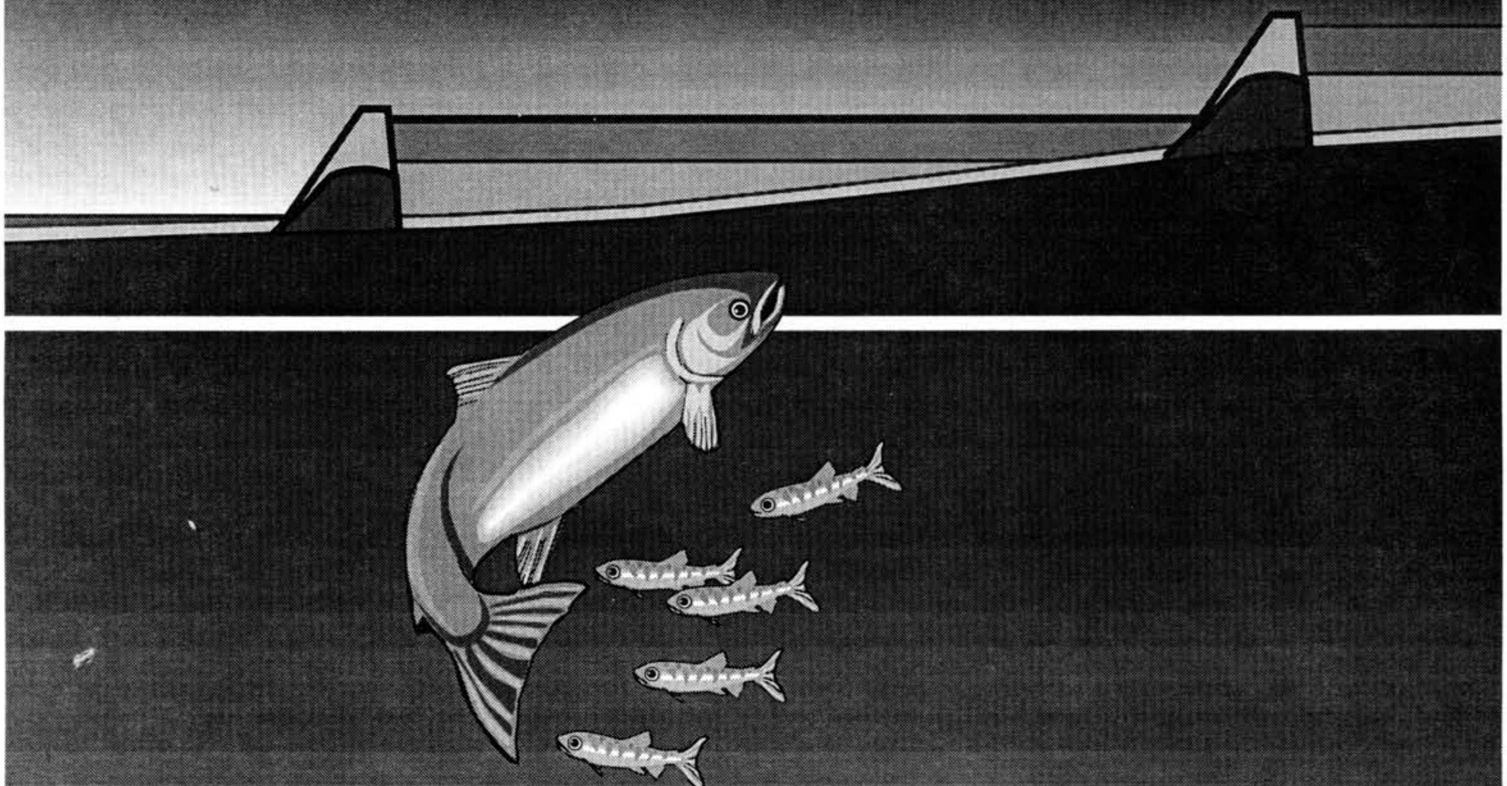
US Army Corps
of Engineers
Walla Walla District

1992 Reservoir Drawdown Test
Lower Granite and Little Goose Dams

Appendix T
Evaluation of 100 Percent Spill on Fish Passage Conditions at Lower Granite Dam



December 1993

APPENDIX T

EVALUATION OF 100 PERCENT SPILL ON FISH PASSAGE CONDITIONS AT LOWER GRANITE DAM

Sarah J. Wik
Walla Walla District
U.S. Army Corps of Engineers

EVALUATION OF 100 PERCENT SPILL ON FISH PASSAGE CONDITIONS AT LOWER GRANITE DAM

JUNE 1, 1991

Sarah J. Wik
U.S. Army Corps of Engineers
1993

EVALUATION OF 100 PERCENT SPILL ON FISH PASSAGE CONDITIONS AT LOWER GRANITE DAM JUNE 1, 1991

I. INTRODUCTION

One measure being proposed to assist in rebuilding declining Columbia River system salmon stocks (*Oncorhynchus* species) is to substantially lower the water level of the reservoirs behind the mainstem dams on the lower Snake River. The water level would be lowered during periods of juvenile fish downstream migration (see Figure 1 for a map of the Columbia and Snake River system).

Lowering pool elevations reduces the cross-sectional area of the reservoir and increases average water velocities. It is believed by some parties in the region that increasing average water velocities will reduce travel time of juvenile salmon and potentially increase their survival through the system of dams and reservoirs.

The benefit of increased average velocities to juvenile survival has not been documented. Existing flow and fish travel time data are somewhat limited and interpreted differently by various parties. While flow is generally believed to play a role in juvenile salmon survival, up to a certain point, it is not the only factor involved.

The Columbia Basin Fish and Wildlife Authority (CBFWA) recommends a minimum flow of 140,000 cubic feet per second (cfs) in the lower Snake River (CBFWA, 1991) during the main portion of the juvenile fish outmigration (mid-April through mid-June). Because this is not possible to achieve with flow augmentation from storage during low water years, reservoir drawdown is being considered as an alternative.

The four lower Snake River reservoirs (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor) were being operated near minimum pool for the 1991 juvenile salmon downstream migration. However, this two- to five-foot reduction in elevation does not achieve velocities equivalent to 140,000 cfs at full pool. To achieve the velocities equivalent to the flows recommended by the CBFWA would require lowering the reservoirs anywhere from just a few feet to over 50 feet, depending on the flow in the river.

The region is proposing operating the projects at near spillway crest, approximately 30 to 50 feet below the normal minimum operating pool, to obtain higher average velocities. See Figure 2 for elevations of project features at Lower Granite Dam.

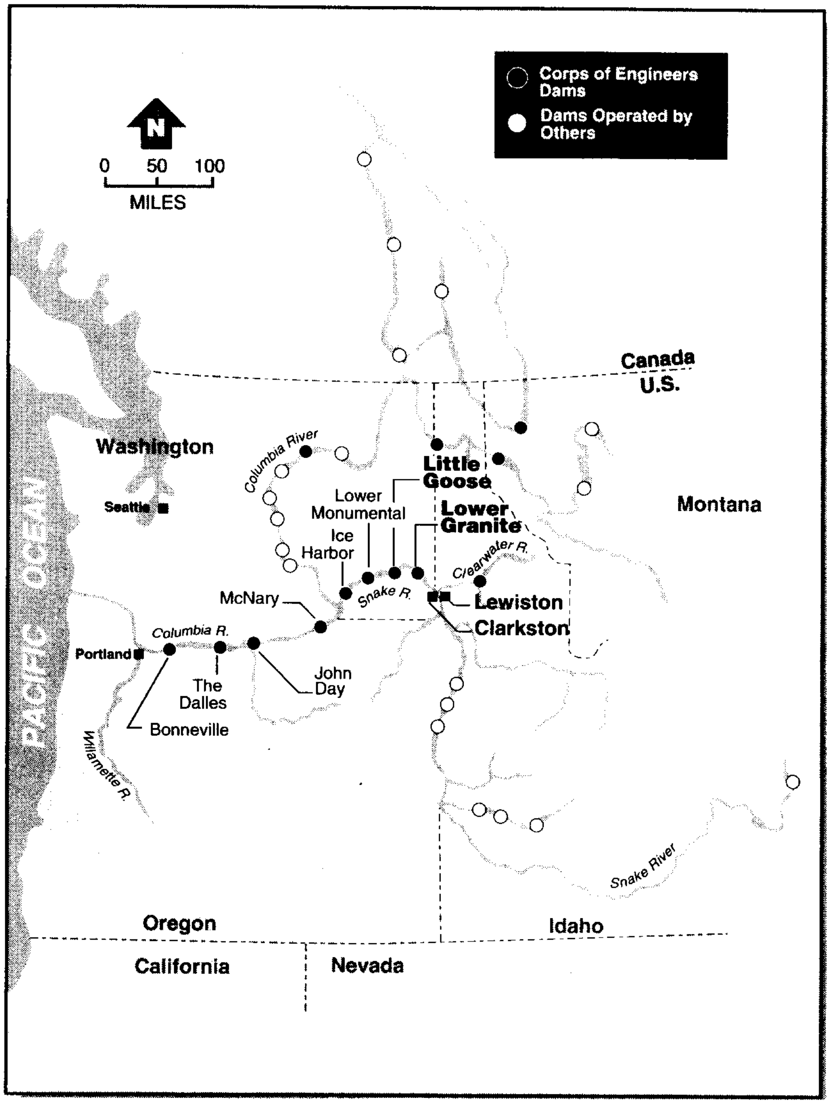


Figure 1. Regional map showing Corps and non-Corps dams on the Snake and Columbia Rivers.

There are many uncertainties associated with the reservoir drawdown concept. The Corps of Engineers (Corps) facilitated a series of meetings in April, 1991, to develop a framework for a 1992 test of the drawdown concept. Table 1 lists the reservoir drawdown test alternatives that were developed in these meetings by Salmon Summit participants and technical representatives from the participating agencies and organizations. (This group subsequently became known as the Reservoir Drawdown Test Design Team.)

Table 1. Reservoir Drawdown Test Alternatives

Alternative	**Project**	**Elevation**	**Duration**
1	All 4 Lower Snake reservoirs	Near spillway crest	15 April - 15 August
2	Lower Granite only or Lower Granite-Little Goose (physical test)	Near spillway crest	January-February, or 15 July-15 August (non-fish window)
3	Lower Granite only	Elev. 710	15 April - 15 June
4	Lower Granite and Lower Monumental	Elev. 710 Elev. 509	15 April - 15 June
5	Lower Granite only	Elev. 710	3 times during 15 April - 15 June

The test alternatives listed in Table 1, along with additional flow improvement measures, were evaluated in a Columbia River Salmon Flow Improvement Measures Options Analysis/Environmental Impact Statement (EIS) for 1992 (U.S. Army Corps of Engineers, 1992).

Once the pool elevation drops below the normal minimum operating range, the powerhouse may be shut off and the entire river discharge passed over the spillway. Since the juvenile fish collection/bypass facility does not function below minimum operating pool, this mode of operation could be taken to prevent the routing of juvenile fish through unscreened turbines. One of the major concerns of pool lowering, raised at the test protocol development meetings, was the potential effect of 100-percent spill on adult fish passage conditions. Past research (Turner, et al., 1983) has indicated substantial delay of adult salmonids at Lower Granite Dam when spill was approximately 60,000 cfs and above, with full powerhouse discharge. (Figure 3 is a diagram of Lower Granite Dam.) Concern was expressed that high spill levels, coupled with altered tailrace flows resulting

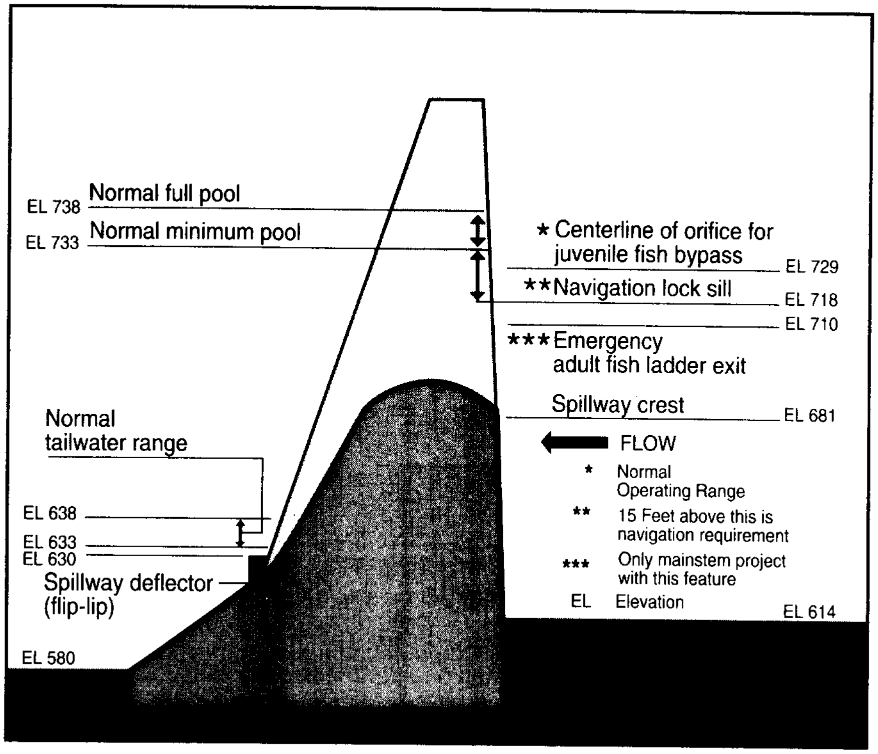


Figure 2. Cross-section of Lower Granite Dam showing elevations of project features. Elevations shown are feet above mean sea level (fmsl).

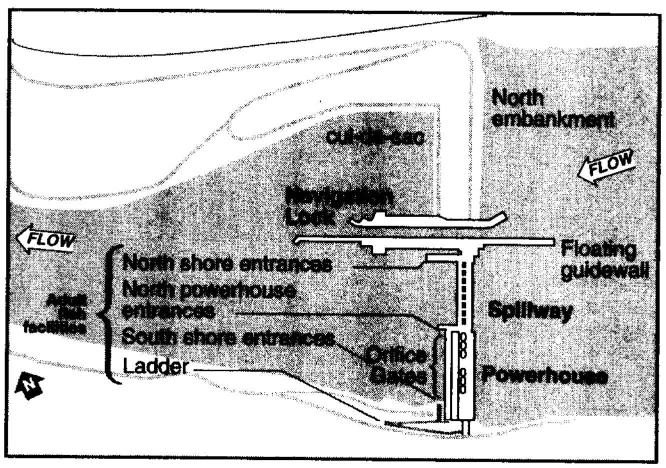


Figure 3. Plan view of Lower Granite Dam showing project features and adult fish passage facilities.

from no-powerhouse discharge, could exacerbate fish passage delays. The Corps was requested to test such an operation prior to the 1992 season. The Reservoir Drawdown Test Design Team members, as well as other interested parties, participated in development of the plan for this test.

This report describes the test of zero powerhouse discharge/100-percent spill performed on June 1, 1991, and the conditions that were observed. (A list of agency representatives in attendance and comments that were received from them are included in Appendix A.) The applicability of the test to potential 1992 drawdown test scenarios is discussed.

This test was designed to gather information regarding turbulent flows and dissolved gas supersaturation levels. The results assist in evaluating potential conditions for the proposed 1992 reservoir drawdown test alternatives. It is acknowledged that proposed 1992 tests will result in different reservoir elevations than were tested. It was not possible to lower the reservoirs for a test in 1991 because of potential significant environmental impact, which required substantially more analysis and preparation than the time frame allowed. Under alternative 1 proposed for 1992, the forebay at Lower Granite would be approximately 35 feet below minimum operating pool, and the tailrace would be approximately 6 feet lower than conditions tested on June 1, 1991. Under alternative 3, Lower Granite reservoir elevation would be 23 feet lower, however tailrace elevation would be the same.

II. TEST DESCRIPTION

The date of June 1, 1991 was chosen for the test to minimize potential effects on adult fish passage (at a low point between the spring and summer adult chinook runs) and to take advantage of existing flows. Although average flows during a low flow year may be considerably less than 100,000 cfs, this level was chosen for the test target flow to represent higher flow conditions that may occur during a 1992 drawdown test, and it represents a potential peak flow even during a low flow year.

Heavy rains during the week prior to the June 1, 1991, test resulted in Snake River discharge in excess of 100,000 cfs, but flows had receded to approximately 85,000 cfs prior to the test. In order to achieve the target flow, discharge was minimally reduced for several hours on the morning of June 1 and the pool elevation was raised to 733.8 (still within the operating requirement of being within one foot of minimum operating pool). This allowed the discharge to be increased to 100,000 cfs during the test without causing the reservoir to drop below minimum operating level.

The duration of the test was limited to approximately four hours during the middle of the day, to minimize impact on adult fish passage. Three spill patterns were chosen for comparison: 1) south-angled (existing; highest spill toward the south shore),

2) crowned (highest spill in the center of the spillway), and 3) north-angled (highest spill toward the north shore). Patterns were developed by the Idaho Cooperative fish and Wildlife Research Unit at the University of Idaho for the crowned and north-angled. Table 2 lists the spill gate settings (gates are numbered from south to north).

Table 2. Spillway gate settings for patterns used during test.

Pattern			**No. of stops gate open***					
	Gate #1	Gate #2	Gate #3	Gate #4	Gate #5	Gate #6	Gate #7	Gate #8
South-angled (existing)	7	10	10	11	10	5	2	1
Crowned	3	6	9	12	11	8	5	2
North-angled	1	2	4	7	9	12	12	9

*One stop equals approximately 1 foot.

At approximately 11:00 am, powerhouse units were sequentially turned off and spill gates opened simultaneously. By 11:15 am, all river flow was passing over the spillway. From 11:15 am to 12:15 pm, tailrace conditions were allowed to stabilize (estimated one-hour minimum required). The existing spill pattern was used for the first test condition. A 20-minute observation period followed stabilization, then spill gates were shifted to a crowned pattern. Following another one-hour stabilization period and 20-minute observation period, the spill was shifted to the north-angled pattern.

During each observation period, personnel (Corps and fish agency) recorded tailrace conditions with video and still cameras. Three primary recording locations were used: 1) north shore from the navigation lock, 2) south shore from a hill above the dam, and 3) overhead from helicopter. Dissolved gas levels were recorded on a stationary instrument located on the north shore approximately one-quarter mile downstream from the dam. Gas levels were also monitored from a boat at three locations across the river below the dam (north, center, and south).

III. RESULTS AND DISCUSSION

A. Flow

During all three spill patterns, a large back eddy was observed in front of the powerhouse, and the downstream extent of the eddy varied with the pattern. The back eddy flow formed a series of standing waves in front of the first five powerhouse units, and continued north to the southern edge of the spill. Considerable turbulence was observed in front of the north shore entrance, becoming worse as the spill pattern shifted from the south to the north-angled.

Under conditions of this test, no powerhouse discharge and high levels of spill (represented by 100,000 cfs) at near minimum operating pools, fish passage could be effectively blocked. The south shore entrances were masked by the upstream flows of the back eddy formed by all tested spill patterns. The floating orifice gates in front of Units 1 through 5 were blocked, at least on the surface, by a top roll of water. High turbulence in front of the north shore entrances would likely have prevented their usage. The north powerhouse entrances appeared to be the least affected, particularly with the north-angled spill pattern, although velocities along the edge of the spill may be too high for fish to approach these entrances. Diagrams in Appendix A illustrate flow patterns observed during each of the spill patterns.

Water levels in the tailrace and adult fishway collection channel dropped approximately two feet within a short period of test initiation. This resulted in an inability to maintain the correct depth of water flowing through the fish collection entrances. It also eliminated use of most of the electronic fish counting tunnels in place for an ongoing adult fish passage evaluation.

Photographs in Figure 4 show the conditions observed during the spill test.

B. Dissolved Gas

Dissolved gas levels within the tailrace began increasing when the spill gates were opened. Levels continued to rise during the four-hour period, reaching 137.9 percent (at standard recording depth of approximately 15 feet) as the test was concluded. See Table 3 for the dissolved gas data. The south-angled and crowned patterns appeared to result in the highest levels of dissolved gas in the center of the river. The north-angled pattern resulted in the highest readings closer toward the south shore. The flow may have been deflected from the navigation lock and north shore to the south shore.

Although a reduced head under proposed conditions would result in lower velocities over the spillway and potentially less turbulence in the tailrace, this may be offset by a reduced pool in the stilling basin that is important in dissipating energy. Significant turbulence disrupting adult fishway entrance flows may occur under the various proposed drawdown scenarios.

Table 3. Dissolved gas data.

Time	BAR[1] mm Hg	P_T[2] mm Hg	% SAT TDG[3]	DELTA P TDG	T H_20[4]	Location in River
10:55	744	761	102.4	18	12.1	North
10:57	Spill	begun				
11:00	744	759	102.1	16	12.0	Center
11:03	744	762	102.4	18	12.0	South
11:32	744	951	127.6	206	12.0	North
11:38	744	960	128.8	215	12.0	Center
11:41	744	950	127.8	206	11.9	South
12:00	744	947	127.3	204	12.0	North
South-	**angled**					
12:23	743	944	127.0	201	11.9	North
12:27	744	956	128.7	215	11.9	Center
12:36	743	948	127.5	205	11.8	South
Crowned						
13:35	743	969	130.4	227	11.9	South
13:45	742	983	132.4	241	11.9	Center
13:56	743	977	131.6	236	11.9	North
North-	**angled**					
14:03	742	994	134.0	253	11.9	North
15:09	742	1005	135.4	263	11.9	Center
15:16	742	1024	137.9	282	11.9	South

1 - Barometric pressure in millimeters mercury.
2 - Total gas pressure in millimeters mercury.
3 - Total dissolved gas.
4 - Water temperature in degrees Celsius.

Dissolved gas levels are affected by the amount of turbulence (potential air entrainment), the depth the water may plunge and force air into solution, and the ability of highly-saturated water to mix with sources of less-saturated water. As noted above, turbulence is likely to remain, but depth of plunge under a no-powerhouse discharge is expected to be less than under normal operating conditions; although it will also be affected by Little Goose forebay level (minimum operating pool or spillway crest).

A reduction in depth of the stilling basin is expected to reduce dissolved gas levels, but this may be counteracted by a loss of spillway deflector (flip-lip) effectiveness. It appeared that under reduced tailrace conditions caused by no powerhouse discharge, the flip-lips were ineffective, resulting in an increase in dissolved gas levels over what would be expected if the flip-lips were effective. The flip-lips were designed to operate at tailwater elevations existing under high flow conditions, which are not present when the entire river discharge is passing over the spillway. (It is important to note that estimates of juvenile fish spillway mortality were obtained with functioning spillway deflectors. Mortality under changed conditions may be significantly higher. Long, et al., indicated 27.5 percent mortality in bays without flip-lips, which may be more representative of conditions that will exist under reduced tailwater levels.) The lack of less-saturated powerhouse flows for mixing with spillway flows will also result in slower dissipation of high dissolved gas levels.

The state water quality standard for dissolved gas is 110 percent. Levels exceeding this value may be harmful for all aquatic organisms, including anadromous fish.

IV. CONCLUSIONS

This preliminary test was not designed to predict exact conditions resulting under a reservoir drawdown scenarios, but to provide information with which to design the proposed 1992 drawdown test. Initial indications are that a test design must be developed to include contingencies should adult fish passage be significantly affected or dissolved gas levels increased beyond an acceptable limit. Preliminary indications are that 100-percent spill of higher flows could potentially negatively impact both upstream and downstream migrant salmonids, by disrupting upstream passage facility flow patterns and increasing dissolved gas levels.

Figure 4a. Tailrace of Lower Granite, south-angled spill pattern; 100,000 cfs over spillway and no-powerhouse discharge. Turbulence in front of the powerhouse.

Figure 4b. Looking downstream from Lower Granite Dam powerhouse tailrace deck. Crowned spill pattern. Flows formed eddy in front of the powerhouse

Figure 4c. Lower Granite tailrace, taken from tailrace deck, north-angled spill pattern. Turbulence in the area of the south shore fish collection channel entrances.

Figure 4d. Lower Granite tailrace, taken from the top of the dam. North-angled spill pattern.

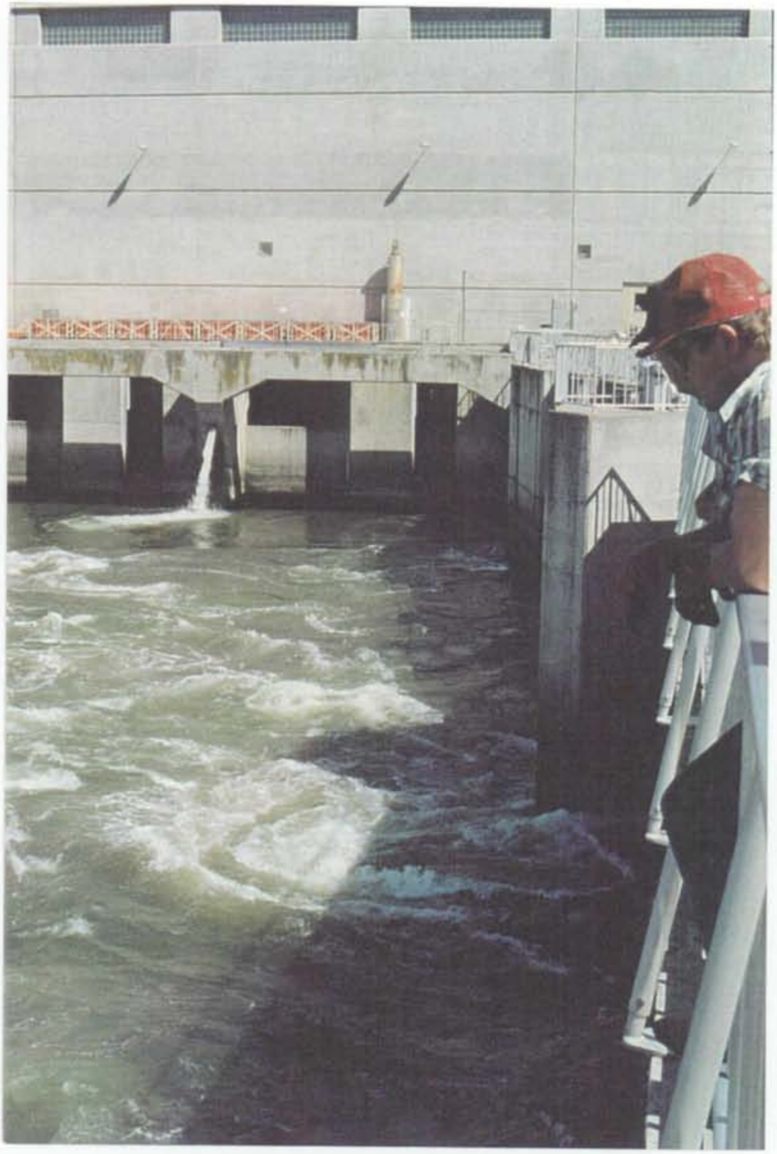


Figure 4e. South shore and floating orifice gate No. 1 entrance conditions. Flow pattern has reversed from upstream to downstream.

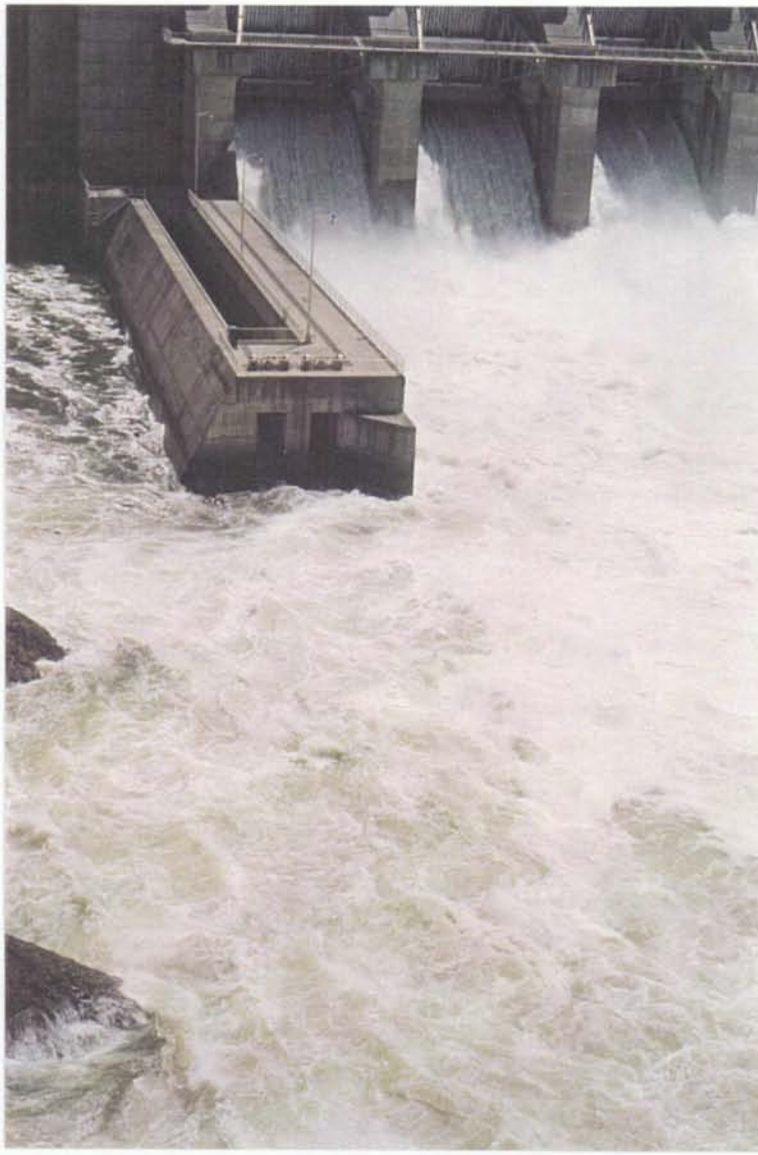


Figure 4f. North shore entrance conditions.
Highly turbulent, masking flow from entrances.

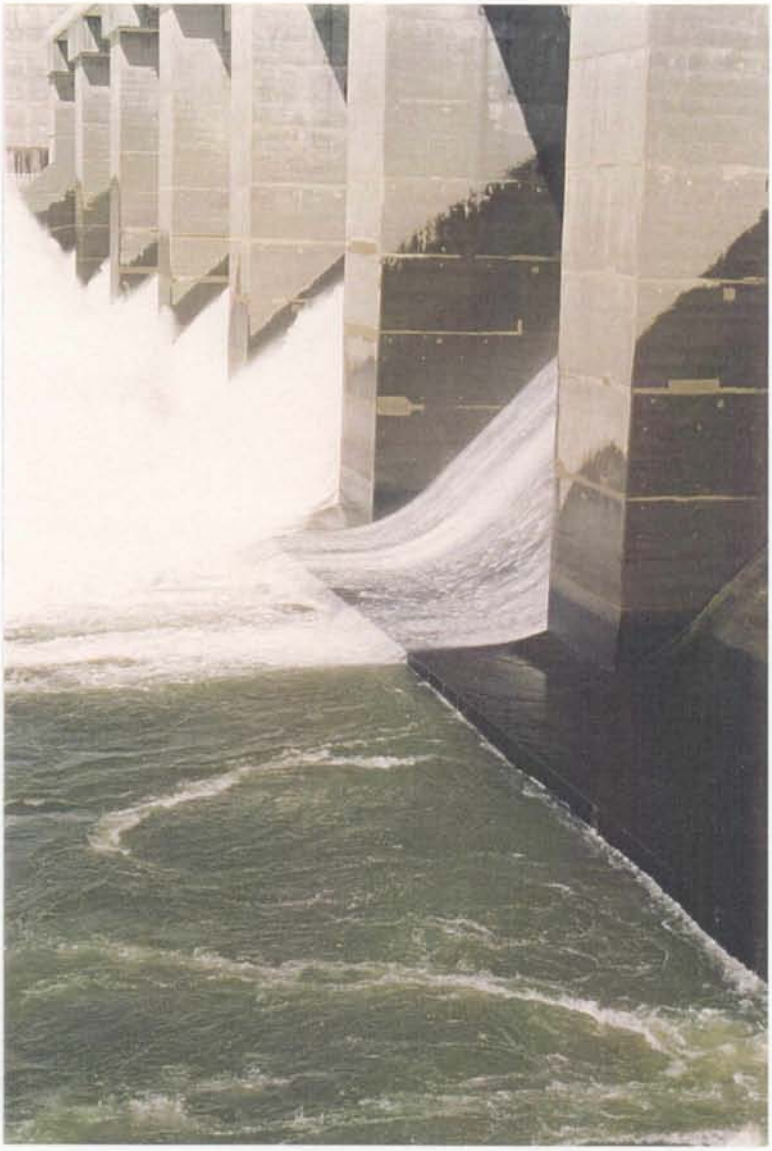


Figure 4g. Spillway deflector as spill was shut off.

Figure 4h. Standing waves in front of powerhouse.

REFERENCES

Columbia Basin Fish and Wildlife Authority, 1991. The biological and technical justification for the flow proposal of the Columbia Basin Fish and Wildlife Authority. February 1991.

Long, C.W., Ossiander, F.J., Ruehle, T.E., and Matthews, G.M., 1975. Survival of coho salmon fingerlings passing through operating turbines with and without perforated bulkheads and of steelhead trout fingerlings passing through spillways with and without a flow deflector. National Marine Fisheries Service. 1975.

Turner, A.R., Kuskie, J.R., and Kostow, K.E. 1983. Evaluation of adult fish passage at Little Goose and Lower Granite Dams, 1981. U.S. Army Corps of Engineers, Portland District. 1981.

U. S. Army Corps of Engineers, 1992. Columbia River Salmon Flow Measures Options Analysis/Environmental Impact Statement. Walla Walla District. Walla Walla, Washington.

APPENDIX A

AGENCY PARTICIPATION COMMENTS

LOWER GRANITE 100% SPILL TEST

1 JUNE 1991

SIGN-IN SHEET

NAME & ADDRESS	AGENCY	PHONE
STEVE PETTIT	IDFG	208-743-6502
Larry Barnett	IDFG	208-743-6502
Paul Wagner	WDF	(503) 922-3630
Bert Bowler	IDF+G	208/334-2646
Larry Basham	FPC	503-230-4287
Ted Bjornn	ID Coop F+W Res Unit	208-885-7617
Ken Tolotti	ID COOP FISH + WLF RESOURCE UNIT	208-885-64
Bob Gilchrist	Red Wolf marina	758-6563

Teri Barila
Charlie Krahenbuhl
Mark Lindgren
Sarah Wik
Dave Hurson
John McKern
Tim Wik

} Corps of Engineers

6 June 1991

To: Sarah Wik

From: Ted Bjornn

Subject: Spill test at Lower Granite Dam

The spill test at Lower Granite Dam on 1 June 1991 was useful to determine the flow patterns that would develop with the three spill patterns tested and their potential effects on adult fish passage. The three patterns were about as different as we could make them with 100kcfs to pass. We should keep in mind that the water was spilling from a nearly full pool and that the tailrace water elevation may have been higher than if the Little Goose pool had been drawn down.

Pattern 1, was an angled pattern with the highest flow on the powerhouse side of the spillway. With this pattern, a large part of the flow moved toward the south shore and formed a backeddy midway between the ladder trap and the juvenile facility (see diagram). The backeddy ran along the south shore and then formed a large toproll when it reached the powerhouse. The backeddy flow then moved north along the powerhouse and joined the south edge of the spill. The south-shore entrances to the fishway would probably be ineffective because the backeddy would lead the fish away from the entrances rather than to them, as is normally the case when there is discharge from the powerhouse. The toproll extended along the powerhouse in front of most of the floating orifice openings and would make them less effective, in my judgement, than when there is discharge from all six turbines. The two north powerhouse entrances (NPE1 and NPE2) were the most usable, if the fish could get to the vicinity of the openings. To get to the north powerhouse entrances, the fish would have to move upstream along the south edge of the spill, but north of the backeddy. The fishway entrance north of the spillway would not be very effective because of turbulent waters along the side of the lock downstream from the fishway. I was hoping that the north entrance would still be usable with the spill angled away to the south, but such did not appear to be the case.

Pattern 2, was a crowned pattern with most of the water spilled through the center spillbays. The primary changes in flow patterns downstream from the dam were: (1) less flow toward the south shore, (2) the backeddy starting point shifted downstream to the juvenile facility, and (3) the turbulence dowstream from the north entrance increased (see diagram). The north powerhouse entrances were the only entrances that appeared usable, if fish could find their way to that vicinity.

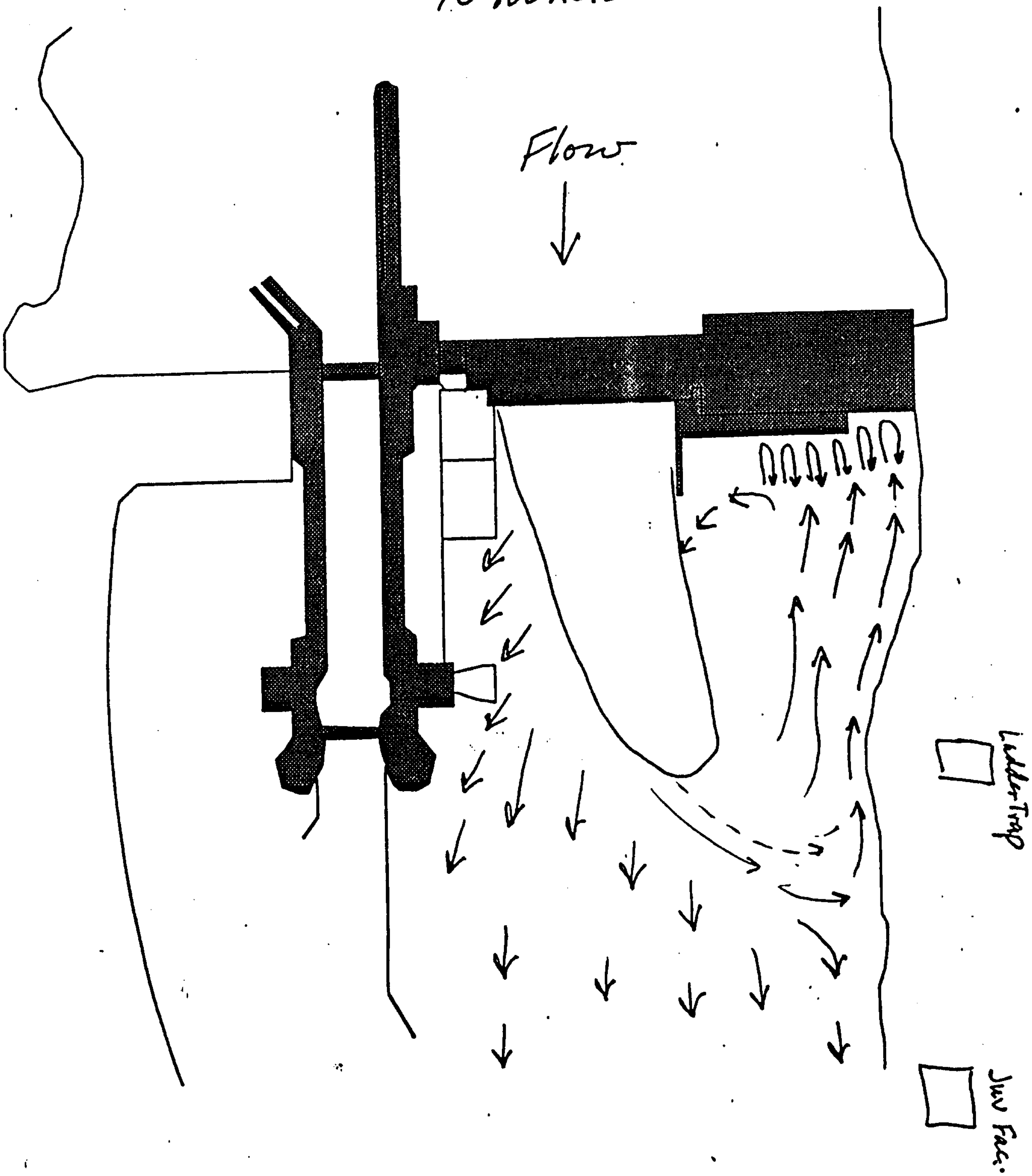
Pattern 3, was an angled pattern with most of the water passed through the north spillbays (see diagram). This pattern resulted in more turbulence along the lock, less flow in the backeddy along the south shore, and more favorable conditions at the north powerhouse entrances. The south entrances to the fishway were still not usable because of reversed flows.

In summary, with large flows over the spillway and none through the powerhouse, successful adult entry into the fishways will be dependent on fish getting to the area near the north powerhouse entrances. If most of the fish move upriver near the shoreline, those on the north shore will end up in the culdesac at Lower Granite Dam, and those moving up the south shore will run into the backeddy and likely get confused. If fish move upstream in mid stream, some will follow the south edge of the spill and could end up near the north powerhouse entrances to the fishway. The flow patterns observed in the 1 June test confirmed for me the earlier observations of Chuck Junge and others that fish will have difficulty migrating upstream when there is a large amount of spill.

cc: Boyce
Pettit

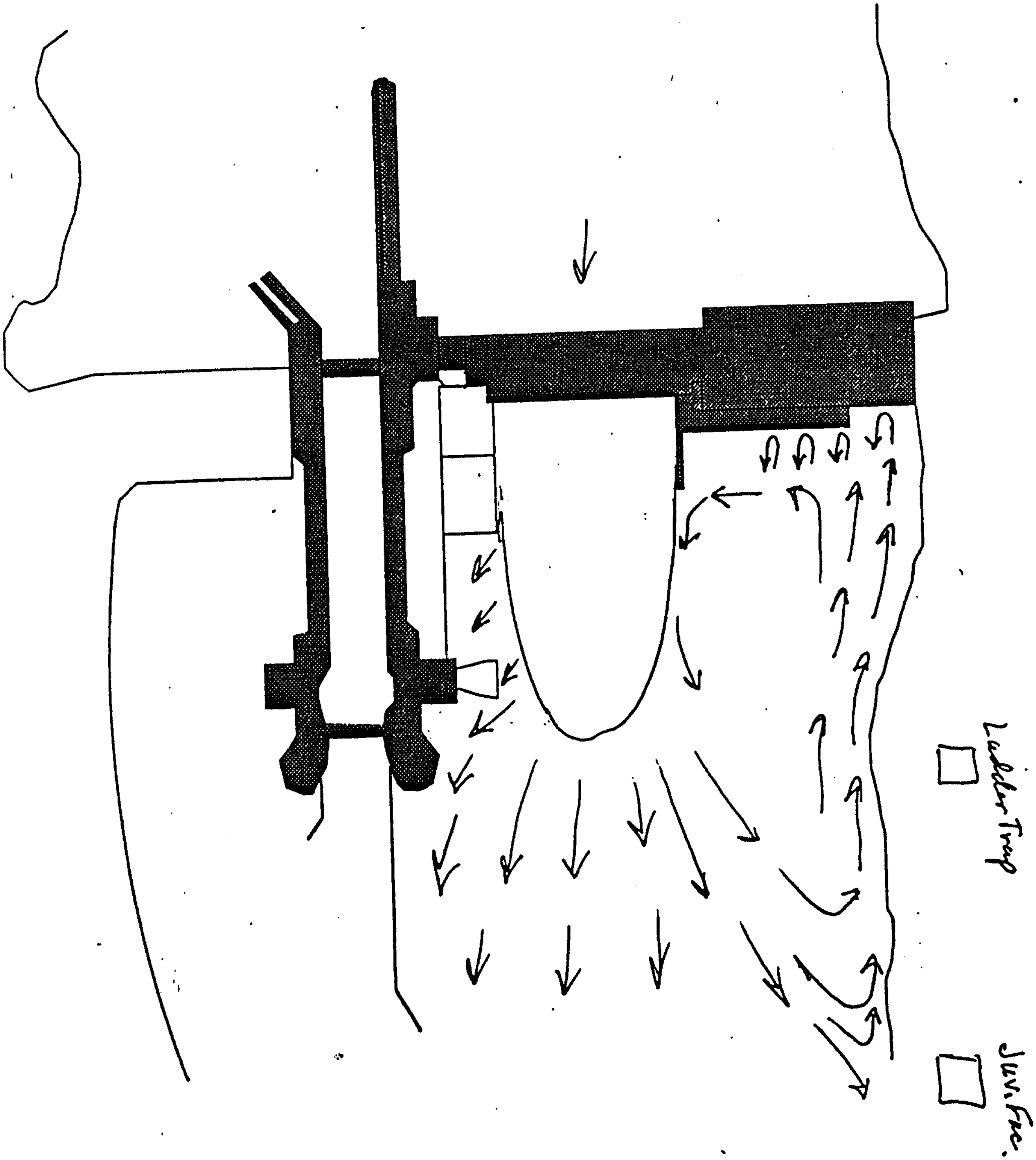
Lower Granite Lock and Dam

1 June 91 Pattern 1, Angled to powerhouse
~ 100KCFS



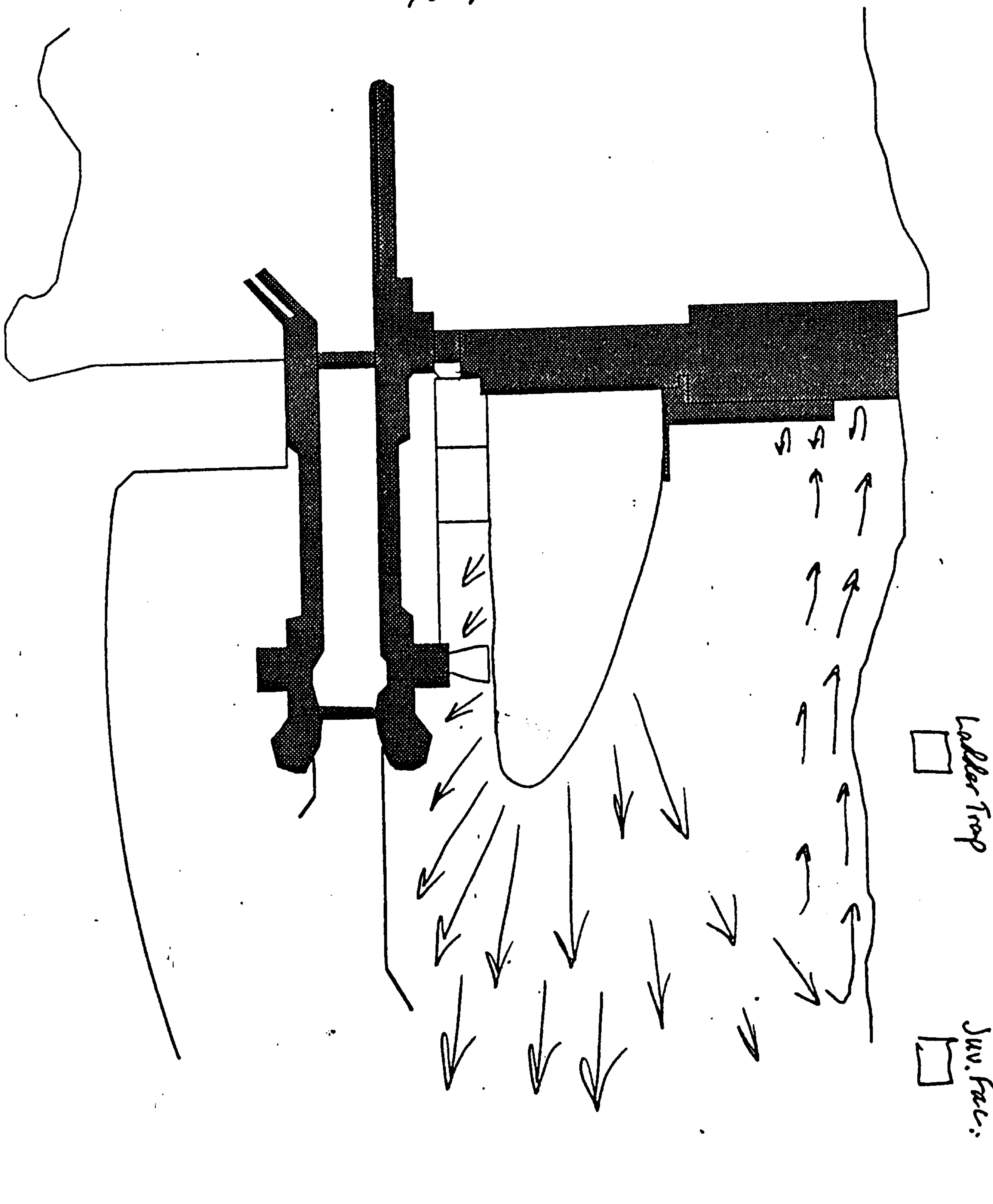
Lower Granite Lock and Dam

1 June 91, Pattern 2, Crowned in center
~ 100 KCFS



Lower Granite Lock and Dam

1 June 91, Pattern 3, Angled to lock
~ 100 KCFS



State of Washington
Department of Fisheries
Room 115 General Administration Building
Olympia, WA 98504

June 3, 1991

MEMORANDUM

TO: Sarah Wik

FROM: Paul Wagner

SUBJECT: Observation of Three Patterns of Spill at Lower Granite Dam on June 1, 1991.

At approximately 1115 hours on June 1, the Lower Granite Dam powerhouse ceased operation and the project discharge was directed through the spillway. The first spill pattern was a "south-angled" pattern. This is the standard pattern of spill used at the Lower Granite Dam. In a south-angled spill pattern most of the discharge is directed toward the southern end of the spillway (toward the powerhouse).

Shortly after the initiation of spill, I observed a large accumulation of floating debris break free from the logboom barricade in the forebay and drift to the spillway. I visited the juvenile fish facility and learned that an increase in the number of juvenile outmigrants crossing the separator had accompanied the initiation of spill. I latter learned from Larry Basham (FPC) that it is common for smolts to hold in the gatewell slots of an operating unit and leave the gatewells and enter the collection channel when the unit is taken out of operation.

After approximately 80 minutes the "south-angled" spill pattern was changed to a "dome" pattern in which most of the spill was directed through the center of the spillway. The final spill was a "north-angled" pattern. The duration of the "dome" and "north-angled" spill patterns was approximately 80 minutes each.

I was informed by Larry Basham (FPC) that the water level in the powerhouse collection channel dropped about 2 feet during the test. Larry also indicated that the water velocity within the channel remained suitable for adult passage during the test but that the main gates at the south shore and north powerhouse entrances might bottom out when the tailrace is at minimum elevation.

My general observations were: 1) All three spill patterns resulted in a large counter-clockwise eddy below the powerhouse which would likely impact adult passage at the southshore fishway entrance. 2) The "north-angled" pattern appeared to produce the least amount of turbulence near the powerhouse collection system. 3) The "north-angled" spill pattern would also likely block adult passage at the northshore fishway entrance.

cc: Woodin

NEIL GOLDSCHMIDT
GOVERNOR

Department of Fish and Wildlife
RESEARCH AND DEVELOPMENT SECTION
17330 SE Evelyn St. Clackamas, OR 97015

June 24, 1991

Dear Sarah,

As requested, I have organized a couple of thoughts and concerns regarding the test spill which occurred at Lower Granite Dam on June 1, 1991. As part of our standard data collection procedures we monitored powerhouse and fishway operation variables before, during, and after the test spill. Impacts of this spill on our adult passage monitoring equipment was of course, our greatest concern. The impacts we observed couldn't be attributed to any single spill pattern, but rather to a function of the spill as a whole.

Extreme decreases in fishway and tailwater elevations during the period of spill had observable impacts on the performance of our electronic equipment. As you may recall, we have installed a multiple-tunnel frame containing 16 tunnels in the collection channel at the north end of the powerhouse. In less than an hour into the test spill, north powerhouse collection channel water elevation had dropped two feet. As you might imagine, this introduced a large amount of air into the top eight tunnels on this multiple-tunnel frame. Since these tunnels were designed to count fish, not air bubbles, it was impossible to collect data from those top eight tunnels.

North powerhouse tailwater elevation decreased to the extent that the multiple-tunnel frames located at NPE-1 and NPE-2 came close to resting on the sill. This is not by itself a problem, however, it means at that tailwater elevation we may have as few as one operable tunnel in each entrance (not unlike putting all your eggs in one basket).

I know your aware of the "washing out" affect that this spill had on the north shore entrances, so I won't get into that. I will remind you that we are attempting to evaluate NPE-3, but wouldn't be able to do so during spill conditions (I realize you already knew that). In summary, if a spill of similar design and magnitude were to occur for an extended duration next year, we would have to modify some of our currently installed electronic equipment.

Sincerely,

Chris

ck
c: Nigro

CENPW-EN-DB-HY (1110) Mr. Lindgren/6518 6 June 1991

MEMORANDUM THRU

Chief, Design Branch

Chief, Engineering Division

FOR Engineering Division Files

SUBJECT: Lower Granite Spillway Test; 1 June 1991

1. At Lower Granite Dam on the 1 June 1991, approximately 100,000 cfs was passed over the spillway with no flow being passed through the powerhouse. The test was conducted for 4 hours with three different spillway operation modes. The purpose of the test was to observe conditions similar to those expected during some of the proposed pool lowering options. The main areas of interest were adult fish passage conditions and gas super-saturation conditions. A schedule for the spillway test along with definition of the spillway operation are enclosed. Videos and still pictures were taken of each condition.

2. The following items were noted during the test.

a. All three conditions caused a large eddy to form in front of the powerhouse. The extent and size of the eddy changed somewhat with the different spillway operations, but the overall affect was much the same. The adult entrances on the south shore were severely impacted and would provide little passage benefit. The north powerhouse entrance was functional, but its location was such that fish would have great difficulty in finding it. The north spillway entrance was blocked by strong currents during all conditions. Though the entrance was somewhat functional during the condition where spillway flows were concentrated on the powerhouse side, the probability of the fish getting passed the higher velocity downstream flows is low. Overall adult passage conditions were very poor for all three conditions.

b. The tailwater prior to spill was 634.5 ft., this is approximately 8 ft. lower than the normal tailwater expected at this magnitude of spill. In addition, the powerhouse was shut down which allowed the spillway flows to expand toward the powerhouse as soon as the flows passed the south stilling basin training wall. This resulted in considerable turbulence leaving the stilling basin. This area should be monitored closely during any long term testing operation. Another aspect of the lowered tailwater was the reduction of downstream depth for dissipation of the high velocity spillway flows. Current estimates for juvenile mortality over the spillway were based on tests conducted at standard tailwater levels. Due to this changed condition, the actual mortality rate over the spillway may be considerably different. This may be somewhat countered by the reduction in total head anticipated during pool lowering operations. The last aspect related to the lowered tailwater is in regards to the function of the flip lips on each of the eight spillway bays. The primary purpose of the flip lips is to reduce the gas-supersaturation content of the water. Downstream measurement of nitrogen supersaturation had preliminary numbers in the range of 126-130 percent. This indicates that though the flip lips appeared to initially direct the water horizontally, due to the lower tailwater, the jet plunged deep into the basin causing the higher gas-supersaturation percentages. This problem may be reduced by either relocating the flip lips or constructing some sort of downstream tailwater control.

c. Measures to be considered to insure successful adult passage during this mode of operation would include major extensions of both the north powerhouse entrance and north spillway entrance, possible use of an extensive guiding system to prevent fish from entering the large powerhouse eddy, the development of additional adult attraction water, the addition of an entrance to attract fish north of navigation lock, and finally development of a solution to the increased nitrogen supersaturation levels. Problems associated with the adult exit will have to be addressed separately. The most effective way to design the above system would include the use of a 1:100 scale general model to analyze adult attraction concerns and a 1:50 scale spillway sectional model to analyze detail spillway operation.

Mark Lindgren

Encl

MARK LINDGREN, P.E.
Chief, Hydraulic Design Section

CF:
Sarah Wik, Env. Res.
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COMMENTS ON 100% SPILL TEST AT LOWER GRANITE - JUNE 1, 1991

TO: Sarah Wik

FROM: Tim Wik

Observations

1. There was a very strong current in front of the juvenile fish facility flowing towards the powerhouse. This is exactly opposite of what the flow looks like under normal powerhouse operation.

2. Lots of turbulence and cross currents in front of all the fish ladder entrances

3. The water level in the adult fishway channel in front of the powerhouse dropped at least a couple feet while the test was being conducted.

4. There was a small amount of bank erosion in front of the juvenile fish facility during the test from wave and current action. This area is well protected by rip rap, so I don't think this is too significant. This observation is based on small pockets of muddy water seen in front of the facility.

5. Juvenile fish collection averaged about 2,000 fish per hour from 0700 to 1100, 19,600 fish per hour from 1100 to 1200, 8,300 fish per hour from 1200 to 1300 and 1,740 fish per hour from 1300 to 1400. Collection remained low for the rest of the day. The numbers given here are corrected hourly counts, rounded off.