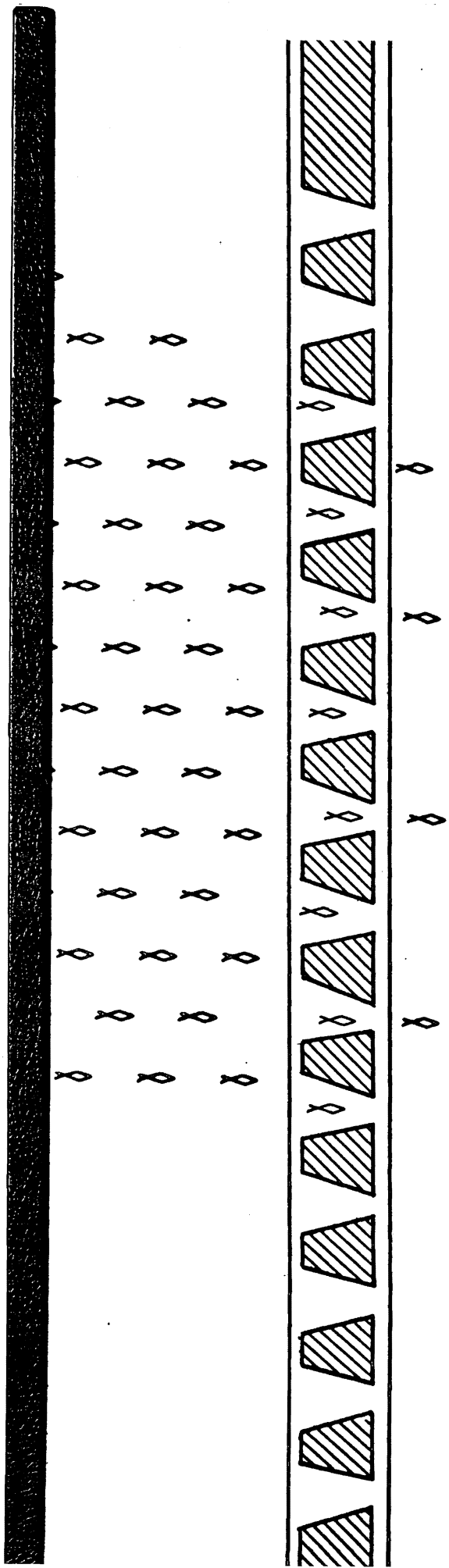

TBNOOMD

PROGRESS REPORT

Survival of Coho Salmon Fingerlings Passing Through A Perforated Bulkhead in an Empty Turbine Bay and Through Flow Deflectors (With and Without Dentates) on Spillway at Lower Monumental Dam, Snake River

April-May 1973

by

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and
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Research performed Under
Contract No. DACW-68-72-C-0101
between U.S. Army Corps of Engineers
and the National Marine Fisheries Service,
U.S. Department of Commerce

March 1974

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INTRODUCTION

To reduce high levels of dissolved nitrogen and other gases in the Snake River, the U.S. Army Corps of Engineers has designed and tested the mechanical and hydraulic performance of perforated bulkheads (Fig. 1) in the intakes of skeleton turbine units and of experimental flow deflectors on spillways at dams in lower Snake River. At Lower Monumental Dam, a flow deflector with dentates was installed in spillway bay No. 2 (Fig. 2) and a plain deflector in spillway bay No. 4 (Fig. 3). Although these hydraulic structures allow the passage of significant volumes of water through the dam with little, if any, increase in dissolved atmospheric gases, they may cause death or injury to young fish that pass through the structures on their migration to the sea.

The National Marine Fisheries Service, under contract to the Corps of Engineers, is evaluating fingerling passage and survival through the bulkhead and flow deflector. Studies in 1972 showed that perforated bulkheads caused high mortality to young fall chinook salmon, but flow deflectors with dentates were less harmful. Similar tests were run in 1973 to compare the effects of flow deflectors (with and without dentates) and to examine the effects of the perforated bulkhead on passage and survival of

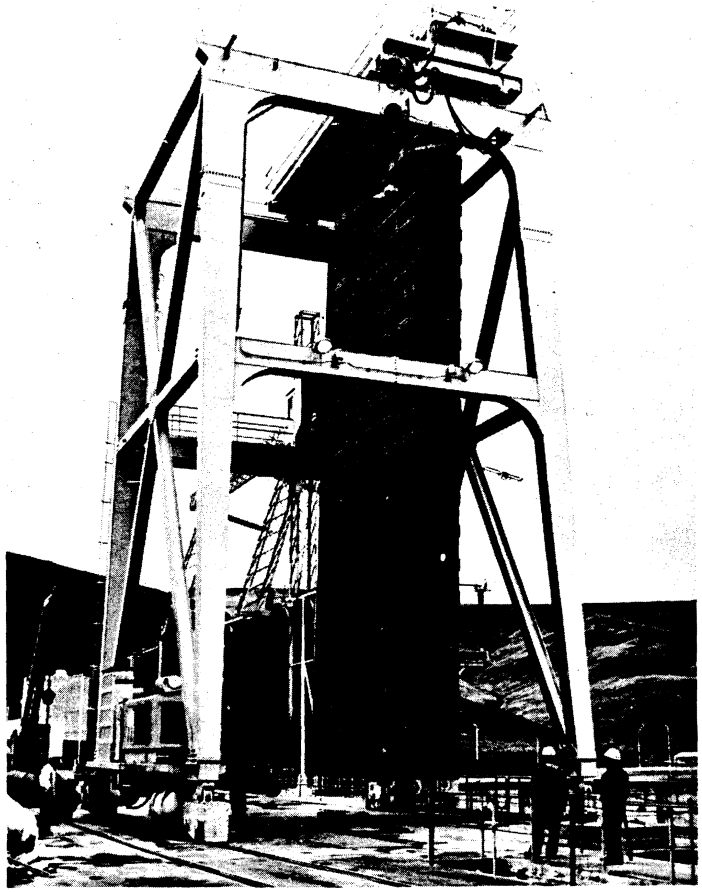

Figure 1.--Perforated bulkhead, upstream view.

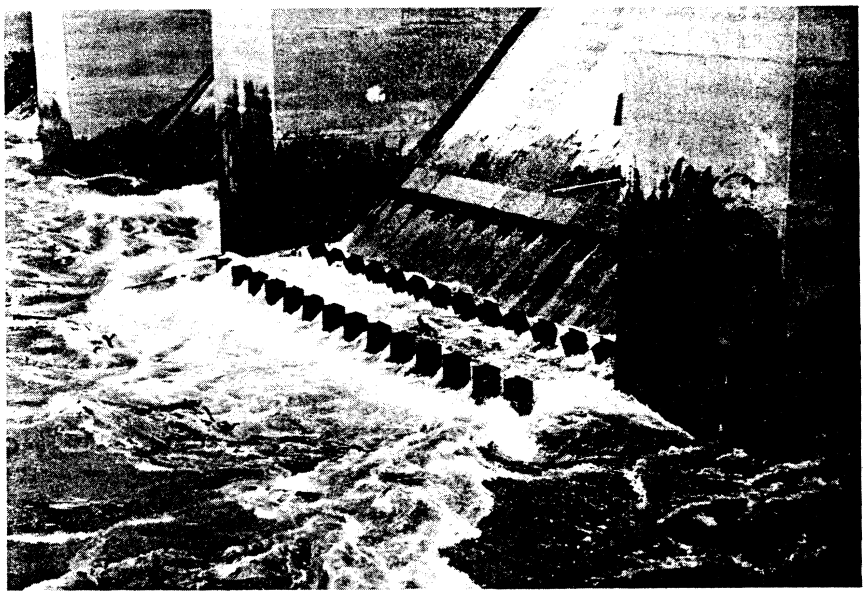

Figure 2.--Flow deflector with dentates in spillway bay at Lower Monumental Dam.

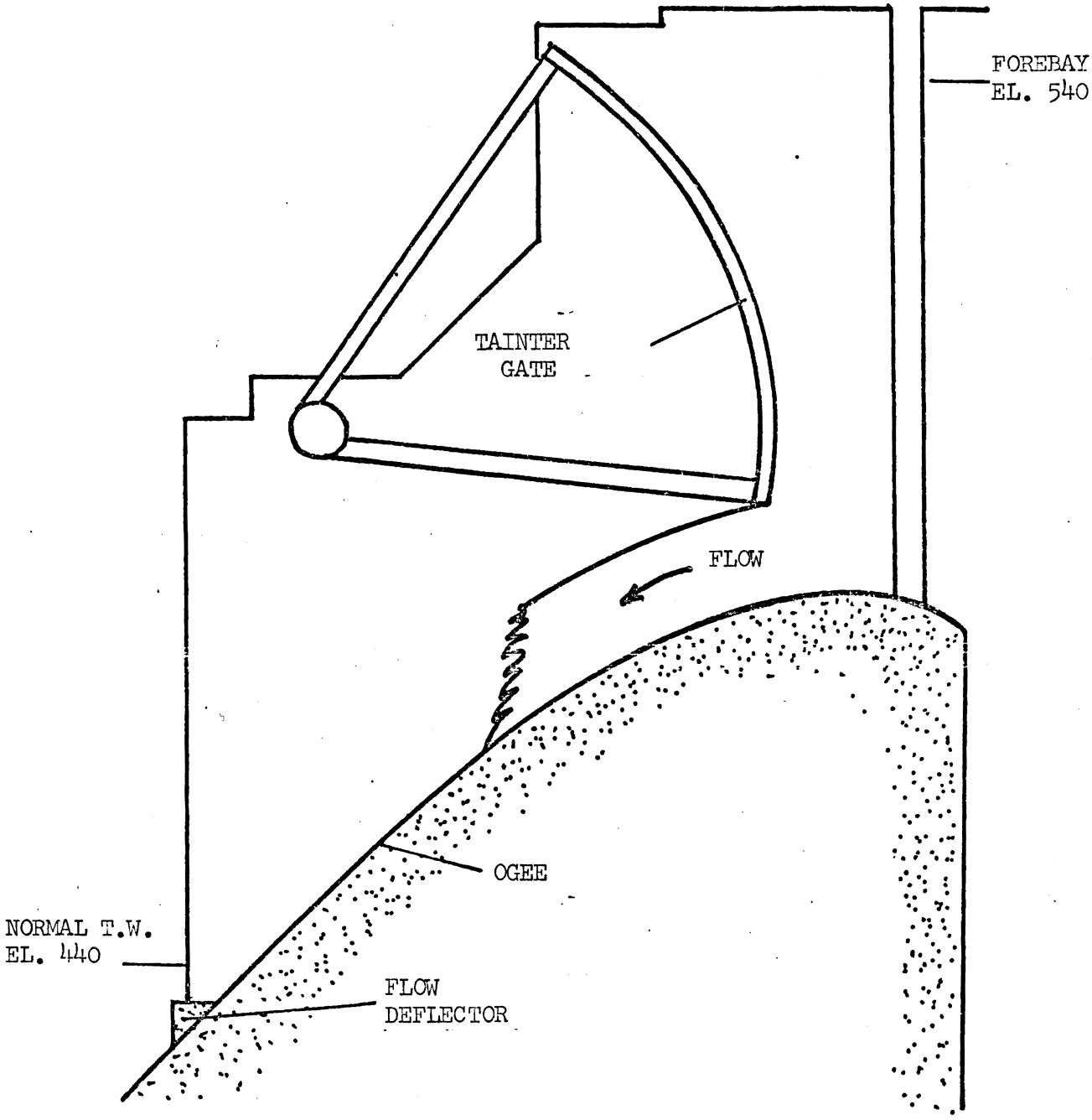

Figure 3.--Typical spillway bay at Lower Monumental Dam showing plain flow deflector.

yearling coho salmon. This report summarizes the results of the latter tests.

EXPERIMENTAL DESIGN

In 1973, seven groups of test and control fish were released simultaneously upstream and downstream from the bulkhead and flow deflector structures on each of 3 days -- April 30, May 4, and May 7. Survivors from all groups were recovered from the fingerling bypass system at Ice Harbor Dam and were dipnetted for inspection from gatewells of McNary Dam. Estimates of mortality were calculated from the change in ratio of the numbers of test to control fish from the time of release to the time of recovery.

Coho salmon smolts were used exclusively. These consisted of about 500,000 progeny from the Elochoman stock reared at the Willard Fish Cultural Station and about 130,000 progeny of the Leavenworth stock reared at the Leavenworth Fish Cultural Station. The Willard fish weighed about 23 per pound (4½-5 inches long) and the Leavenworth fish weighed about 17 per pound (5½-6 inches long).

Fish were transported by truck from the fish cultural stations to the NMFS fish marking facility at Ice Harbor Dam where they were thoroughly mixed, and each of the seven groups

of fish used in each of the three tests received a distinctive brand. The brand symbol denoted date of release, and the location of the brand on a fish denoted where the fish was released; this provided assurance that even though a brand might be unreadable, its location on the fish would identify the release site.

After being marked, fish were immediately transferred to tank trucks and transported to Lower Monumental Dam. Each of the seven groups were placed in separate holding compartments of tanks supplied with river water pumped from the forebay or the tailrace. Owing to prevailing low river discharges, dissolved gas saturation levels remained at or near normal and no equillibration of supply water was required during fish holding. At the start of a test, fish and water were drained directly from the tanks into hoses leading to the designated release location.

At Ice Harbor Dam, fish were recovered from the fingerling collection system which operates 24 hours per day, 7 days per week. In this system, fish enter the intake gatewells and volitionally pass through submerged ports leading to a common flume. Fish were collected at the foot of the flume, anesthetized and examined. After the necessary data were recorded, the fish were placed in a tank until fully recovered and then released into the ice and trash sluiceway for passage to the tailrace and

continued their downstream migration. This method satisfied a requirement in statistical procedure that fish recovered at Ice Harbor Dam be carefully handled and returned immediately to the river to become part of the population of experimental fish migrating toward the second recovery site, McNary Dam. At McNary Dam fish were dipnetted from the gatewells, inspected for marks, and returned to the river to continue their migration.

RELEASE OF FISH

All seven groups of fish used in each test were released simultaneously over a 45-to 50-minute period beginning about 8:50 pm (DST)--at least 20 hours after the last fish were delivered to the holding tanks at Lower Monumental Dam. Fish and water were drained from each holding tank through a 3-inch (I.D.) hose leading to the desired release location. Total head on the dam at 9:00 pm was 99.3 feet on April 30, 99.0 feet on May 4 and 97.6 feet on May 7.

To examine effects of the flow deflector, test fish were released to pass through spill bay No. 2 containing a flow deflector partially equipped with dentates, and spill bay No. 4 containing a plain flow deflector. Position of the release hose is shown in figure 4. Control fish were released downstream in the common boundary between flows from spill bays No. 1 and 2.

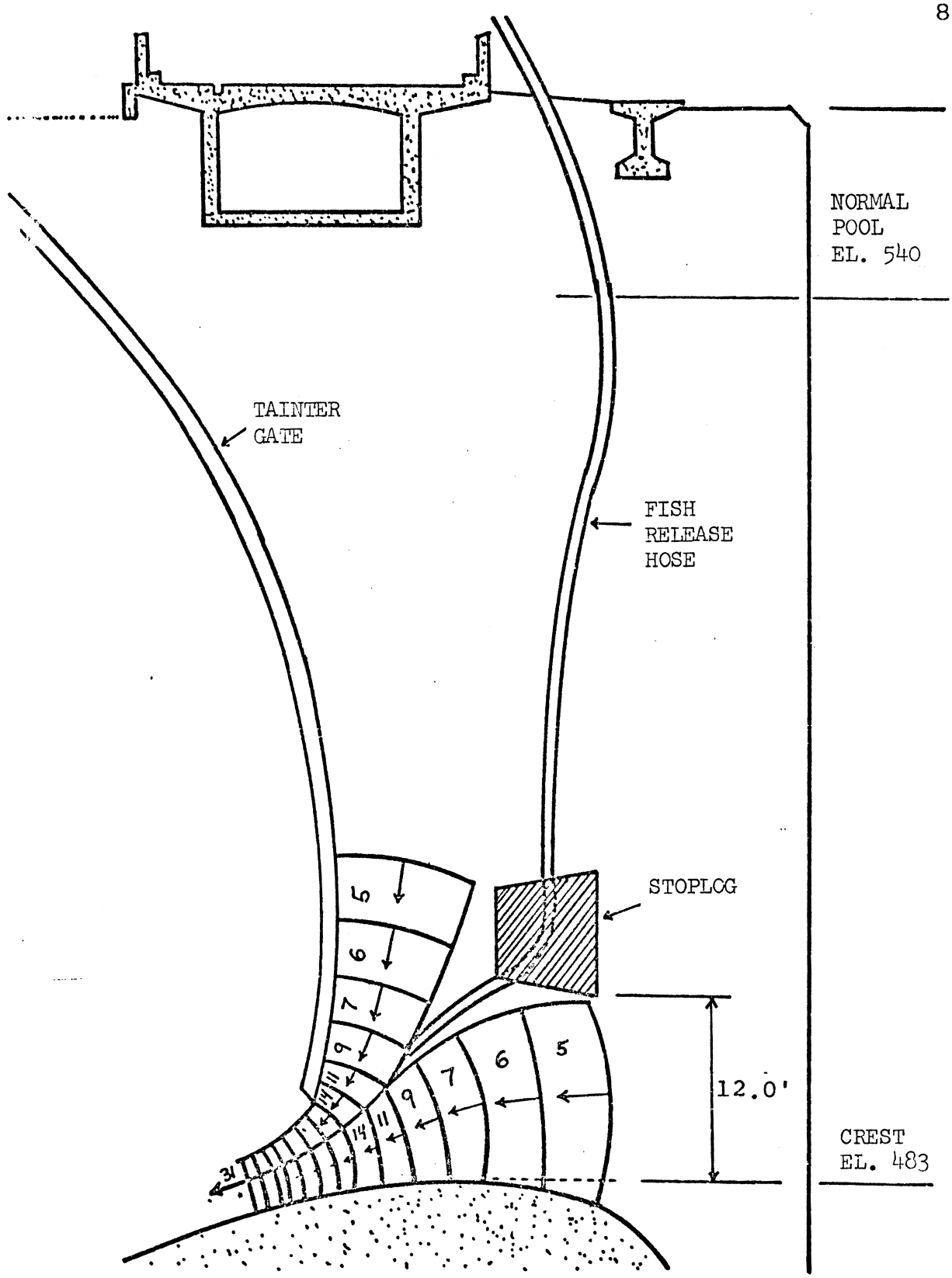

Figure 4.--Position of fish release hose in relation to flow net at crest of spillways containing flow deflectors.

During these releases, each of spill bays No. 2 and 4 were opened to discharge 4500 cfs.

For the perforated bulkhead study, test fish were released in intake B of a skeleton unit upstream from the bulkhead (1, Fig. 5), and in the generator bay (2), and control fish (3 and 4) were released in the tailrace. Some departure from proposed releases of controls in the front and back rolls was necessary due to extreme turbulence in these areas. Specifics of the various skeleton bay releases follow.

In the first test, fish were released in skeleton unit No. 4 (Fig. 6) at a discharge of only two-thirds of full capacity owing to closure of intake A in that unit; control groups of fish were released in the back roll downstream from skeleton unit No. 4 and in a counterflow near the base of unit No. 6 (not operating). In tests Nos. 2 and 3, test fish were released in skeleton unit No. 6 with the unit discharging at full capacity. In test No. 2, two control releases were made in the back roll of unit No. 6 (Fig. 7), and in test No. 3 the control release was made in the front roll of operating unit No. 2 and the back roll of skeleton unit No. 6 (Fig. 8).

Arrangements were made with the Corps of Engineers to control the discharge of water through the spill bays, skeleton units and turbines while the fish were being released to begin each

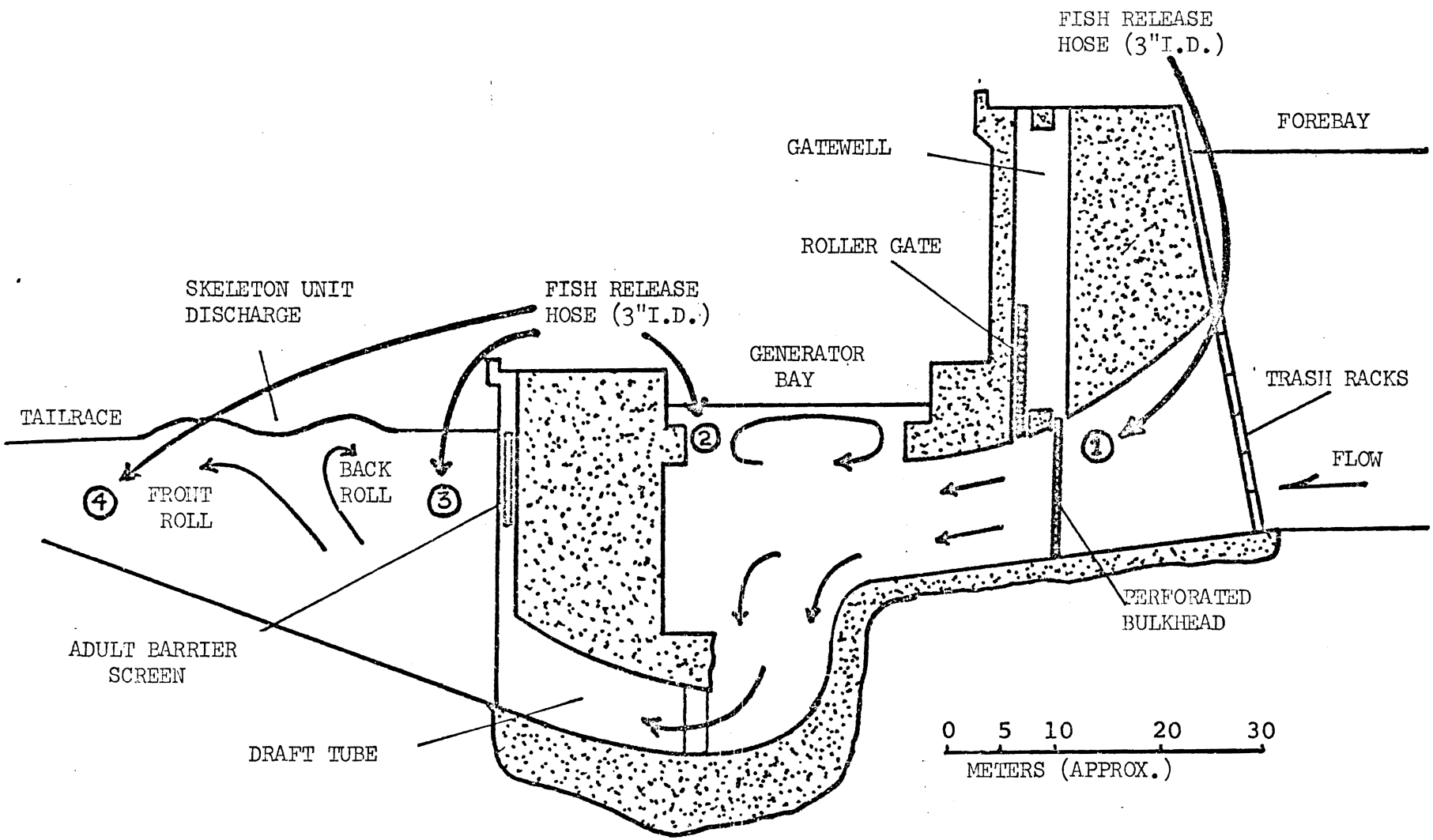

Figure 5.--Typical cross section at Lower Monumental Dam showing approximate upstream (1) and downstream (2), (3), (4) release points to measure survival of juvenile coho salmon passing through perforated bulkhead and generator bay.

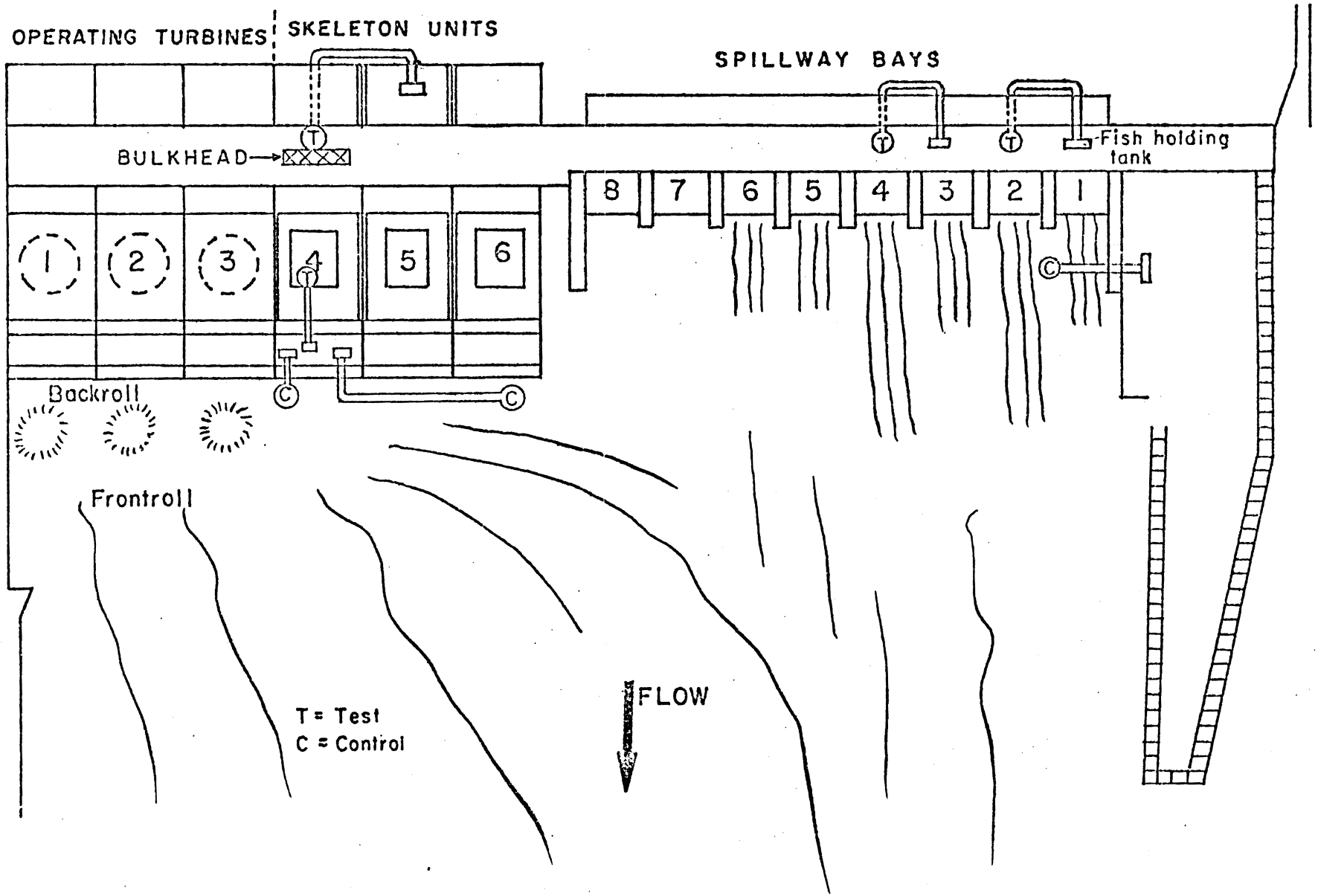

Figure 6.--Release points for fish released in test No. 1 to evaluate effect of perforated bulkhead, generator bay, and flow deflectors on survival of yearling coho salmon.

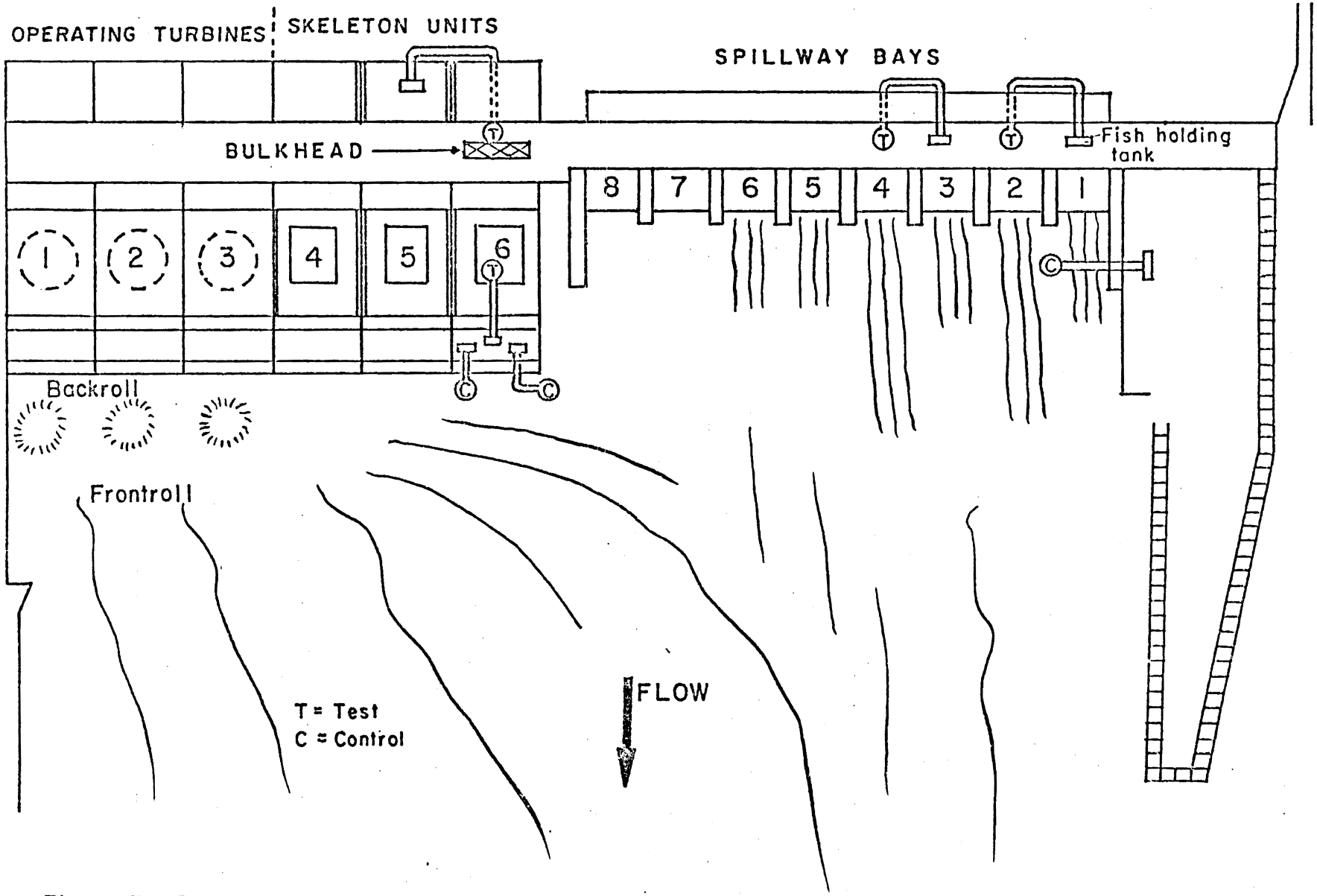

Figure 7.--Release points for fish released in test No. 2 to evaluate effect of perforated bulkhead, generator bay, and flow deflector on survival of yearling coho salmon.

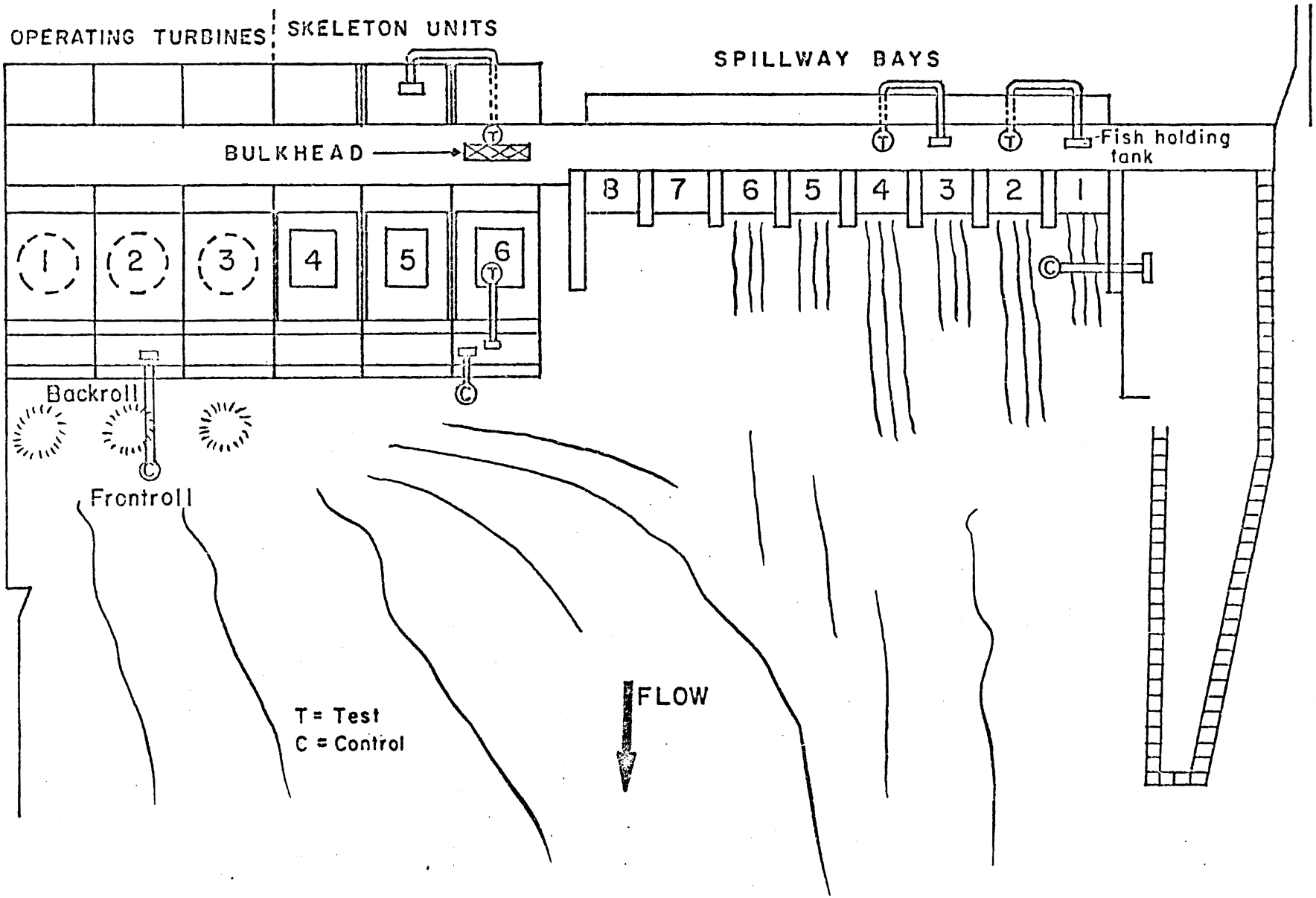

Figure 8.--Release points for fish released in test No. 3 to evaluate effect of perforated bulkhead, generator bay, and flow deflector on survival of yearling coho salmon.

test. Spill bays 1, 3, 5, and 6 were opened to discharge 1200 cfs each and, as previously noted, bays 2 and 4 discharged 4500 cfs each. Spill bays 7 and 8 and the two skeleton units not in use remained closed. All three turbines were in operation at about 75 percent of rated capacity. This flow regime was maintained for 1 hour and 15 minutes--about 45 minutes while the fish were being drained from the tanks and 30 minutes after the last fish was released.

To minimize the possible accumulation of debris in the perforations of the bulkhead (which could cause mortality) we ensured, through arrangements with the Corps, that the perforated bulkheads would not be in operation prior to their use in the tests.

Another possible source of fish mortality was eliminated by raising the adult barrier screens at the mouth of the draft tube (Fig. 5) to their maximum position without actually removing them from the water. We estimate the bottom of these screens was at least 76 feet above the ceiling of the draft tubes.

MORTALITY ESTIMATES

Numbers of fish released at Lower Monumental Dam and recovered at Ice Harbor and McNary Dams from each test and the combined recoveries are shown in Table 1. Analysis of these data showed that:

Table 1.--Numbers of juvenile coho salmon released at Lower Monumental Dam and survivors recovered at Ice Harbor and McNary Dams from each of three tests to evaluate perforated bulkhead and flow deflectors.

Release Point	Number of fish Released	Number of fish recovered Ice Harbor Dam	McNary Dam	Combined
TEST NUMBER 1				
Perforated Bulkhead	28,439	1,814	633	2,447
Generator Bay	27,313	2,624	856	3,480
Spillway #2 1/	27,658	3,108	919	4,027
Backroll (skeleton unit #6)	28,163	3,231	1,092	4,323
Spillway #4 2/	28,150	3,511	1,283	4,794
Backroll (skeleton unit #4	28,024	2,854	928	3,782
Spillway Tailrace 3/	28,182	3,006	1,019	4,025
Subtotal	195,929	20,148	6,730	26,878
TEST NUMBER 2				
Perforated Bulkhead	28,897	925	310	1,235
Generator Bay	28,021	1,077	448	1,525
Spillway #2 1/	27,459	1,615	590	2,205
Backroll (skeleton unit #6)	27,541	1,541	557	2,098
Spillway #4 2/	28,517	1,881	702	2,583
Backroll (skeleton unit #6)	28,000	1,607	585	2,192
Spillway Tailrace 3/	28,174	1,755	731	2,486
Subtotal	196,609	10,401	3,923	14,324
TEST NUMBER 3				
Perforated Bulkhead	27,598	671	501	1,172
Generator Bay	28,114	604	436	1,040
Spillway #2 1/	26,864	1,082	837	1,919
Backroll (skeleton unit #6)	28,307	1,217	936	2,153
Spillway #4 2/	30,017	1,350	1,037	2,387
Frontroll (operating turbine #2)	28,114	1,242	834	2,076
Spillway Tailrace 3/	27,705	1,160	869	2,029
Subtotal	196,719	7,326	5,450	12,776
TOTALS	589,257	37,875	16,103	53,978

1/ Flow deflector with dentates.
2/ Plain flow deflector.
3/ Near outer extremity of discharge between spillway bays 1 and 2.

(1) all seven groups of fish in each test were well mixed in time and space upon arrival at Ice Harbor and McNary Dams and recovery effort was equivalent within each test;

(2) recoveries of marked fish at the above dams were statistically independent and could be combined;

(3) mortality estimates of fish released upstream from the perforated bulkhead and in each of the two spillway bays with flow deflectors were consistent between tests and could be respectively combined for further analysis; and

(4) mortality estimates of fish released in the skeleton generator bay were highly variable and could not be combined.

Based on the foregoing, estimated mortality was determined by comparing recoveries from test groups of fish with those of their matched control groups (Table 2). Average mortality of young coho salmon passing through the perforated bulkhead was 44%; loss in each of the three tests were remarkably consistent. Mortalities in these tests were about the same as those incurred by young chinook salmon (50%) in 1972. Some of this mortality may be directly attributable to passage through the perforated bulkhead and some to subsequent stresses in the empty generator bay or to predation on stunned fish in the tailrace.

Table 2.--Survival (and mortality) of juvenile coho salmon released upstream from a perforated bulkhead, in a generator bay, and in modified spillways at Lower Monumental Dam, 1973.

Test structure	Replicate	Relative survival (Percent)[1/]	Estimated mortality (Percent)
Perforated bulkhead	1	56	44
	2	56	44
	3	55	45
Generator bay	1	83	17
	2	71	29
	3	49	51
Flow deflectors with dentates	1	102	0
	2	91	9
	3	98	2
Flow deflector without dentates	1	119	0
	2	103	0
	3	108	0

1/ Quotient of the proportion recaptured from test release and that from the matched control.

Although mortalities of fish released in the generator bay varied considerably between tests (17, 29, & 51%, respectively), the results infer that substantial numbers of fish can be killed in the generator bay and vicinity after passage through the jet stream from the perforated bulkhead. Some of these losses could have resulted from contact with protruding steel reinforcement bars in the generator bay, others from repeated contact with the bulkhead jet stream due to recycling of fish in counter currents of the generator bay. In both instances the fish could have been killed immediately or stunned and, hence, subject to predation in the tailrace.

Differences between mortalities in the three generator bay tests cannot be fully explained, but could have resulted from different dispersions of fish following each release in the bay. In the first test it may be recalled that discharge through the bay was only two-thirds of capacity. Hydraulic patterns created by this discharge could have circulated the fish in a different manner than those in tests 2 & 3 when discharge was at full capacity. Mortalities were highest in the latter tests and lowest in the first. If variations in the dispersion of fish released in the generator bay account for the differences in mortality between tests, then all test fish released upstream from the

bulkheads must have followed a consistent route during passage through the generator bay. In the latter tests, losses were virtually identical between tests even though flow discharge patterns in the generator bay were the same as those affecting releases in the generator bay (both releases made simultaneously). We can only surmise from this that fish released upstream from the bulkhead entered the generator bay in a different flow regime than those released in the generator bay, and that their dispersion after passage through the bulkhead was consistent for all tests regardless of flow dynamics in the generator bay.

Mortality of young fish passing over the flow deflector with dentates (spillway bay No. 2) was insignificant (2%) when compared with control fish released downstream between spillway bay No. 1 and 2. This is in contrast to a 15% mortality observed on young fall chinook in 1972 and may be the result of a change in the number of dentates on the deflector; in 1973 about 1/3 of the dentates was missing.

Fish passing through the flow deflector without dentates (spillway bay No. 4) showed an average of 10% greater survival than the control fish released between spillway bay No. 1 and 2. Apparently conditions for survival in the tailrace were better for fish passing downstream in the discharge from spillway bay

No. 4 than for fish released directly into the tailrace between boundary flows from spillway bays 1 and 2. In any event, no losses could be attributed to passage of juveniles over a plain flow deflector.

From the tests in 1973 we conclude that perforated bulkheads and associated water passages cause high mortality to juvenile coho salmon, whereas no losses would be expected from passage of these fish through a spillway bay equipped with plain flow deflectors.