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SUMMARY REPORT

EVALUATION OF THE JUVENILE COLLECTION AND BYPASS SYSTEMS AT BONNEVILLE DAM - 1984
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by
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INTRODUCTION

Studies to evaluate the juvenile bypass and collection facilities at the Bonneville Dam Second Powerhouse began in 1983. The studies indicated very poor (<30%) fish guiding efficiencies (FGE) (Krcma et al. 1984). During the 1984 field season, the National Marine Fisheries Service (NMFS) was contracted by the U.S. Army Corps of Engineers (CofE) to conduct additional FGE tests, implementing various modifications/additions to the submersible traveling screens (STS) and trash racks. Tests were also conducted to evaluate the newly completed juvenile bypass and indexing facilities at the Bonneville Dam First Powerhouse.

The 1984 research had the following primary objectives:

1. Evaluate modifications/additions to the Second Powerhouse STS and trash racks.

2. Continue monitoring the Second Powerhouse juvenile bypass and indexing facilities.

3. Evaluate the First Powerhouse juvenile bypass and indexing system.

4. Determine fish quality and stress through the First Powerhouse juvenile bypass and indexing system.

5. Determine orifice passage efficiency (OPE) at both powerhouses.

OBJECTIVE I - EVALUATION OF MODIFICATIONS/ADDITIONS TO THE STS AND TRASH RACKS AT THE SECOND POWERHOUSE

STS FGE Tests

Methods and Procedures

The modifications/additions can be broken down into two major categories and several subcategories:

I. Items for reducing deflection and/or increasing the concentration of fish in the upper area of the intake.

A. Blocked trash rack sections--solid plates were attached to sections of the trash rack (Figure 1).

B. Reduced turbine load.

C. Louvered trash rack section--trash racks with horizontal sloping plates attached at a 30° angle to the existing horizontal support member inside the rack.

D. Trash rack deflector--a frame with wedge wire screen that attached to a special trash rack section and was designed to screen off the area from the trash rack to the STS or be lowered into a non-fishing stream flow position (a short deflector was used at the 60° angle and a long deflector at 48°).

E. Removing the perforated plates from inside the STS--increased overall porosity from 32 to 40% open area.

F. Lighting the forebay--portable light towers illuminated a part of the forebay during some of the prototype tests.

II. Items for improving gatewell collection for fish intercepted by the STS.

A. Lowering the STS--STS was positioned 1 foot lower in the intake.

B. Turning vane--a curved plate attached to the underside of the support beam at the top of the STS and used in conjunctiuon with II, A above.

C. Side wings on the STS--solid plates that closed off the gap along the side of the STS and the turbine intake wall (one STS was modified with a tubular frame for attaching nets for evaluation).

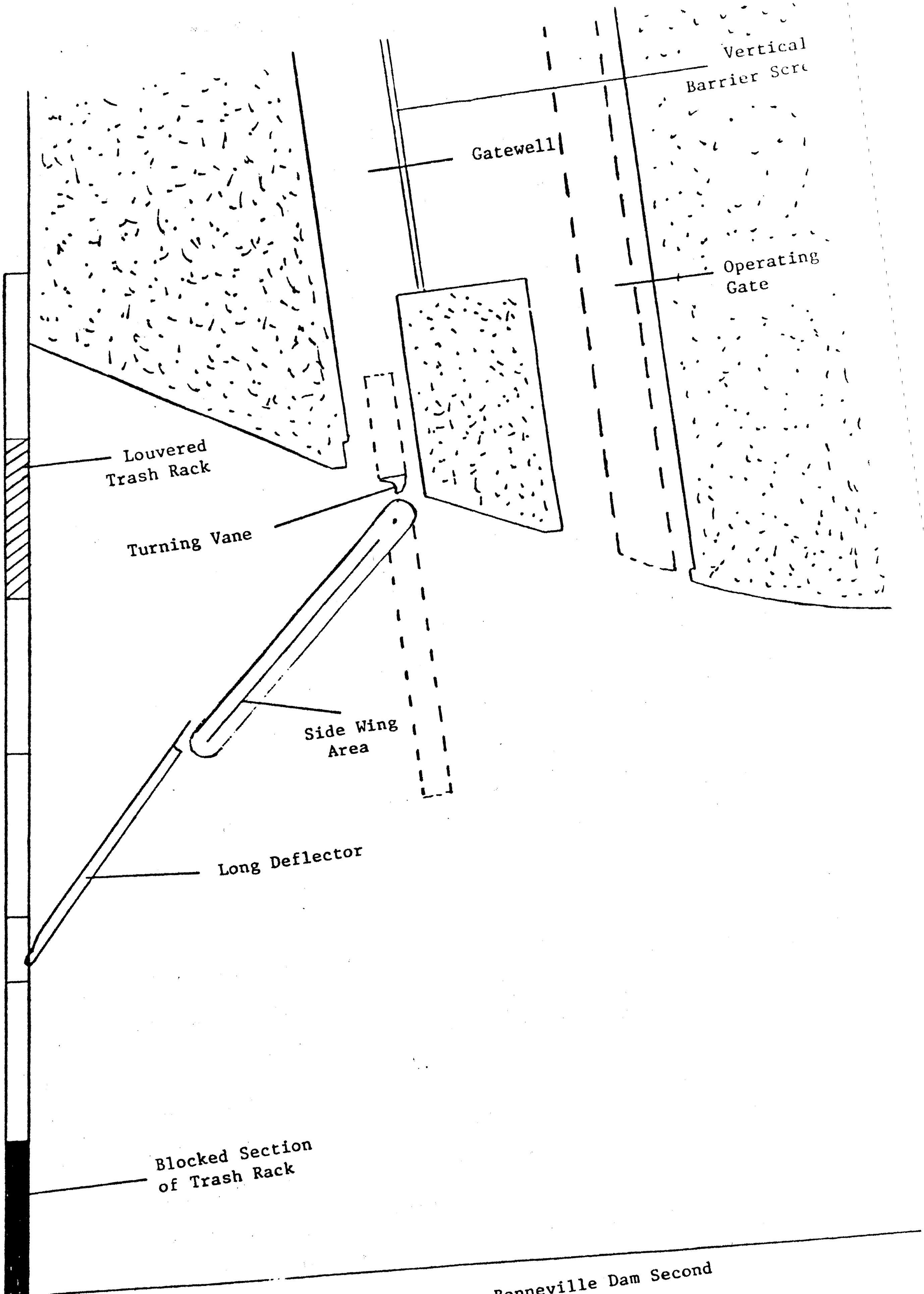

Figure 1.--Cross-section of turbine intake at Bonneville Dam Second Powerhouse showing the items tested in 1984.

D. Raising the operating gate.

FGE tests were conducted using the same procedures developed in previous years. Nets attached to the traveling screen provided data for determining numbers of unguided fish, and gatewell dipping was used to determine numbers of guided fish. Figure 2 illustrates the location and number of nets fished. FGE was calculated as guided fish divided by the total number of fish passing through the intake (guided plus unguided) during the test period.

For statistical evaluation, tests usually require three to five replicates (about 200 STS guided fish per replicate). However, due to the large variety of test conditions and the relatively short time available for testing individual species, many of the test conditions were not replicated. If the initial test results did not approach 70% FGE or the fish incurred unacceptably high descaling or mortality, only one or two replicates were conducted.

Target species for the FGE tests were yearling and subyearling chinook salmon; information on other species was collected as available.

Results

A total of 21 different test conditions consisting of 36 individual tests were conducted from 2 May through 27 July. Table 1 lists these tests and the corresponding FGE and descaling percentages. The initial series of tests (Numbers 1, 2, and 3, with a 48° STS in Unit 12B and Numbers 11, 12, 13, and 14 with a 60° STS in Unit 12A) indicated several things. First, although FGE was improved over 1983, it was still very low. Second, descaling was extremely high for yearling chinook salmon for all test conditions. During these tests, it was also determined that the side

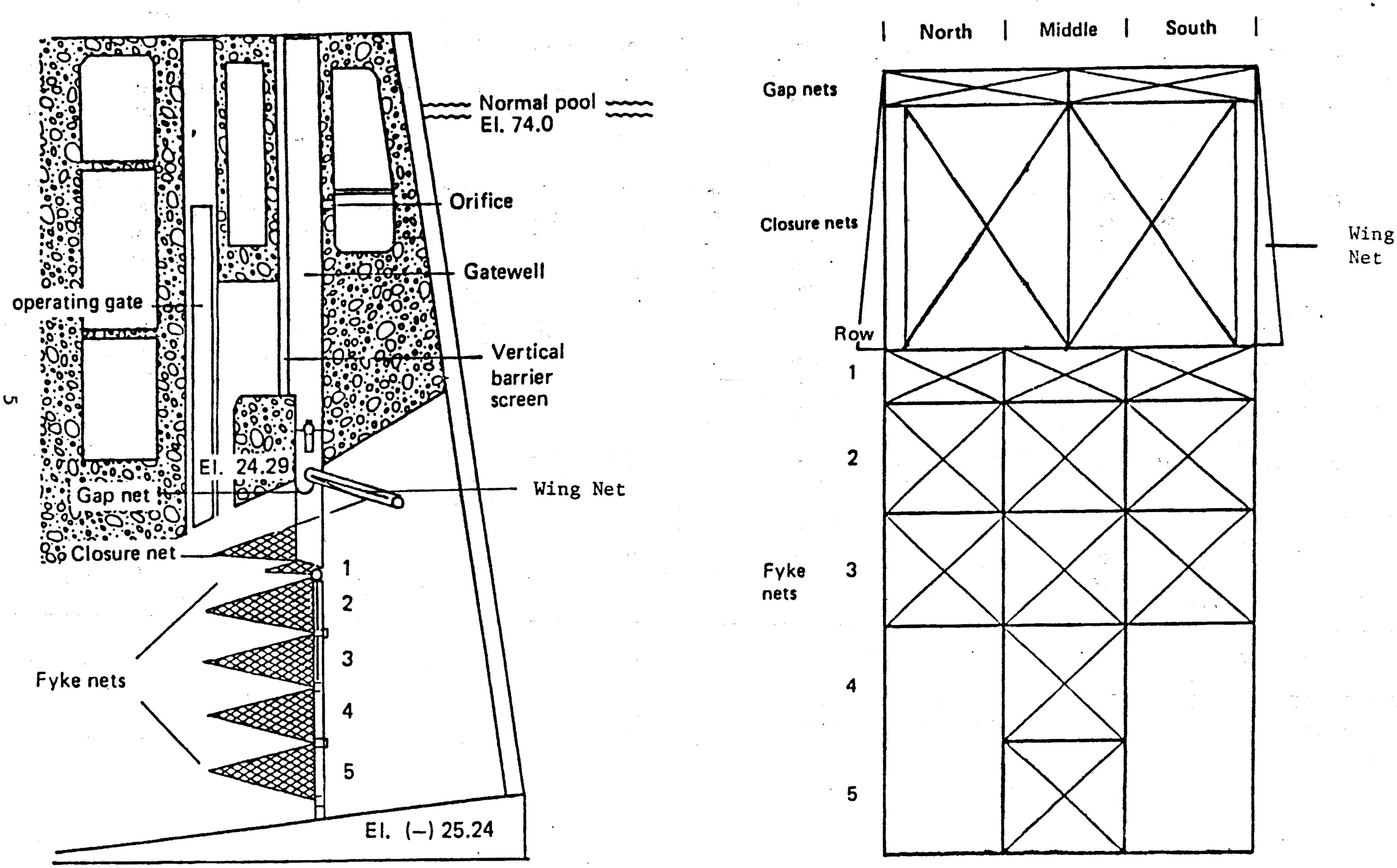

Figure 2.--Cross-section of the turbine intake with a traveling screen and various attached nets at Bonneville Dam Second Powerhouse and also a view showing the net layout - 1984.

Table 1.--Traveling screen fish guiding efficiency (FGE) tests on yearling and subyearling chinook salmon conducted at Bonneville Dam Second Powerhouse during the FY84 field season.

Test no.	STS angle (degree)	Dates(s) of test(s)	Deflector and angle		Unit load (cfs)	Louvered[1/] trash rack	Blocked[1/] trash rack	STS lowered (1 foot)	Turning vane	Forebay lights	Perforated plate in STS	Operating gate position	Yearling Percentages FGE	Yearling Percentages Descaled (mortality)[2/]	Sub-yearling Percentages FGE	Sub-yearling Percentages Descaled (mortality)[2/]
1	48	May 2 & 4[3/]	Yes	48	20,000	2nd	6th	Yes	Yes	Yes	In	Normal	46	48 (10)		
2	48	May 3	Yes	48	20,000	2nd	6th	Yes	Yes	No	In	Normal	27	46 (14)		
3	48	May 5 & 6	Yes	48	12,000	2nd	6th	Yes	Yes	Yes	In	Normal	36	17		
4	48	May 19	Yes	48	12,000	None	6th	No	No	No	In	Normal	44	32		
5	48	May 20	Yes	48	18,000	None	6th	No	No	No	In	Normal	48	53		
6	48	May 23	Yes	48	10,000	None	5 & 6	No	No	No	In	Normal	86	57		
7	48	June 2 & 3	Yes	48	20,000	None	None	No	No	No	Out	Normal	26	61	20	62 (11)
8	48	July 31 to Aug. 1	Yes	48	20,000	None	None	No	No	No	In	Up-38'			22	7
9	48	Aug. 2 & 3	Yes	48	20,000	None	None	Yes	No	No	Out	Normal			29	9
10	48	Aug 6	Yes	48	20,000	None	None	Yes	No	No	Out	Up-38'			30	8
11	60	May 2	Yes	60	20,000	2nd	6th	Yes	Yes	Yes	In	Normal	34	57 (35)		
12	60	May 3	Yes	60	20,000	2nd	6th	Yes	Yes	No	In	Normal	35	77 (41)		
13	60	May 4	Yes	60	20,000	None	6th	Yes	Yes	Yes	In	Normal	41	57 (24)		
14	60	May 5 & 6	Yes	60	12,000	None	6th	Yes	Yes	Yes	In	Normal	26	19		
15	60	May 20	Yes	60	18,000	None	6th	Yes	Yes	Yes	In	Normal	37	53		
16	60	May 23	Yes	60	10,000	None	6th	No	No	No	In	Normal	37	65		
17	60	June 2 & 3	Yes	60	20,000	None	None	No	No	No	In	Normal	32	33	22	43
18	60	July 16, 18 & 20	In stream		20,000	None	None	No	No	No	In	Up-23'			29	7
19	60	July 17, 19, 20 & 22	In stream		20,000	None	None	No	No	NO	In	Normal			27	11
20	60	July 23, 24 & 25	Yes	48	20,000	None	None	No	No	No	In	Up-23'			24	5
21	60	July 26 & 27	Yes	48	20,000	None	None	No	No	No	Out	Normal			32	5

1/ This powerhouse has six trash rack sections stacked on top of each other that cover each turbine intake bay; louvered trash rack in the 2nd means the 2nd section from the top. Blocked trash rack in the 6th means the bottom section was blocked.

2/ Indicates the percentage mortality of the various test conditions; descaling percentage includes these data.

3/ Each date represents one replicate (one date equals one replicate, 2 dates equals 2 replicates, etc.).

wing nets intercepted a very small percentage (1.7%) of the fish entering the intake. Acceptable FGE was attained in only one test (Test 6, FGE 86%). During this test, almost the entire intake was blocked or screened. The area below the deflector and the STS was totally blocked except for a small section of trash rack (approximately 3 feet high) where the deflector was attached. During these tests, the unit was operated at minimum load (approximately 35 MW) to reduce velocity through the screened area as much as possible; descaling still exceeded 50%.

Vertical Distribution Tests

Methods and Procedures

Vertical distribution tests were conducted to determine if trash rack modifications altered the distribution of the fish as they entered the turbine intake and to determine the potential FGE for the various test modifications.

The tests were conducted by lowering a fyke net frame with attached nets into the same gate slot normally used by the STS (Figure 3). Nets 4-7 were standard size (6.0 x 6.5 feet at the mouth and approximately 15 feet long). Nets 1-3 were divided in half in an attempt to better define the distribution of the fish in the area intercepted by the STS or deflectors. Unit load for all tests was full load--70 ± 5 megawatts (approximately 20,000 cfs).

Results

Twenty-one replicates of vertical distribution tests were conducted from 5 May through 20 June (Tables 2 and 3). Half net data for Rows 1, 2, and 3 have been combined for comparison to 1983 data.

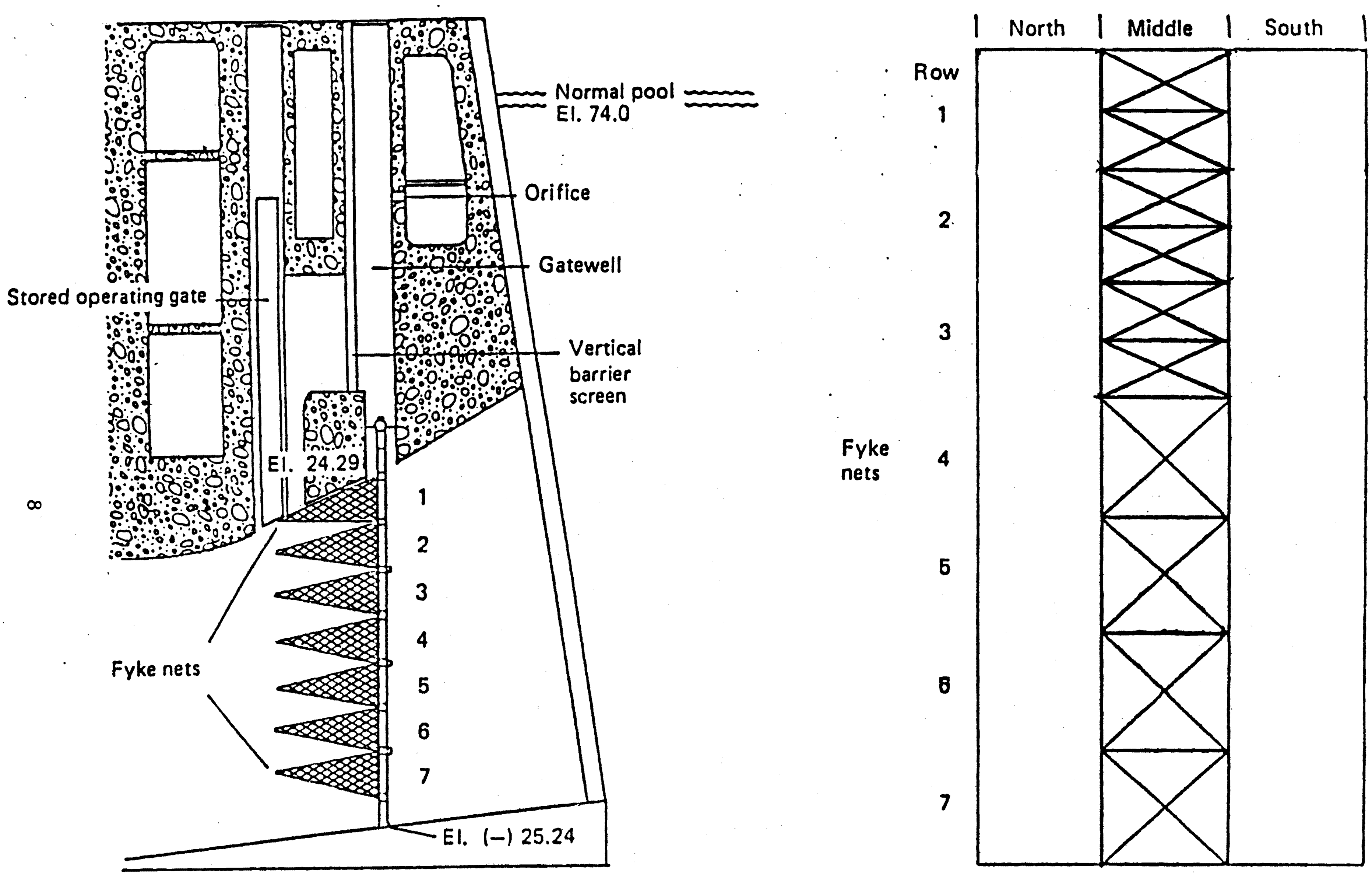

Figure 3.--Cross-section of the turbine intake at Bonneville Dam Second Powerhouse with a vertical distribution frame and fyke nets including a view showing the net layout - 1984.

Table 2.--Percentage of yearling chinook salmon in gatewells and fyke nets during vertical distribution tests conducted at Bonneville Dam Second Powerhouse.

		1984							
		Test 1 Louvered rack (2nd) Blocked rack (6th)		Test 2 48° deflector, louvered rack, blocked rack		Test 3 60° deflector blocked rack (6th)		1983 Net-frame only	
Location	Approximate distance from intake ceiling (feet)	Individual	Cumulative	Individual	Cumulative	Individual	Cumulative	Individual	Cumulative
Gatewell		8.8		17.6		23.6		12.1	
Net 1	6.5	32.1	40.9	48.3	65.9	34.1	57.7	20.0	32.2
Net 2[a/]	13.0	23.9	64.8	14.8	80.7	12.2	69.9	15.7	47.9
Net 3[b/]	19.5	12.2	77.0	5.1	85.8	8.3	78.1	13.4	61.3
Net 4[c/]	26.0	9.1	86.1	4.0	89.8	14.7	92.8	13.4	74.7
Net 5	32.5	3.5	89.6	5.7	95.5	4.7	97.5	12.3	87.0
Net 6	39.0	4.3	93.9	4.0	99.5	2.5	100.0	9.8	96.8
Net 7	45.5	6.0	99.9	0.6	100.1	0.0	0.0	3.1	99.9

a/ Level that could theoretically be intercepted by the STS at the 48° angle.

b/ Level that could theoretically be intercepted by the STS at the 60° angle and a trash rack deflector.

c/ Level that could theoretically be intercepted by the STS at the 48° angle and a trash rack deflector.

Table 3.--Percentage of sub-yearling chinook salmon in gatewells and fyke nets during vertical distribution tests conducted at Bonneville Dam Second Powerhouse.

Location	Approximate distance from intake ceiling (feet)	1984 Test 1 48° deflector		1984 Test 2 Net frame only (12B)		1984 Test 3 Net frame only (15B)		1983 Net-frame only	
		Individual	Cumulative	Individual	Cumulative	Individual	Cumulative	Individual	Cumulative
Gatewell		10.1		9.6		13.7		11.3	
Net 1	6.5	29.0	39.2	21.0	30.6	20.0	33.7	15.0	26.3
Net 2[a]	13.0	17.6	56.8	15.1	45.6	16.6	50.3	15.9	42.4
Net 3[b]	19.5	11.8	68.6	12.4	58.1	17.4	67.7	20.4	62.6
Net 4[c]	26.0	7.6	76.2	8.5	66.6	12.2	79.9	13.2	75.8
Net 5	32.5	8.2	84.4	6.6	73.2	7.9	87.8	11.4	87.2
Net 6	39.0	11.6	96.0	17.0	90.2	87.7	96.5	8.2	95.4
Net 7	45.5	4.0	100.0	9.8	100.0	3.5	100.0	4.5	99.9

a/ Level that could theoretically be intercepted by the STS at the 48° angle.

b/ Level that could theoretically be intercepted by the STS at the 60° angle and a trash rack deflector.

c/ Level that could theoretically be intercepted by the STS at the 48° angle and a trash rack deflector.

These tests indicated that the deflectors in conjucntion with the traveling screens should be capable of intercepting and guiding at least 70% of the fish. But, by comparing vertical distribution with FGE under similar test configurations, an avoidance or rejection problem becomes apparent. For one combination of conditions tested (Table 2, Test 2), vertical distribution indicated a potential FGE factor of 90% for yearling chinook salmon, but only 46% were guided under similar conditions with the STS (Table, Test 1). Similar results occurred with subyearling chinook salmon. Vertical distribution indicated a potential FGE of 76% (Table 3, Test 1), but actual FGE was 20% (Table 1, Test 7).

OBJECTIVE II - CONTINUED MONITORING OF THE SECOND POWERHOUSE DSM AND SMOLT INDEXING FACILITIES

The random sampler in the downstream migrant bypass system (DSM) of the Second Powerhouse provides the means to index smolt migrations passing Bonneville Dam and to monitor their condition. The primary research objectives for the 1984 evaluation of the DSM and indexing system were: (1) enumerate fish collected by species, measure descaling, and record marks each day through the 1984 juvenile salmonid outmigration; (2) improve the size grading capability of the wet separator; (3) evaluate a modified sampling system for taking sample sizes of less than 10%; and (4) monitor DSM operations to determine if recommended improvements to correct deficiencies identified during the past 2 years were satisfactory.

Smolt Indexing

Methods and Procedures

At least twice a day fish were collected from the raceways in the observation room. Fish were anesthetized, enumerated by species or race, and examined for descaling or marks.

Results

Between 23 April and 4 October, the random sampler operated for 2,153 hours. During this time, a total of 80,379 juvenile salmonids were captured, and 36,099 were examined for descaling and marks. The amount of descaling varied by species. Sockeye salmon had the highest rate (28.3%) and coho salmon the lowest (1.9%). Descaling of yearling and subyearling chinook salmon and steelhead was 9.6, 3.2, and 5.9%, respectively. Significant mortalities were only noted on sockeye salmon (23.5%). A total of 4,254 adipose fin clipped and/or branded salmonids were captured.

Wet Separator Evaluation

Methods and Procedures

The wet separator in the Second Powerhouse consists of three grading compartments and an overflow area, each emptying into separate raceways. During a 4-week period, data were recorded for both day and night operation. During the day when operating personnel were in the vicinity of the wet separator, water levels were kept at or near the optimum level for separation. During evening hours, wet separator water levels were raised to reduce the threat of stranding caused by fluctuating water levels in the DSM. Species composition and length frequencies were recorded for each raceway and combined weekly for analysis.

Results

By evaluating the wet separator during daytime (controlled water levels) and nighttime operation (high and fluctuating water levels), more accurate data on size separation of salmonids were obtained. An average of 71.6% of the subyearling chinook salmon were separated into the first compartment (3/8-inch gap between grader bars) during the day and only 41.3% during the night because water levels fluctuated due to failure of the automatic control system.

Modified Sampling System

Because of mechanical problems associated with raising and lowering the random sampler these test were cancelled.

DSM Improvements Evaluation

None of the improvements recommended were completed thus no evaluation was conducted.

OBJECTIVE III - EVALUATE THE FIRST POWERHOUSE JUVENILE BYPASS AND SMOLT INDEXING FACILITIES

The bypass system at the First Powerhouse was completed during 1984 and began operations 17 April. This system differs from the DSM of the Second Powerhouse in several ways: (1) the inclined screen at the downstream end of the DSM is supposed to adjust automatically with changing flows, (2) the system also has a pumpback feature that can pump a portion of the water back to the forebay, (3) the water level in the bypass channel is supposed to automatically maintain a constant level, and (4) the method for collecting a random sample of fish from the system requires the manual installation of a fish collection tank and sample flume during each sample period (Figure 4).

The primary objectives of these tests were, first, to determine the utility of the sampling equipment, and second, to determine the efficiency of the sampling equipment. Accomplishment of the objectives was hindered by repeated mechanical failures within the system. Downtime for sampling purposes totaled 49 days between 17 April and 10 June. During downtime, transportation channel flow ran to the south (away from the sampling facilities).

Utility of Sampling Equipment

Methods and Procedures

Sampling equipment at the First Powerhouse consists of sample flume, fish collection tank, dump chute, holding tank, anesthetic trough, and recovery tanks. The sampling procedure begins by lowering the fish collection tank and sample flume onto a support arm over the downwell. The sample flume is then tipped to bridge the gap between the inclined screen crest and fish collection tank. After fishing for the desired time, the sample flume is removed from the flow and the collection tank raised. Fish are transferred to the holding tank, examined, allowed to recover, and released.

Results

Considerable difficulty was experienced handling the collection tank and flume, specifically during placement into the fishing position and transfer of catch to the holding tank. These and other deficiencies have been addressed, and modifications are underway and should be completed by the 1985 field season.

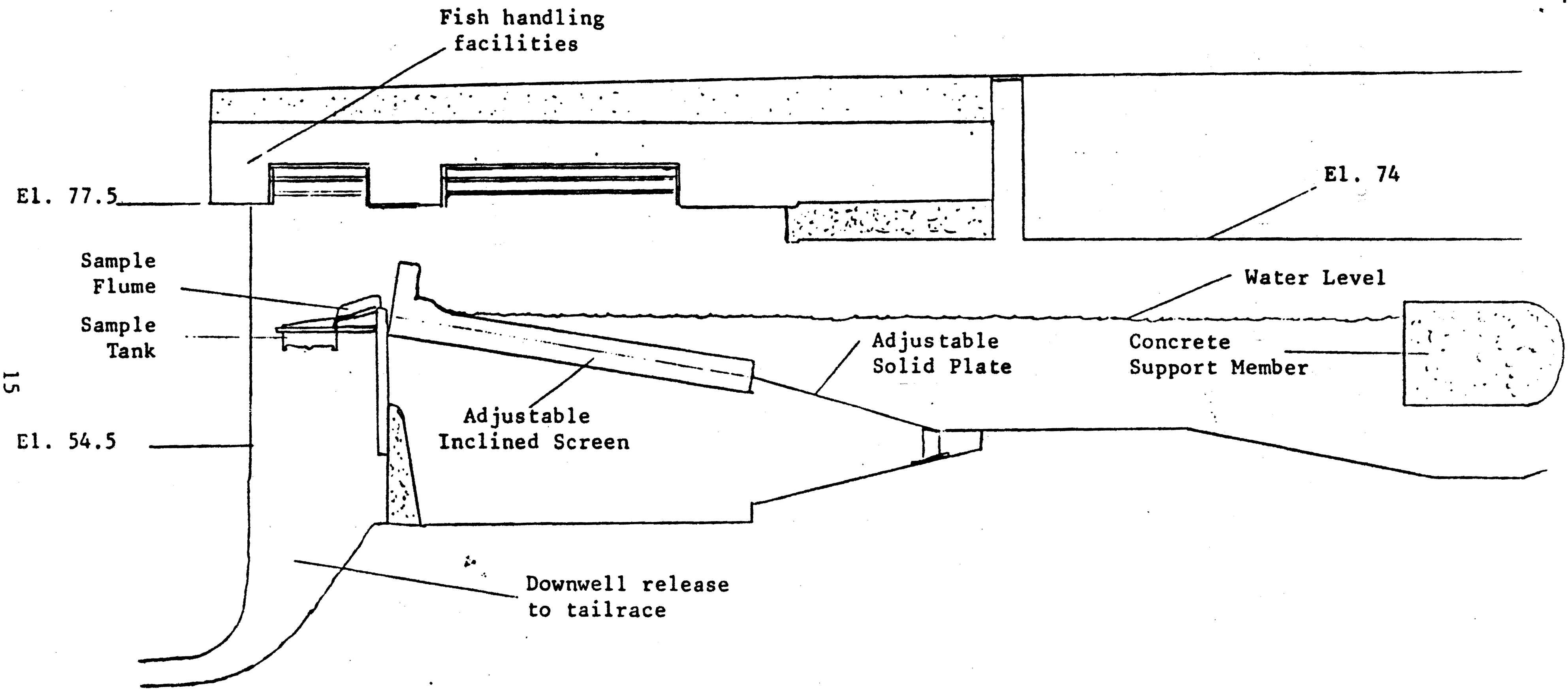

Figure 4.--Cross-section of the juvenile bypass (downstream end) system at Bonneville Dam First Powerhouse, 1984.

Efficiency of Sampling Equipment

Groups of marked subyearling chinook salmon were released at several points within the bypass system to provide information on descaling (see Objective IV) and to determine the efficiency of the sampling equipment. This method provided some information toward sampler efficiency but was not adequate for complete evaluation. An average of 10% of the fish released into Gatewell 1A were recovered by the sampler (244/2,451, range 12.7 - 6.2% for three replicates). The major problem was that the sampler could not be fished on a continuous basis. This problem has been addressed, and an improved technique will be implemented during the 1985 field season.

OBJECTIVE IV - DETERMINE FISH QUALITY AND STRESS THROUGH THE BYPASS SYSTEM

Fish Quality

Methods and Procedures

Groups of freeze branded and partially caudal clipped subyearling chinook salmon (Tule stock, Spring Creek National Fish Hatchery) were released at various points within the bypass system to provide descaling information. Release locations included: (1) Gatewell 1A, (2) the upper portion of the transportation channel, and (3) upstream and downstream from the concrete support member obstructing a portion of the lower channel (Figure 4). Releases began on 25 June, and each was replicated three times on successive days. Numbers released ranged from 692 to 916 fish per individual group. Sampling was done for 20 minutes each hour from first release until catches indicated marked fish were clear of the system.

Results

Only four subyearlings (0.1%) out of the total recapture of 3,275 were classified as descaled. It should be noted that these fish were not in a smolting condition, consequently, they may have been less susceptible to descaling than natural migrants. During a period when a direct comparison between DSM descaling and gatewell descaling could be made on subyearling chinook salmon, descaling was 3.5 and 1.0%, respectively, indicating a slight amount of descaling might be attributable to the DSM. Further evaluation is planned for 1985.

Stress Tests

Seawater challenge was the method used to measure stress on yearling chinook salmon at the First Powerhouse. These tests were to be conducted for two purposes. First, to determine stress levels at various points within the bypass system (continual mechanical failures precluded this portion of the tests). Second, to determine if a stress difference exists for fish in gatewells equipped with either a standard (SVBS) or a balanced flow vertical barrier screen (BFVBS). The BFVBS is designed to evenly distribute flows between the upstream and downstream portions of the gatewell, thereby alleviating any turbulent areas (potential stress areas) that may exist with the SVBS.

Samples of yearling chinook salmon were collected from gatewells equipped with SVBS or BFVBS during three periods of the juvenile migration (15 and 16 May; 22, 23, and 24 May; and 30 and 31 May and 1 June). Fish were collected and handled using standard seawater challenge techniques developed in previous tests of this nature (Park et al. 1983). Data analysis was based on 24-h mortality counts.

No significant difference in stress was found between the two groups ($P<0.05$, df=1).

OBJECTIVE V - ORIFICE PASSAGE EFFICIENCY

Orifice passage efficiency (OPE) tests were to be conducted at the First and Second Powerhouses during the 1984 field season. Tests were not conducted at the Second Powerhouse because the orifice trap is located in Unit 12B, and FGE tests took priority. Tests were conducted at the First Powerhouse to determine OPE for 12- and 14-inch diameter orifices with SVBS and BFVBS and with three different types of lights: standard quartz, high pressure sodium, and metal halide.

OPE Tests

Methods and Procedures

A trap attached to an orifice in Unit 9C was used for the OPE tests. Target species were yearling and subyearling chinook salmon. All tests were 24 h in duration. OPE was determined by direct comparison of the number of fish in the trap to the number of fish that were collected from the gatewell by dipnetting at the end of each test. A minimum of three replicates with at least 200 fish of the target species were required for statistical analysis. OPE approaching 75% in a 24-h period were considered acceptable.

Results

No significant difference ($P<0.05$, df=1) was found in OPE for yearling chinook salmon when comparing the 14- and 12-inch diameter orifices (70.0 and 73.1%). A significant difference ($P<0.05$, df=1) was determined for subyearling chinook salmon when comparing the SVBS with a 12-inch diameter orifice and the BFVBS with a 12-inch diameter orifice (78.7 and 84.5% respectively). Statistical evaluation of the different types of orifice lights could not be made. These test were requested late in the smolt migration season, and by the time the lights were ordered and installed, fish numbers were dropping rapidly, and there was a large degree of variability between tests. For example, OPE ranged from 60 to 95% for the quartz, 37 to 99% for the high pressure sodium, and 39 to 98% for the metal halide.

GENERAL CONCLUSIONS

1. Modifications of the trash rack and STS improved FGE over 1983, but it was still very low. Even more important, descaling of fish was high for all conditions tested.

2. Vertical distribution tests indicated that the deflectors in conjunction with the traveling screen should be capable of intercepting and guiding at least 70% of the fish. The low FGE measured for similar test conditions indicates that the major problem is deflection of fish under the screen.

3. Sockeye salmon had the highest mortality and descaling among fish sampled in the DSM of the Second Powerhouse.

4. Evaluation of the First Powerhouse smolt bypass and indexing facilities was not possible because of mechanical breakdowns.

5. No significant difference in stress was found between groups of yearling chinook salmon collected from gatewells with a SVBS and those collected from gatewells with a BFVBS.

6. No significant difference in OPE was found between 12- and 14-inch diameter orifices for yearling chinook salmon. OPE for subyearling chinook salmon was significantly higher in gatewells with BFVBS.

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