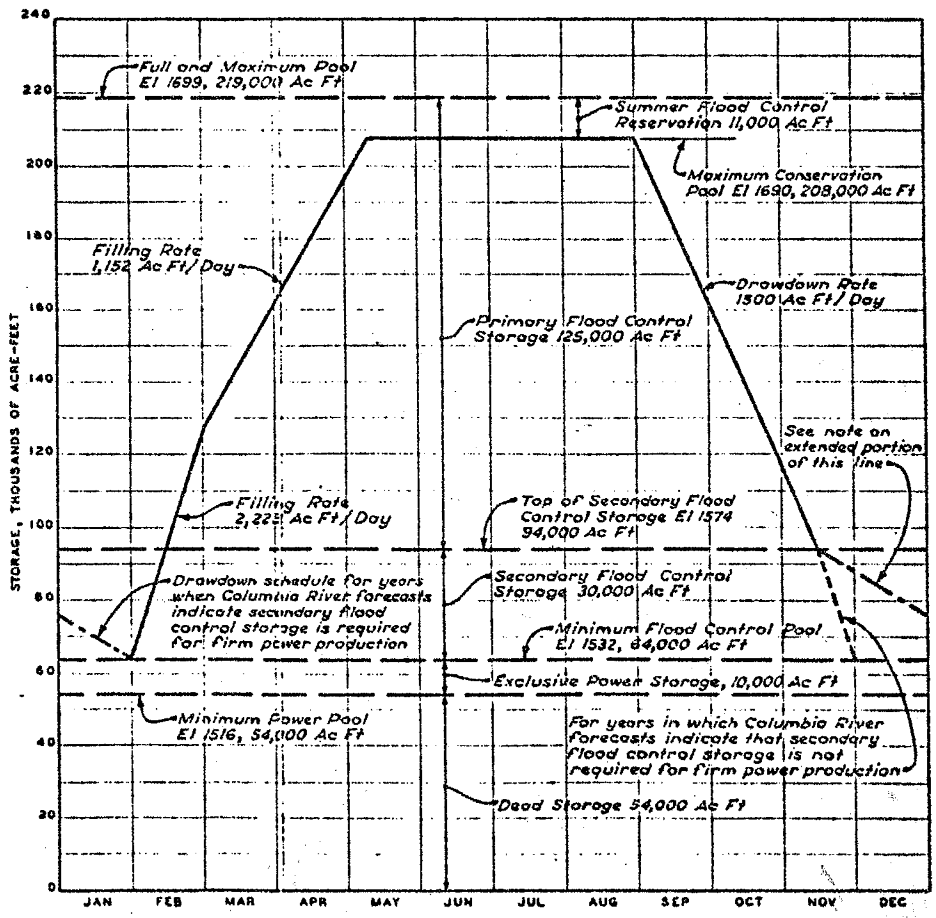
MAJOR FLOOD SEASON
Hold evacuated for flood control
CONSERVATION STORING SEASON
Fill reservoir for conservation purposes but not exceeding schedule shown below except as required to regulate floods during this season.
CONSERVATION RELEASE SEASON
Release stored water for conservation as required
Full and maximum pool El. 1015, 430,000 acre-feet
Summer Flood Control Reservation, 20,000 ac.-ft.
Maximum conservation pool El. 1010, 410,000 acre-feet
Outflow equals inflow
500 C.F.S.
450 C.F.S.
MINIMUM LOW-WATER RELEASE 300 C.F.S.
Note: Minimum flows are mean daily values. Instantaneous minimum limited to not less than 50 c.f.s.
Primary Flood Control Storage 200,000 acre-feet
Filling Rate 1,831 acre-feet/day
Stored water should not be retained later than indicated by this schedule, except in case of a flood
Filling Rate 4,286 acre-feet/day
Top of secondary flood control storage El. 952 230,000 acre-feet
See note on the extended portion of this line
Drawdown schedule of secondary flood control storage in years when Columbia River forcasts indicate secondary flood control storage is required for firm power production.
Secondary Flood Control Storage 70,000 acre-feet
For years in which Columbia River forcasts indicate that secondary flood control storage is not required for prime power production.
Minimum flood control pool El. 922, 160,000 acre-feet
Exclusive Power Storage 63,000 acre-feet
Minimum power pool El. 887, 97,000 acre-feet
Dead Storage 97,000 acre-feet
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
0
40
80
120
160
200
WILLAMETTE RIVER BASIN, OREGON
MIDDLE SANTIAM RIVER
GREEN PETER RESERVOIR
SEASONAL REGULATION SCHEDULE
DRAINAGE AREA 277 SQUARE MILES
U.S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS
HYDROLOGY SECTION
JUNE 19
J.W.H.-G.E.
R

FIG. NO. 8



POWER DURATION

28 YEAR PERIOD 1926-1953



RESERVOIR STORAGE AND RELEASE SCHEDULE

WILLAMETTE RIVER BASIN, OREGON
SOUTH FORK McKENZIE RIVER

COUGAR RESERVOIR

POWER GRAPHS

SCALES AS SHOWN

PORTLAND DISTRICT, CORPS OF ENGINEERS — NOV 1, 1956

SUPERVISED: D. G. Baird — CHIEF, POWER SECTION
RECOMMENDED: — CHIEF, ENGINEERING DIVISION
SUBMITTED: — CHIEF, PLANNING BRANCH
APPROVED: — COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN: SRS
TRACED: WJM
CHECKED: HHB

TRANSMITTED WITH REPORT DATED NOV 1, 1956

CU-20-5/2

FIG NO. 9

REVIEW OF THE OPERATION OF THE NEW SAN CLEMENTE DAM RESERVOIR

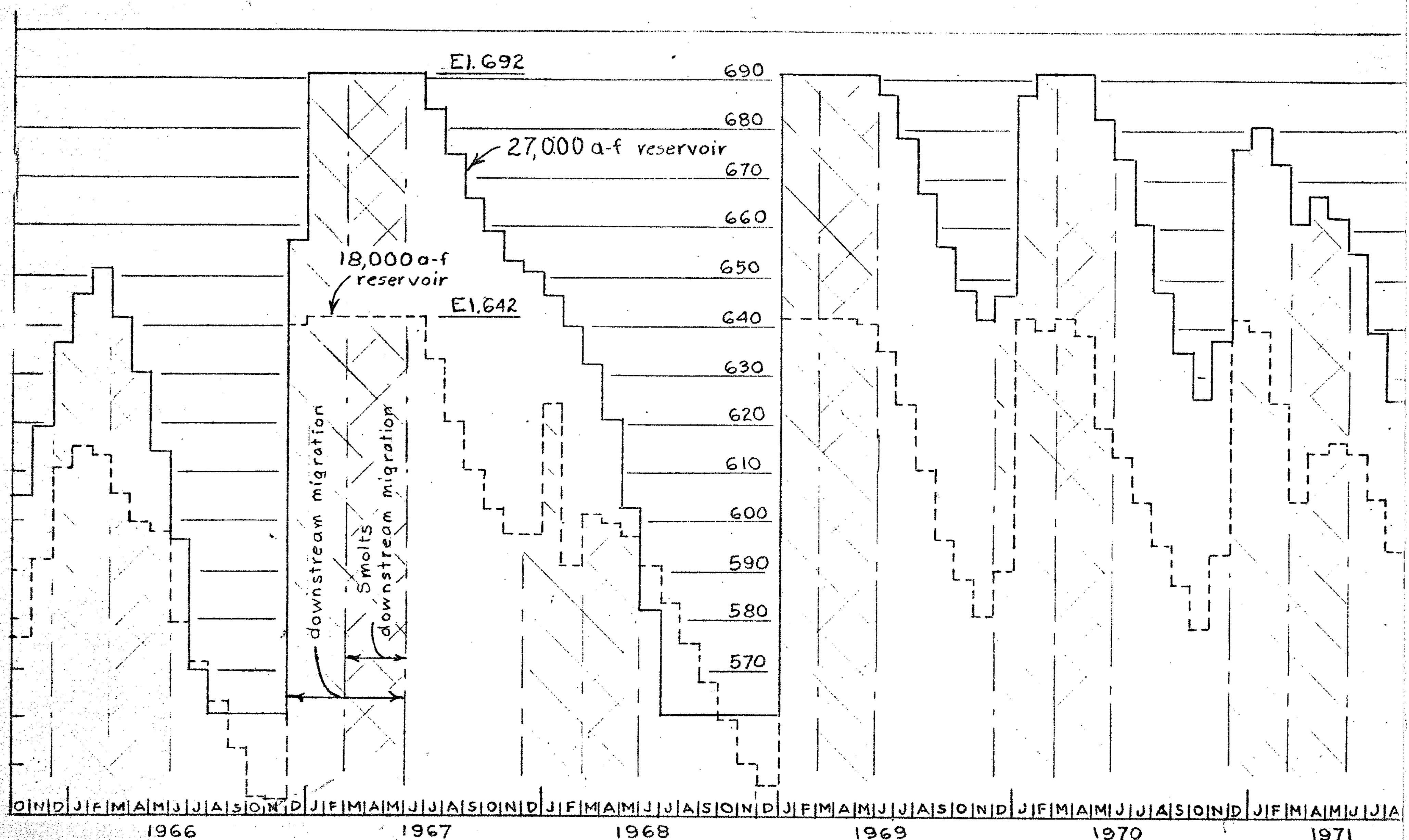
The reservior depth data in Converse Consultants' Report of 1982 and their letter report of 1983 was converted to reservoir water surface elevation for a randomly picked 6-year period from October 1965 to September 1971 and is shown on the graph, Fig. 10. This period covered both wet and dry years.

The graph illustrates the mode of operation where winter storm runoffs are stored and drawn upon during the late spring and summer months. Once the reservoir is filled, inflow into the reservoir is passed through the project.

The period of concern with downstream juvenile migration is from December through May with smolt migration being from March through May.

With the 18,000 acre-feet reservoir, the number of years in the 76 years of record the reservoir would be filled is 43 years in February, 47 years in March, 43 years in April and 16 years in May.

On those years when the reservoir is not filled, the reservoir is usually being drafted during the months of March through May with the water stored during the winter months. This mode of operation of storing winter heavy runoff for summer releases, is in contrast to the Corps' projects where flood runoff storage is short term (days) and reservoirs are then filled from spring runoff.



RESERVOIR REGULATION SCHEDULE
NEW SAN CLEMETE DAM

FIG. NO. 10

MIGRATION OF JUVENILES THROUGH THE RESERVOIR

On the Columbia River where juveniles must migrate 20 to 80 miles through a reservoir and through as many as 9 reservoirs (Wells Dam to Bonneville Dam), a great concern is the downstream travel time of the fish.

One method of computing this travel time of fish through a reservoir is published in the report, "Effects of Power Peaking on the Survival of Juvenile Fish at the Lower Columbia," April 1976, U.S. Army Corps of Engineers, North Pacific Division. This method uses the fish' own swimming effort and the velocity of the water. The swimming effort is assumed to be the cruising speed of the fish (young salmon), in feet per second, equaling one-sixth of its length. The velocity of the water is based on displacement time (volume of the reservoir divided by the inflow). This of course considers that no stratification has taken place and a well mixed flow exists throughout the reservoir.

Under this method for the New San Clemente Project, with an average March inflow of 300 cfs and an average fish size of 5 inches, the total travel time for the 18,000 acre-feet reservoir would be:

$$\text{Displacement} = \frac{18{,}000}{300\ (1.983)} = 30 \text{ days}$$

$$\text{Average water velocity} = \frac{3 \text{ miles}}{30} = 0.1 \text{ l/sec.}$$

$$\text{Swimming speed of the fish} = 1/6 \text{ of } 5'' = 0.83 \text{ l/sec.}$$

$$\text{Total travel time would be } \frac{3 \text{ miles}}{(0.140.83)(3600)(6 \text{ hours travel per day})} =$$

0.8 of a day

This methodology is not applicable for all reservoir conditions, such as that which occurred in the Brownlee Reservoir where water quality, temperature and dissolved oxygen greatly delayed downstream migration. Also, in the large reservoir of Round Butte Dam, many downstream migrants did not negotiate the reservoir.

In the smaller reservoirs, the downstream migrant fish apparently do pass through the reservoirs, but with some delay. The upper parts of the reservoirs are usually narrow and relatively shallow having a flow through them at a higher velocity than through the remainder of the reservoir. In many reservoirs there is also a thread of flow at a higher velocity through the reservoir itself.

Studies conducted at Wynoochee showed "Migrant coho salmon and steelhead trout appeared to have no problems passing through Wynoochee Reservoir, but examination of the fish captured in the lake and downstream from Wynoochee Dam showed that both species (1) milled in the forebay of the dam for several days prior to passing through the dam, and (2) exhibited a large degree of delay in the reservoir. The principal factor affecting fish migration and influencing delay was attraction to the outlet pipes." (Progress Report No. 45, Evaluation of Downstream Fish Passage Through Multi-level Outlet Pipes at Wynoochee Dam, Washington Department of Fisheries, March 1978.)

There is no question that delay will occur in passage through the reservoir as compared to passage down an open stream.

DOWNSTREAM PASSAGE PAST THE DAM

The major problem in downstream migration past a dam lies in the successful attraction and collection of these migrants. The downstream migrant facility installed at Green Peter Dam (OR) has proven successful with winter run steelhead. At Wynoochee the type of downstream facility also proved its capabilities to attract and collect the fish. However, more delay occurs here and discharge regulation through this system is important.

Modification of a spillway bay to provide a surface spill was required at Foster Dam to provide downstream migrating steelhead adequate attraction collection and pasage of the fish.

At most of the projects on the Columbia River even during a low water year when all the river flow can be passed through the powerhouse, spill is provided to pass the juveniles. The spill is often scheduled for certain hours during the day when migration rate is the highest, to conserve water. Although a major purpose to pass the fish through a spillway is to bypass the mortality the fish would encounter passing through turbines, it also assists in reducing delay in passing the dam.

With the downstream migrant passage facilities, once the fish are collected, transportation of the fish to below the dam is usually done by pipeline, but can be done by hauling. The fish ladders at Pelton Dam and North Fork Dam were used to transport the downstream migrants. Of course, when spill is used for fish passage, the spillway design is required to provide safe hydraulic conditions.

NEW SAN CLEMENTE DAM

RECOMMENDED FACILITIES

UPSTREAM ADULT STEELHEAD MIGRANT FACILITIES

The adult facilities recommended with this project would be essentially as described in Converse Consultants, Inc. October 18, 1982 letter report:

> "Upstream migration of steelhead past the new San Clemente Dam will be provided at the Sleepy Hollow area approximately one mile downstream of the dam. (Figure 1.) The steelhead will be collected at Sleepy Hollow and trucked upstream of the dam and released into the reservoir. A barrier will be constructed in the river to divert the steelhead to a ladder and holding pond. A 12-inch diameter water supply line will be constructed from the dam to provide water for the attraction flow at the barrier."

Upstream migrant fish passage will be required from December through March.

With the 27,000 acre-feet alternate project, the adult upstream migrating fish collection needed to be located downstream of the plunge pool of the spillway. Had the facilities been located at the outlet structure, upstream fish passage, during times of spill, would be at least partially blocked and those fish trying to pass through the turbulent pool would be subject to injury and disorientation. In addition, should there have been any difference in water quality between that water spilling and that passing the regulating outlet, fish would be reluctant to proceed to the outlet structure. The flow from the spillway and the outlet flow would be well mixed by the time it reaches the fish barrier downstream.

With the 18,000 acre-feet project it would be possible to locate the fish ladder and holding pool at the outlet works. However, the question of difference in water quality from the spill, outlet works, and fishway as a hindrance to collection of upstream migration remains. Also, the method of discharging and energy dissipation of the flow from the regulating outlet may not be compatible to providing the necessary attraction flow patterns in the tailrace to lead fish to the fish ladder entrance.

At this time similar facilities as that described for the 27,000 acre-feet project should be used.

When developing design details, consideration should be given to supplying water for the holding pool, fish ladder and attraction flow from above the fish barrier dam in lieu of the 12" diameter water supply pipe. This would lessen the concern of difference in quality of water discharging from the fish ladder and the water in the river downstream.

The adult fish barrier recommended would be a fish barrier dam, similar to the one described previously for the Los Padres Dam. However, the height and length of the structure will meet the requirements for the flows and river stage at this site.

Transportation of fish over a dam has been accomplished by various methods including a fish ladder, fish hauling by truck, elevator and fish locks. At this stage of project planning the most feasible method is the fish hauling by truck.

Discussion:

Fish surmounting a fish ladder of the height required for this project would not be a problem. This has been well demonstrated by the results in the endless fish ladder at the Fishery Laboratory at Bonneville. Also, the fish ladder at the North Fork Dam on the Clackamas River in Oregon rises 196 feet and is 1.7 miles in length and is successfully negotiated by salmon and steelhead. (North Fork Reservoir fluctuation is 19 feet.)

A fish ladder for this project presents a special design problem in that it must function through a very large range of reservoir levels. One method by which this can be accomplished is to pump water through a "false weir" at the head of the ladder over which the fish would swim and find themselves in a flume to slide into the forebay. This method was used during the final year of construction of Wells and Wanapum Dams on the Columbia River. At that time the river was closed to passage and their reservoirs had not yet been filled to operate the fish ladders. The drawbacks to this method are the dependence on the pumps and power, (also availability of electricity), some delay in fish to passing through the false weir, maintenance of the flume both structurally and of the smooth surface required, and assurance of equal quality of water down the ladder with that in the river downstream.

Fish hauling by truck, elevator and fish locks all will require a holding pool to hold fish during periods when fish are not being transported.

With a fish lock, fish are urged into a lock chamber, usually constructed vertically, adjacent to the dam and at periodic intervals the water is raised in the chamber to reservoir level. Once this level is reached, a gate is opened to a channel connected to the reservoir and fish are urged out of the chamber exit by a rising crowder. Such facilities were provided at Bonneville, The Dalles and McNary Dams on the Columbia River. The range in forebay levels at the Columbia River projects is 10 feet or less. Since the fish ladders have proved themselves at these projects the fish locks are no longer used.

With the New San Clemente Dam, the reservoir range would be over 80 feet and a modified design of the fish lock will be required.

The lock chamber could be constructed on the upstream side of the dam with a long deep exit gate that would operate through the range of reservoir water levels. However, not only would this gate have to be designed for the pressures of a full reservoir, a channel through the dam extending from the fish ladder downstream to the bottom of the lock chamber is then required.

If the lock chamber is constructed on the downstream side of the dam, the lock chamber could be pumped full whenever the reservoir level is below full pool. Once the lock chamber is filled, the fish could be urged from the chamber with a crowder onto a flume or chute to slide into the reservoir.

A fish lock passage facility is not recommended for this project.

The main difference between hauling fish to the reservoir by truck or by elevator is the truck conveys the fish to the reservoir over a roadway, whereas, the elevator lifts the fish vertically or on a slope over the top of the dam and back down to the reservoir. Both require a specially designed tank for the fish. The main advantages of the elevator over trucking are that it does not have to rely on road conditions and fish are usually confined in the elevator transfer tank for a shorter period than in the fish tank on the truck.

The elevator can be automated to operate on a selected schedule, (this will require the crowder that urges fish into the elevator hopper to also be automated), however, experience has shown the elevator is not usually so operated.

A fish elevator with this proposed project will require a channel for fish to swim from the fish barrier dam to the holding pool at the base of the dam.

Trucking of adult fish runs to above dams has and is being successfully done at many projects. A primary concern with trucking is maintenance of the equipment and dependence of operating personnel.

Of the projects listed in Table A., truck hauling of fish runs is being done at Baker, Fall Creek, Merwin (to a hatchery), Mud Mountain (over 30 years), and Wynoochee. Trucking of fish is also being done from the fish trap at Keswick Dam (CA) to the Coleman Hatchery.

SPILLWAY DESIGN

To arrive at a recommendation for the spillway design, a review was made of the monthly average reservoir depth data and monthly outflow data in the New San Clemente Dam Report prepared by Converse Consultants.

It was found that in the 76 years of record the reservoir would have been filled 50 of the years for a 27,000 acre-feet reservoir and 55 of the years for a 18,000 acre-feet reservoir. During any of these flow periods spill could have occurred. However, release can also be made through the regulating outlet. The average monthly outflow from the dam would have exceeded the full capacity of the regulating outlet during 9 of the years with a 27,000 acre-feet reservoir and during 20 of the years with the 18,000 acre-feet reservoir.

Frequency of spill, therefore can be greatly influenced by the operation of the regulating outlet. The variation being 9 to 50 of the 76 years of record with the 27,000 acre-feet reservoir and 20 to 55 of the 76 years with the 18,000 acre-feet reservoir.

The maximum monthly outflow for the 18,000 acre-feet reservoir was found to be 69,570 acre-feet. This represents a monthly average flow of 1,157 cfs. Only during 5 years of record would the average monthly flow exceed 1,000 cfs and during one half of the years (38 years), did the monthly average exceed 240 cfs. The 240 cfs was never exceeded in May, and only 13 times in April and 25 times in March.

Once the reservoir is filled, the project will pass at least the inflow into the reservoir. A new look at U.S.G.S. daily flow records at the Robles Del Rio Gage, shows that inflow can fluctuate greatly from day to day. Some of this daily fluctuation will be dampened through the flood surcharge storage in the reservoir. The amount going over the spillway again will depend on the regulating outlet operation.

The apparent frequency that spill will occur will require special spillway design considerations for safe passage of fish.

A Rollcrete type dam is proposed for the 18,000 acre-feet reservoir being similar in design to that constructed by the Corps of Engineers on Willow Creek, Oregon.

Personal communication with Edward Oliver of the North Pacific Division Office of the Corps of Engineers indicated that the spillway surface at Willow Creek Dam was rough and this surface was only approved because spillway usage is to be very minimal; averaging approximately 15 minutes per year over the life of the structure. Mr. Oliver indicated that had any more spill been anticipated, a smoother surface would have been provided.

In addition to smoothness as a consideration for fish, an adequate depth of water is required, preferably a minimum depth of 6 inches.

Consideration of spill flows most likely to occur during the downstream migration period, particularly during smolt migration March through May, suggests that good safe passage should be provided for a flow of at least 250 cfs.

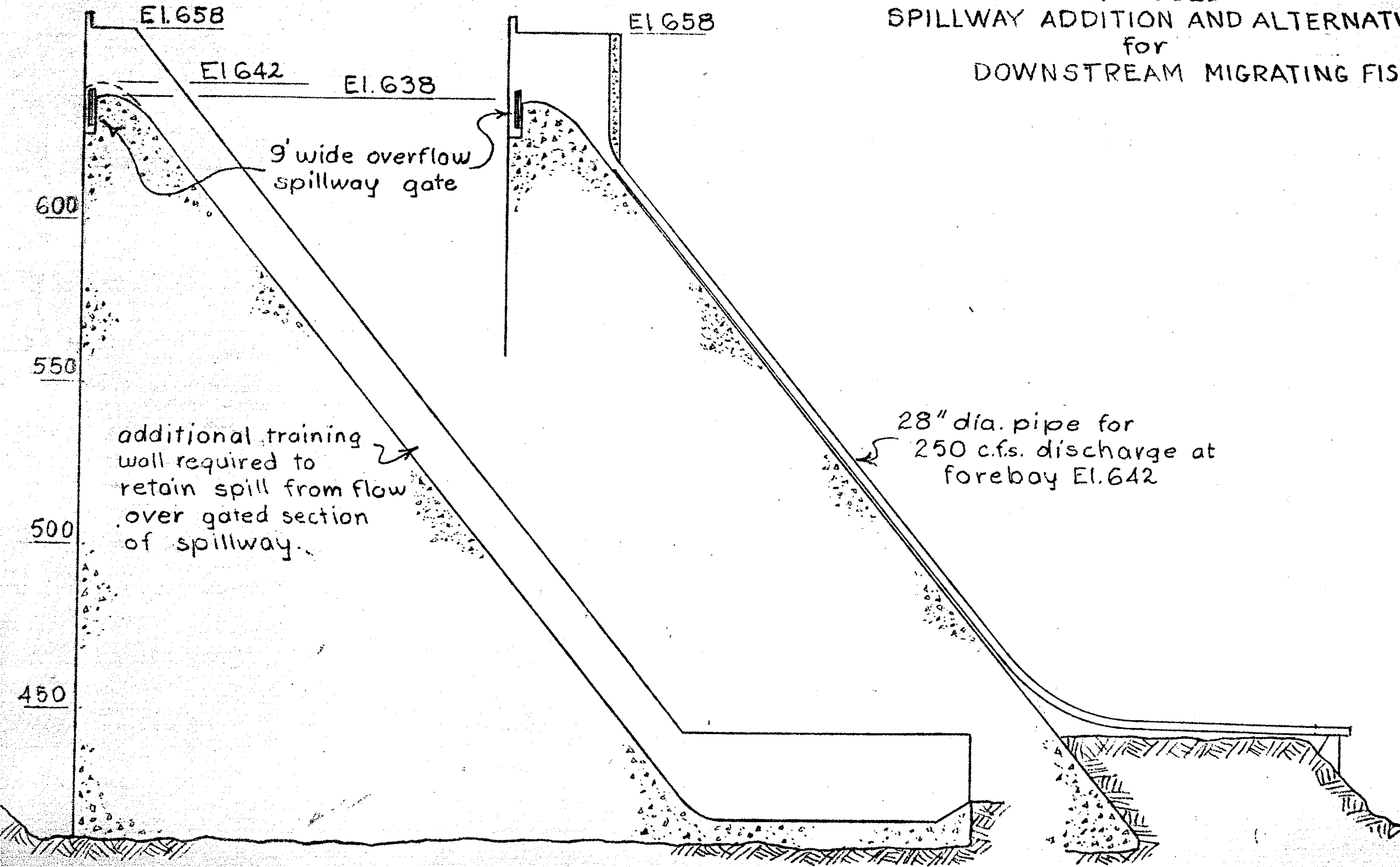
To provide for the passage of fish over the spillway, it is recommended that special design considerations be given to the first 250 cfs of spill. This could be accomplished by either of the two following methods. The first would be by lowering an 8 to 9 foot section of the spillway crest about 4 feet and be gated with an overflow gate. A training wall will be required to separate it from the rest of the spillway. The training wall would extend down the spillway and continue through the stilling basin. The stilling basin design to be such that no negative pressures occur. The alternate method would be to spill the first 250 cfs, also gated, adjacent to the spillway into a smooth conduit that would discharge into a pool in tailwater.

Salmon and steelhead are generally reluctant to pass over a sill having flows less than one foot deep. Therefore, the special spill section should pass most of the fish for spills approaching 900 cfs.

In addition, and an important consideration, is that when daily average outflows are less than 250 cfs, the gated structure would permit increasing spill flows during the hours when peak diurnal fish movement occurs. The spill flows during the other hours would be reduced accordingly. Such spillway operation procedure is being done at the main Columbia River projects, particularly during short water years where not only is this done to reduce delay in passage, but also to reduce the numbers of fish passing through the turbines.

The proposed modification of the spillway is shown in Figure 11.

PROPOSED
SPILLWAY ADDITION AND ALTERNATIVE
for
DOWNSTREAM MIGRATING FISH



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DOWNSTREAM MIGRANT FISH PASSAGE FACILITY

The facility recommended for the attraction and collection of downstream migrating fish during times when there is little or no spill is the Green Peter type fish attraction horn. The success of this facility is again reported in a recent Oregon Department of Fish and Wildlife Progress Report, 1982, Restoration of the Native Winter Steelhead Run on the South Santiam Above Foster Dam.

The proposed facility in general is as described in Converse Consultants' letter report of October 28, 1982:

> "The steelhead migrants are induced into an attraction horn to be constructed adjacent to the multiple intake structure. They travel through a fish transportation line and are discharged into the river downstream of the dam....
>
> "The major components of the attraction facilities are the separator unit, attraction water pumps, pump well, fish transport pipe, hoists, attraction horn and the additional required work for the multiple intake structure.
>
> "The attraction horn is approximately ten feet high and five feet wide and is sized to operate with the center line from ten to 25 feet below the reservoir surface. The attraction flow of 90 cfs is provided by two 40 horsepower pumps. The pumps draw water from the bottom of the attraction well and discharge it back into the forebay near the bottom of the pump well. With the pumps in operation a differential of three to four feet would be maintained between the reservoir and the collection well.
> The differential causes water to flow into the horn, through the vaned conduit, and across the separator unit. Fish enter the

horn at a velocity of approximately 2 feet per second (fps). The velocity increases to about 10 fps at the throat of the horn and across the separator screen. All but approximately 5 to 10 cfs passes through the upper part of the separator unit. The remaining 5 to 10 cfs and captured fish enter a trough at the end of the separator leading to a 12-inch diameter flexible hose.

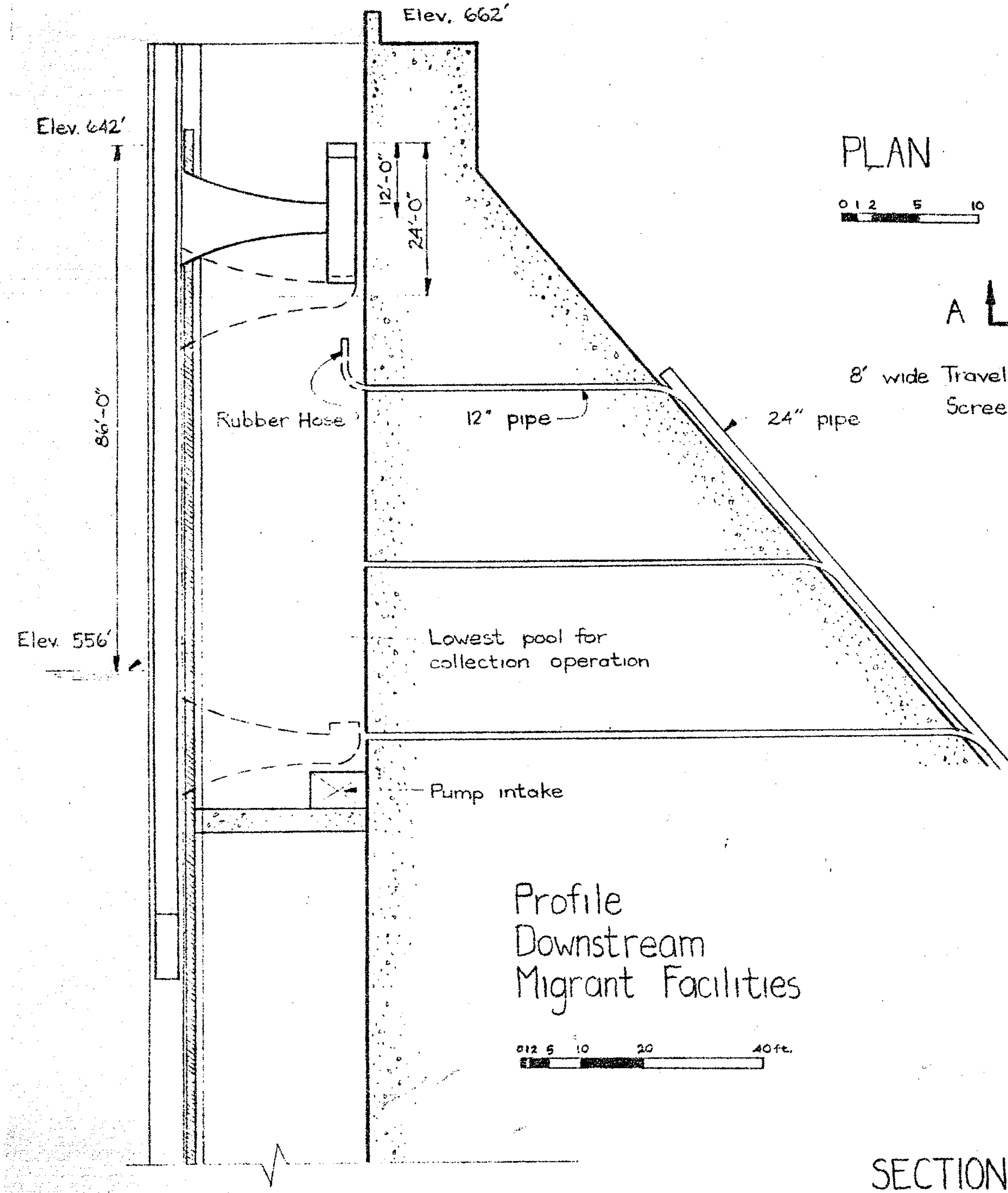
"The flexible hose is reinforced rubber with a smooth interior surface to prevent abrasion to the fish. The flexible hose is connected to one of the six laterals depending on the reservoir elevation. From the laterals, the fish and water enter the stainless steel fish transport pipe and travel through the tunnel to the downstream outlet structure and are discharged into a holding pond and then into the river.

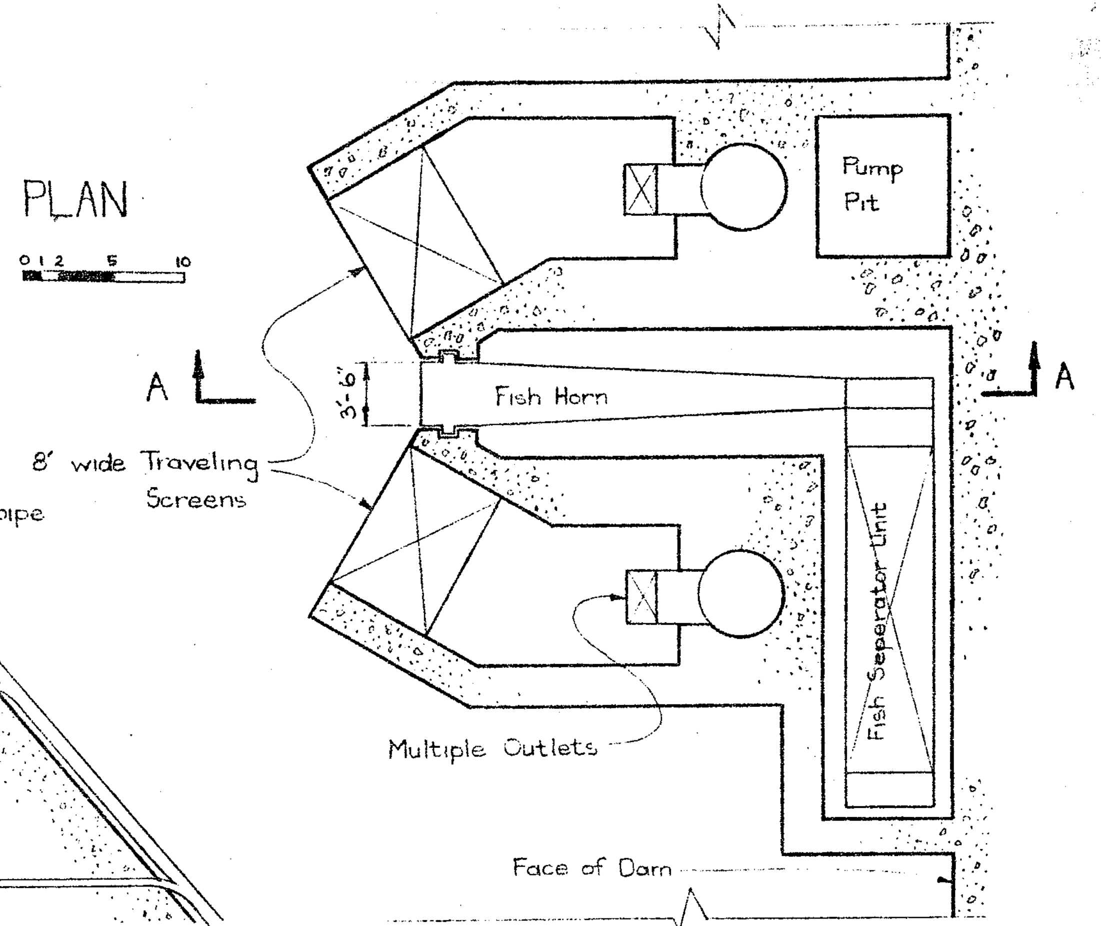
"The fish attraction facilities require additional construction to be included for the multiple intake structure. The additional work will provide for the fish attraction horn, pump well, and a fish screen for the butterfly valves."

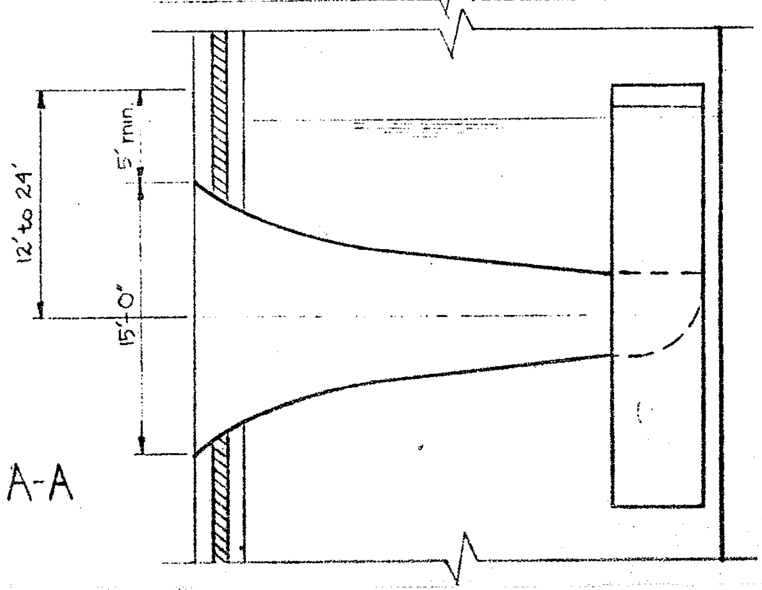
For the 27,000 acre-feet project, the attraction horn would be raised or lowered from El. 682 to El. 534 or approximately 132 feet vertically.

For the 18,000 acre-project, the attraction horn would be raised or lowered from El. 632 to El. 556 or approximately 86 feet.

The general arrangement of the facilities recommended for the 18,000 acre-feet project is shown on Fig. 12. The multiple level intake structure is divided into two sets of multiple level intakes, one on each side of the fish attraction horn. The vertical pipe riser to each set of multiple level intakes would be joined together at the bottom and then to a single conduit through the dam. The fish screens are so arranged to







SECTION A-A

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form a "V" with the horn intake in the apex. This arrangement takes advantage of any regulating outlet discharge providing more attraction flow for the fish to the vicinity of the horn intake.

The arrangement of the screens will also help to guide the fish along the screen to the horn intake.

The screen will be sized to have no more than 0.5 foot per second approach velocity to prevent impingement and the mesh of the screen will be such as to prevent junvenile steelhead from passing through. Consideration should be given to using a commercial vertical traveling screen. The screen would be equipped to operate automatically for cleaning whenever a small head, due to debris, develops.

It is also possible to provide a valved connection from the bottom of the attraction well to the multiple level outlet conduit. When at least 90 cfs of water is being discharged from the project, 90 cfs could be drawn through the horn by the outlet conduit and the pump then shut down.