III. 1990 SPILL IMPLEMENTATION

The objective of the 1990 Spill Program was to implement the fish spill provisions of the Northwest Power Planning Council's Fish and Wildlife Program. This includes the Fish Spill Memorandum of Agreement, which is intended to "provide fish passage conditions through the commitment of spill for juvenile anadromous fish and avoidance of turbine impacts" at Lower Monumental, Ice Harbor, John Day and The Dalles dams. The NPPC Fish and Wildlife Program also provides for spill at Bonneville Dam.

A. SPILL PLANNING

The Mainstem Executive Committee negotiated a program for spill to improve fish passage survival at federal hydroelectric projects on the Snake and Columbia rivers that are not presently equipped with, or have inadequate, fish bypass facilities. The negotiations culminated in a ten-year Fish Spill Memorandum of Agreement (Agreement) that commenced on December 31, 1988. Participants in the Agreement were BPA, PNUCC (who participated in the negotiations but did not sign the Agreement), and the region's state and federal fishery agencies and Indian tribes. In February of 1989, the NPPC incorporated the spill terms of the Agreement into the Fish and Wildlife Program. The COE was not party to the Agreement, and did not endorse the ten year agreement. However, the COE did provide spill as described in the NPPC Amendments during 1989, and agreed to implement the Agreement again in 1990.

The Agreement specifies that an annual monitoring plan be developed by November 1 each year, for implementation during the following spring and summer season. The Agreement also states that this plan be integrated with the annual Smolt Monitoring Program of the fishery agencies and tribes. This was accomplished for 1990. The spring and summer migrations were monitored at Lower Monumental Dam through gatewell sampling using a dipnet. At John Day Dam, a gatewell airlift system was used during the summer months. Monitoring at The Dalles Dam occurred during the spring and summer months using a dipnet, which was replaced by an airlift system on July 5. No monitoring was conducted at Ice Harbor Dam in 1990.

On February 21, 1990, the FPC hosted the pre-season spill plan meeting that is required by the Agreement. At this meeting it was agreed that there would be no pre-season adjustments to spill percentages at either Lower Monumental or Ice Harbor dams. The pre-season forecast for Jan-Jul runoff volume was discussed, as were plans for in-season implementation.

Load factoring describes a power marketing strategy whereby, with a given amount of water, flows are decreased during nighttime hours when power demand is low, and are increased during daytime hours when electricity demands are high. Spill is most often requested at night when there is peak

fish passage at a project, and is coincident with the lower flow regime. The Agreement recognizes that load factoring would result in a lesser percentage of daily average flow being used as spill than intended. To compensate for load factoring, the Agreement allowed instantaneous spill percentages to be increased at some projects. At Lower Monumental and Ice Harbor dams, the April 1 forecast for Jan-Jul runoff volume is used to determine if instantaneous spill levels can be adjusted based on daily average flow. At The Dalles Dam, since spill is allowed on a 24 hour basis, in-season adjustments to instantaneous spill levels may be made based on daily average flow during both the spring and summer spill periods. No load factoring adjustment is allowed for John Day Dam. Spill adjustments for load factoring are not transferrable among projects, even if load factoring results in an instantaneous spill percentage greater than 100% of instantaneous flow, while comprising only a small percentage of the daily average flow.

On any given day, the FPC relied on COE hourly flow data from the previous day to determine instantaneous spill percentages for the following day's spill period. BPA would notify the FPC through the COE Reservoir Control Center when the load factoring was going to be different from what was expected based on the previous day's account. The COE would relay to the FPC what percentage BPA had advised would yield the appropriate daily average. As was pointed out last year, this "guessing" as to what the flow shaping would be two days out based on prior flow data presents a serious flaw in implementation. BPA measures success of the spill program's implementation as whether or not they met the instantaneous spill percentage requested by the A&T. The A&T measure success on the basis of whether or not the daily spill achieved the intent of the Agreement. It appears that implementation should share a common goal--to achieve the intent of the Agreement. With this common goal, the implementation would rely less on "second guessing" what the flow and flow shape will be, and place more responsibility on BPA to achieve the objective of the Agreement.

B. SPILL IMPLEMENTATION

1. Spill at Lower Monumental Dam

The spring spill season at Lower Monumental Dam extended from April 19 through May 31. The January-July runoff forecast as of April 1 was less than 23 MAF. According to the Agreement, with this April 1 runoff forecast, spill levels requested during April, May, June, and July were to be estimated using the Daily Average Method. This method allowed the instantaneous spill percentage to be increased by compressing the hours of spill, and allowed increases in the instantaneous spill percentage to compensate for load factoring. The instantaneous spill percentage specified in the Agreement is 70%. With flat loading of the project, and a 12-hour spill period, this translates to 35% of daily average flow. The daily average spill percentage averaged approximately 32.4% of the daily average flow during the spring spill period (Figure 5). An instantaneous spill percentage of at least

70% had been implemented, but did not always result in the 35% daily average. This occurred because when flow levels decreased during May, project flow was decreased to a minimum during spill hours, and 100% of flow was spilled.

In late May and early June, the flows began to increase, creating excess spill in the river. The Snake River projects were given high priority as places to spill the excess water. A Systems Operational Request (SOR) was submitted to the COE requesting that the summer spill program be initiated subsequent to the surplus spill situation, at which time it was expected that the 10% migration date would have been passed. The daily average spill percent averaged 37.3% of daily average flow for the summer spill period (Figure 5). This average included any spill when flow exceeded project hydraulic capacity, or spill to avoid generation in excess of that needed to meet all available power markets (overgeneration spill). After accounting for overgeneration spill, and spill in excess of hydraulic capacity, the adjusted spill percentage for fish averaged only 15.2% of daily average flow for the summer spill period.

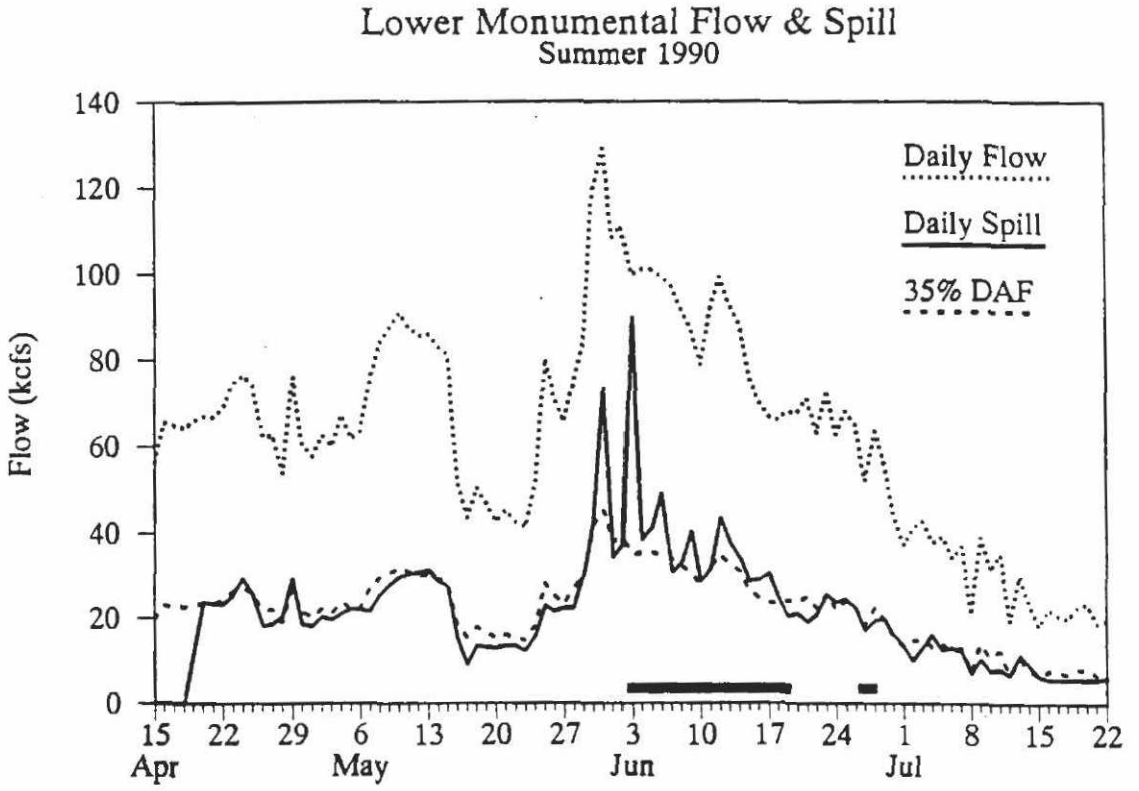

Figure 5. Daily Average Flow (DAF) and spill at Lower Monumental Dam compared to 35% of DAF. Less than 100% of spill is accountable as fish spill on days when spill in excess of hydraulic capacity or was to avoid overgeneration (solid lines).

The summer spill period extended to the last day specified in the agreement. It was extremely difficult to use the Lower Monumental passage index information to predict the 90% passage date in-season, or to calculate the 90% passage date post-season. This was because in the summer spill period when flows were generally low, it was more economical to decrease flow to the project minimum, and spill 100% of the flow. This meant that no units were operated, so a reliable passage index estimate for that day could not be developed. A similar situation occurred for the 1990 spring migration when flows decreased mid-May, and 100% of project flow was spilled during nighttime hours.

The high Snake River flows during June helped to move fish quickly out of the Snake River. The freeze branded Lyons Ferry fall chinook, which were released from the hatchery on June 6, had a 10% passage date of June 20 and a 90% passage date of July 14 at McNary Dam. However, the entire Lyons Ferry Hatchery production was not released on June 6 because of a hatchery program that coded wire tagged all fish released this year. Approximately 2.8 million Lyons Ferry fish were released between June 6 and July 12 and, therefore, spill was continued at the project until 0600 on July 23. Subsequent monitoring indicated many fish were passing the project through the remainder of the month.

2. Spill at Ice Harbor Dam

The instantaneous spill percentage at Ice Harbor Dam specified in the Agreement is 25% of instantaneous flow during 12 spill hours. When the project is flat loaded, this translates to 12.5% of daily average flow. According to the Agreement, adjustments to the instantaneous spill percentage at Ice Harbor Dam are estimated in the same fashion as for Lower Monumental Dam.

The spring spill season extended from April 22 through May 31, and the summer migration extended from June 1 through 0600 on July 23. During the spring season, spill averaged 14% of daily average flow, while in the summer it averaged 20.6%. Overgeneration spill occurred during June and, when the spill amount was adjusted for excess hydraulic capacity and overgeneration spill, it averaged 12.5% and 5.3% of the season daily average flow for spring and summer, respectively. Figure 6 shows the actual daily average spill and flow compared to the 12.5% that would have occurred in a flat-loaded system.

If monitoring was conducted at Ice Harbor Dam, it would be to determine the 10 and 90% passage dates for the spring and summer migrations. During low flow conditions when load factoring can be extensive, the instantaneous spill percent increases to a maximum (some flow is allocated to the operation of the sluiceway and the remainder is spilled). Because of the way spill is provided, it was not believed that accurate migration timing information would be derived from such a program and, therefore, no monitoring was conducted at Ice Harbor Dam during 1990.

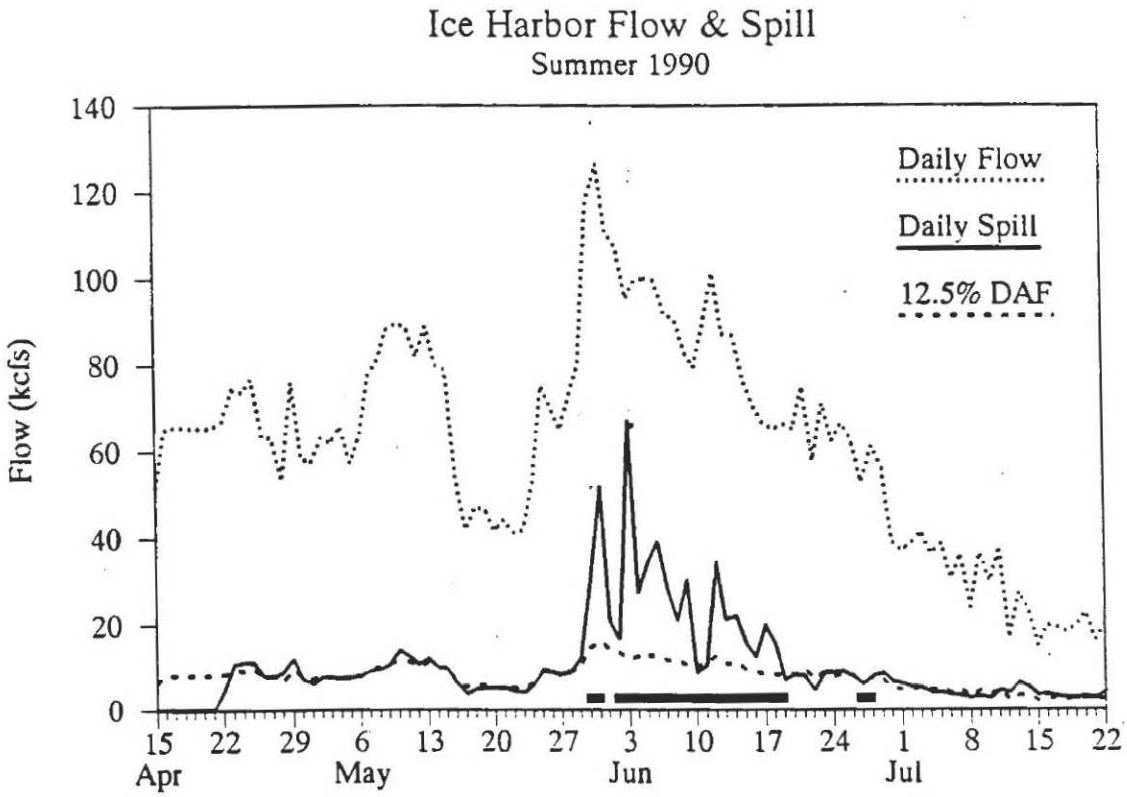

Figure 6. Daily Average Flow (DAF) and spill at Ice Harbor Dam compared to 12.5% of DAF. Less than 100% of spill is accountable as fish spill on days when spill was in excess of hydraulic capacity or was to avoid overgeneration (solid lines).

3. Spill at John Day Dam

The Agreement establishes a summer spill program at John Day Dam to begin on June 7. At that time, overgeneration spill was occurring, as well as spill that was occurring at John Day Dam as a result of the accident that occurred on May 29. Technically, the summer spill program was initiated on June 7th and extended through 0600 on August 23. The instantaneous spill percentage that is specified in the Agreement is 20% for 10 hours. This translates to a spill level equal to 8.33% of daily average flow in a flat loaded system. The instantaneous spill percentage may not be adjusted to compensate for load factoring at this project. The seasonal average was 10.7% of flow (Figure 7), which amounted to just 0.5% after overgeneration spill and spill due to the accident were removed. The daily spill hours were from 2000 to 0600.

At John Day Dam, spill was terminated based on the end date specified in the Agreement. Outages in Unit 5 during the periods May 30 to June 10, June 21 to June 23, and August 13 to 16 made it virtually impossible to estimate the migration timing from the monitoring sample. Since the 90% passage of subyearling chinook at McNary Dam was similar to the median 90% passage date of past years, the assumption was made that the 90% passage date at John Day Dam would also be similar to the historical data.

On May 29 at about 5:15 p.m., a fire in the powerhouse at John Day Dam caused the shutdown of the turbine units, affecting spill levels at the project. High levels of spill resulting from increased flows and an inoperable powerhouse caused dissolved gas levels of about 135% below the project for several days. Because John Day Dam's spillbays are not equipped with fliplips like some of the other projects, these high levels of spill increased dissolved gas saturation above levels safe for fish. The level at Bonneville Dam and the monitoring station about 6 miles below Bonneville recorded over 120% saturation by May 31. As turbine units were being repaired at John Day, the amount of water spilled was reduced. As a result, the saturation levels dropped to about 120% at The Dalles Dam by June 5.

When fish are exposed to high dissolved gas levels (commonly called nitrogen supersaturation) for an extended period of time, gas bubble disease will likely occur unless the fish are able to compensate by swimming at deeper water depths. A review of the literature (Ebel *et al.*, 1979; Dawley *et al.* 1975; Dawley 1986) indicates that at above 115% dissolved nitrogen, fish are subject to severe nitrogen gas bubble disease. The long term chronic effects of this may lead to indirect effects other than those manifested by death.

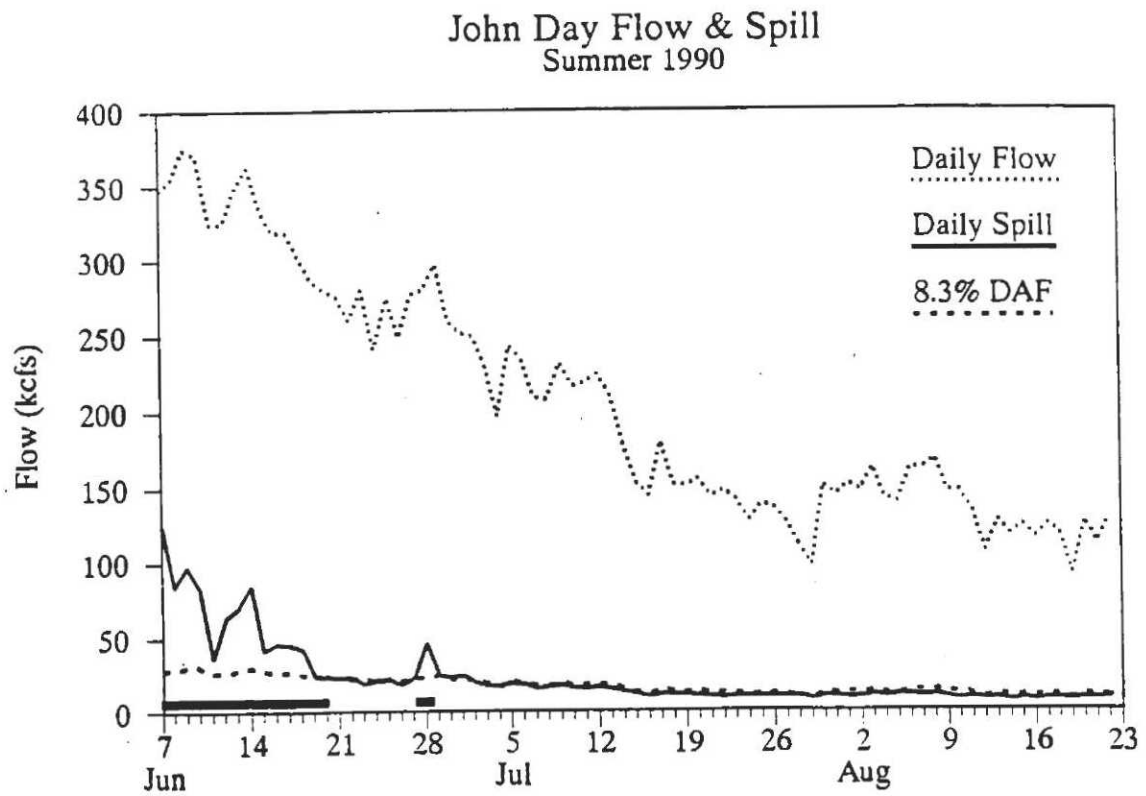

Figure 7. Daily Average Flow (DAF) and spill at John Day Dam compared to 8.33% of DAF. Less than 100% of spill is accountable as fish spill on days when spill was in excess of hydraulic capacity or was to avoid overgeneration (solid lines).

In response to increased flow levels in the Snake River, fish numbers in the Snake River reached peak levels for the season. A tug with two fish barges was on its way to release fish below Bonneville Dam when the incident occurred at John Day Dam. Navigation lock passage was impossible due to the loss of power, and there was uncertainty as to when the power/station service would be restored at the dam. Because of the large number of fish that were still being collected at the Snake River projects, the decision was made to release the barge loads about 2 miles below McNary Dam so that the tug could return quickly to the Snake River juvenile collection facilities to load fish before they exceeded the raceway capacity. The barges were dumped on May 30 at 1:30 p.m. The barges were transporting about 595,000 smolts. About 85% of these fish were steelhead originating in the Snake River. These barged fish and those present in the lower river were subjected to these high dissolved gas levels from the John Day Dam tailwater to below Bonneville Dam, a distance of 69.5 miles. The barge release group began arriving in large numbers in The Dalles Dam sample (6 a.m. - 6 a.m.) the evening of June 1 and sample numbers remained high through the evening of June 2. The Bonneville 1st powerhouse sample (4 p.m.-midnight) began seeing some increase in fish numbers on June 1, probably due to flow increase. On June 2 and 3, the crew at Bonneville Dam observed large numbers of steelhead in the sample, from the barge release on May 30.

Table 6 lists the percentage of fish observed with gas bubbles at The Dalles and Bonneville dams to illustrate the problems that fish encounter when passing through impoundments with high dissolved gas levels. The percentage of gas bubbles increased as the fish were exposed for longer durations. The incidence of gas bubble disease in steelhead was much higher than in the other salmon species. The percent of steelhead affected by the high level of dissolved gas at Bonneville Dam ranged from 22 to 74% of those sampled. The zero-age chinook appeared the least affected by the high saturation of dissolved gases. When the dissolved gas level lowered to near 120%, the gas bubble disease incidence subsided somewhat, but was still evident on a daily basis. To conclude, the high spill levels caused high dissolved gas readings throughout the lower Columbia River that had some degree of adverse impact to fish migrating through the lower reach. The additional mortalities resulting from the high dissolved gas levels present below Bonneville Dam and the lower Columbia River are unknown, but likely were higher, especially on juvenile steelhead.

4. Spill at The Dalles Dam

According to the Agreement, spill can occur at The Dalles Dam for 24 hours a day at a level equal to 10% and 5% of daily average flow during the spring and summer, respectively. In pre-season discussions among the power interests and the fishery agencies and Indian tribes, it was recommended that the available spill be compressed into an 8-hour period in order to increase the instantaneous spill percentage. It was hoped that compressing hours would make the amount of spill

Table 6. Gas bubble incidence observed on salmon and steelhead from May 31 to June 6, 1990 at The Dalles and Bonneville Powerhouse 1 sampling sites.

THE DALLES										
DATE	CHIN 1		CHIN 0		SOCKEYE		COHO		STEELHEAD	
	# samp	% gas disease	# samp	% gas disease	# samp	% gas disease	# samp	% gas disease	# samp	% gas disease
5/31-6/1	26	7.7			2	0	3	33	40	12.5
6/1-6/2	63	7.9			10	20.	4	0	807	1.
6/2-6/3	153	4.6			29	6.9	16	18.8	865	8.2
6/3-6/4	4	0			5	20.			15	20.
BONNEVILLE POWERHOUSE I										
DATE	CHIN 1		CHIN 0		SOCKEYE		COHO		STEELHEAD	
	# samp	% gas disease	# samp	% gas disease	# samp	% gas disease	# samp	%gas disease	# samp	% gas disease
6/1	115	3	638	1<	199	2.5	358	8	189	29
6/2	104	0	466	0	102	0	212	1	663	23
6/3	108	4	461	1<	76	14.	223	38	1314	74
6/4	100	5	791	0	102	5.	214	11	227	37
6/5	73	0	487	0	131	3.	301	1	147	22
6/6	55	2	611	0	218	1.	259	2	121	25

available more effective in passing fish by the project via a non-turbine route.

The spring spill season extended from 2000 hours May 1 through 0400 hours on June 7. Smolt monitoring was conducted using a dip-net basket in one gatewell during the spring season. Since this was the first year of spring monitoring at this project, it was impossible to predict the 90% passage date in-season. The post-season estimated 10 and 90% passage dates for yearling chinook were April 17 and May 28, respectively. The dates for steelhead were April 26 and June 2, respectively. Both 90% passage dates were estimated following subtraction of 4,000 yearling chinook and 38,000 steelhead from the passage indices of June 2 and 3, to account for the fish recovered at The Dalles Dam from the barge release on May 30 below McNary Dam, which was due to the lock outage at John Day Dam resulting from the powerhouse fire.

By June 3, there was substantial overgeneration spill in the hydrosystem. Some of this spill was allocated to The Dalles Dam and, therefore, spill was not terminated on June 6. Instantaneous spill percentages were changed many times throughout the season to compensate for load factoring. The spill hours remained constant (2000-0400) while the amount of spill fluctuated both above and below

10% of daily average flow. The seasonal spill (the average of daily spill during the spring period) was 14.1%. When the amount of spill identified by BPA as overgeneration spill is subtracted, the seasonal spill averaged 8.6%.

A request was submitted to start the summer spill season subsequent to the cessation of overgeneration spill. The summer spill season extended from 2000 hours on June 7 and continued through 0400 hours on August 23. Smolt monitoring occurred throughout the season. It started by gatewell dipnetting, and was replaced on July 5 by a gatewell airlift system. It was not possible to develop reliable 10 and 90% passage dates for the subyearling chinook migration because of the extremely low numbers of fish captured. In addition, the impact to the passage index of switching to the airlift sample mid-season was unknown. The numbers of fish collected prior to the change were much higher than the numbers subsequent to the change. However, it is impossible to determine if the decrease was due to a decrease in the number of fish passing, or to change of equipment.

Since the 90% passage date of subyearling chinook at McNary Dam was similar to the median 90% passage date of past years, the assumption was made that the 90% passage date at The Dalles Dam would also be similar to the historical data. Therefore, it was decided to continue The Dalles spill program through the end date specified in the Agreement, so the summer spill program was

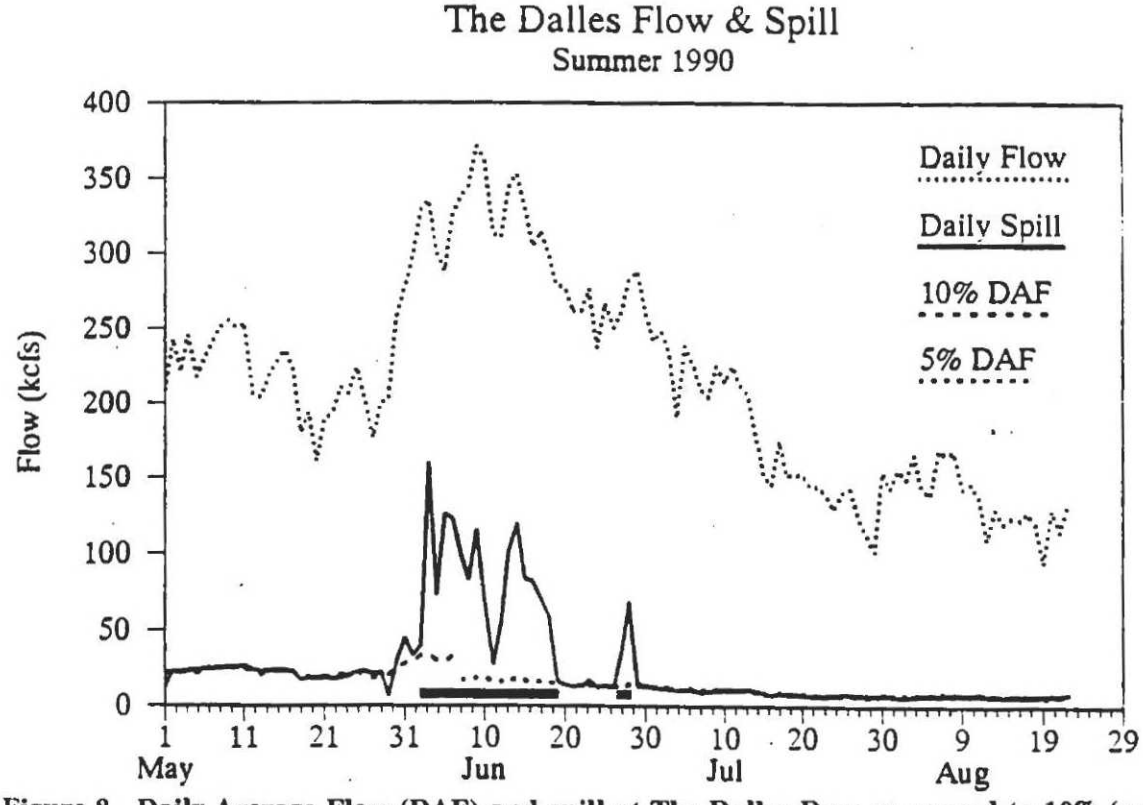

Figure 8. Daily Average Flow (DAF) and spill at The Dalles Dam compared to 10% (spring) and 5% (summer) of DAF. Less than 100% of spill is accountable as fish spill on days when spill was in excess of hydraulic capacity or was to avoid overgeneration.

terminated on August 23 at 0400 hours. Figure 8 compares the actual percent of daily average flow that was spill to the amount specified in the Agreement. The seasonal average spill was 10.2% with overgeneration spill, and 3.5% without overgeneration.

5. Spill at Bonneville Dam

On February 5, 1990 the CBFWA submitted to the COE a recommended operational plan for Bonneville Dam. The proposal for 1990 operations incorporated the criteria listed in the NPPC's 1987 Fish and Wildlife Program, which specifies an 85% fish passage efficiency (FPE) for juvenile fish passage at Bonneville. The CBFWA proposal established a reasonable interim objective of attaining a 70% FPE during the spring, and a 50% FPE during the summer. Based on values of weighted mean fish guidance efficiencies, the CBFWA proposal requested that, in addition to not operating the second powerhouse, 49% of daily average flow be spilled in the spring and 44% of instantaneous flow be spilled during the summer migration (Figure 9).

The COE responded to the February 5 letter on April 11 after receiving input from the power interest groups BPA, PNUCC and the NPPC. This letter stated that 1990 operations at Bonneville Dam would be consistent with constraints used in past years. The COE cited necessary violations of reservoir operating limits, and inability to serve notice to all entities having an interest in Bonneville Project operations, as reasons for denying the CBFWA requested operational plan for 1990.

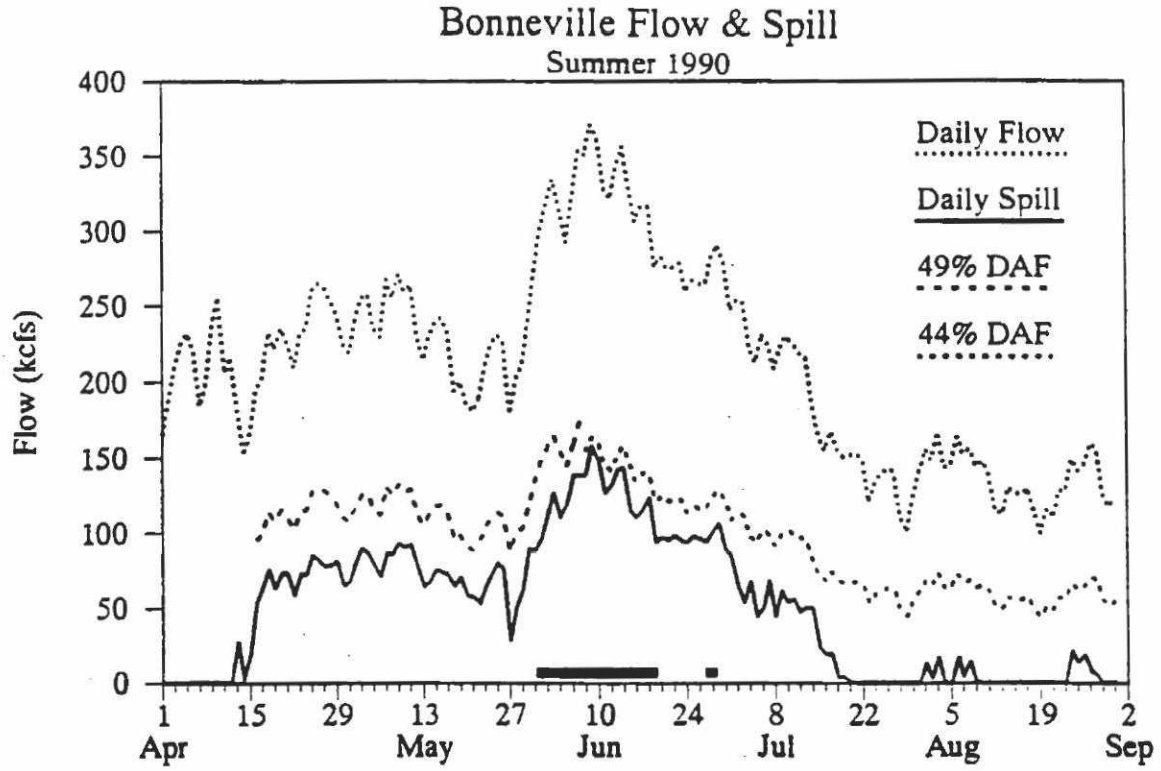

Figure 9. Daily Average Flow (DAF) and spill at Bonneville Dam compared to 49% (spring) and 44% (summer) of DAF. Less than 100% of spill is accountable as fish spill on days when spill was in excess of hydraulic capacity or was to avoid overgeneration.

Spill at Bonneville Dam averaged 24% of daily average flow through the spill season (April 13 through August 31) with overgeneration spill included, and 16.7% with overgeneration spill removed. During July and August when the CBFWA had requested that 44% of instantaneous flow be spilled, there were 28 days on which no spill occurred, and 7 days on which spill was less than 5 kcfs.

C. SUMMARY

The 1990 implementation of the Fish Spill Memorandum of Agreement was successful. All parties carried out the Agreement as written, and no deviations were made. The 1990 season saw more spill than was seen in 1989. Most of this spill came in the form of overgeneration spill and, therefore, the actual cost of the spill program was similar to the cost of 1989 spill.

Monitoring for spill management during 1990 did not generate the data needed for the in-season determination of 90% passage dates. This was partly due to project operation, such as the 100% spill at Lower Monumental Dam and the numerous outages of unit 5 (unit being sampled) at John Day Dam. There was also a change in the way the gatewell slot at The Dalles Dam was monitored.

Because of the high levels of spill that occurred in 1990, monitoring crews were alerted to note any evidence of "gas bubble" disease in the fish sampled. There were no reports of major injury to fish as a result of gas supersaturation. However, large numbers of sockeye, coho and steelhead exhibited symptoms of the disease, with the highest incidence recorded from the group of steelhead released from the barge above John Day Dam subsequent to the fire in the John Day powerhouse. These fish passed John Day Dam when 100% of the flow at the project was being spilled and dissolved gas levels reached 135% supersaturation.

Seasonal totals of flows and spill, including spill due to overgeneration, are listed in Table 7. The 1990 spill program at the four MOA projects resulted in a total of 663,691 MWH being spilled for fish. This total is very close to the total amount spilled for fish in 1989 (646,339 MWH). As stated in the beginning of this section, the primary problem with spill implementation in 1990 was developing a request for an instantaneous flow percentage based upon "after-the-fact" flow data. This information could be more easily provided or implemented by BPA.

Table 7. Seasonal totals of flow, spill, and spill due to overgeneration. (Data provided by PNUCC)

	MOA PROJECT	FLOW (ksfd)	SPILL (ksfd)	FISH SPILL (ksfd)
SPRING	IHR	2,703	382	339
	LMO	2,984	966	966
	TDA	8,690	1,228	746
SUMMER	IHR	2,920	602	175
	LMO	3,041	1,136	461
	TDA	15,793	1,617	546
	JDA	15,673	1,697	796
COMBINED	BVL	32,578	7,797	5,433