APPENDIX B

Final reports on chinook salmon spawning surveys - Sultan River, Washington

B-1. 1987 Report.

B-2. 1988 Report

APPENDIX B-1

Final report on 1987 chinook spawning survey -
Sultan River, Snohomish County, Washington

FINAL REPORT ON

1987 CHINOOK SPAWNING SURVEY

SULTAN RIVER, SNOHOMISH COUNTY, WASHINGTON

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Appendix B-1

INTRODUCTION

The Jackson Hydroelectric Project on the Sultan River in northwestern Washington was completed in 1984. The Sultan River and its tributaries are utilized for spawning and rearing by chinook, coho, pink, chum and steelhead salmon, sea-run cutthroat trout, and Dolly Varden. These anadromous salmonids utilize the area between the mouth of the Sultan River and the Everett Diversion Dam located at River Mile (RM) 9.7. The Everett Diversion Dam is the upstream limit of accessible spawning and rearing habitat.

Recognizing that certain flow regimes may create passage problems for adult fish migrating upstream past the powerhouse, the fish management agencies required mitigative steps by the owner/operator Public Utility District No.1 of Snohomish County (District). The key element for this mitigation is a low-head dam, referred to as the fish passage berm, installed at the upstream end of the powerhouse. A study of the fish passage berm's ability to facilitate the upstream migration of adult salmonids was initiated in the fall of 1984 (Parametrix, 1987). A portion of this study included comparing pre-project and post-project spawning distribution above and below the powerhouse.

Chinook spawning ground surveys have been conducted in 1984, 1985, and 1986 to determine spawner distribution in the Sultan River for the post-project operation period. The data from those surveys were compared to historical pre-project spawner distribution data (1978-80). Pre-project data were also collected in 1981 through 1983 but the data are not considered to be representative of the actual pre-project conditions. In 1981, the survey was conducted well after the peak in spawning activity and the 1982 and 1983 runs may have been affected by construction activity in the river channel.

The pre- and post-project comparisons have indicated less spawner use of the habitat upstream from the Jackson Project powerhouse during the post-project years (Parametrix, 1987). Surveys were conducted in 1987 to further document the post-project distribution of chinook salmon in the Sultan River.

METHODS

Two spawner surveys were conducted during the 1987 chinook spawning season. These surveys occurred on September 28 and October 2, 1987. The latter survey was a joint effort with the Washington Department of Fisheries. The survey methods followed those used in previous years. Three index areas were surveyed on foot in the section upstream from the powerhouse. These areas include the Diversion Dam reach, Gold Camp reach, and Chaplain Gage reach. One index reach downstream from the powerhouse (BPA powerlines, river mile 2.7 to mouth) was surveyed from a raft.

Of the 9.7 miles available to anadromous fish in the Sultan River, slightly less than one-half (4.2 miles) were surveyed. Counts of live chinook, dead chinook, and jacks were recorded. Counts of pink salmon spawners (live and dead) were also made during the surveys. These counts are presented in this document, but no analysis of the pink data are made. Pink salmon spawn principally in the lower 2.7 river miles below the river

crossing of the BPA powerlines, and, therefore, they are not a species involved in migratory passage past the powerhouse. Counts of chinook redds are not possible during years of pink spawning because of the inability to differentiate which species formed the redds.

In addition to maintaining fish counts, estimates of the percent visibility were made for each index area. The numbers of observed fish divided by the corresponding visibility factor for that reach provides an estimate of the fish present on the day of the survey. These adjusted data allow comparisons of index areas between years, regardless of viewing conditions. The ratios of lower river to upper river spawner distributions are used to compare pre-project and post-project years. Since the actual number of fish in a section is affected by run size as well as accessibility, a ratio is more appropriate for comparing distributions between pre- and post-project years than total counts. The occurrence of similar ratios is indicative of a naturally balanced habitat utilization for spawning as well as juvenile rearing. On the other hand, significant changes in the ratio between pre- and post-project years would indicate that the project is causing an imbalance in habitat utilization between the upstream and downstream reaches.

RESULTS

The results of the 1987 surveys are summarized in Table 1. There was a substantial increase in the number of fish observed in each index area on the October 2 survey, with the exception of the Gold Camp reach. Therefore, the data from the October 2 survey were used in subsequent comparisons with the previous years' spawning ground data.

Comparisons of the 1987 data with previous years' data were made using the raw counts expanded only for visibility. The comparisons are based on chi-square analysis. The data used in these analyses are summarized in Table 2. The post-project years (1984 - 1987) were compared amongst each other to determine if there was significant variation in the distribution of spawners during the post-project years. The result indicated there was significant variation ($p=.0041$) among the post-project years. This is likely due to the fact that in 1984 and 1985 the use of the area upstream from the powerhouse was very minimal compared to 1986 and 1987.

The 1987 distribution was compared against the distribution that occurred during the pre-project years (1978-1980). The result of this comparison indicates a significant difference ($p=.0004$) in the percentage of total fish using the upper spawning habitat in 1987 compared to the pre-project years. While the distribution in 1987 was more similar to pre-project conditions than other post-project years (1984 and 1985), a significant difference was still detected.

Although there has been a significant decrease in the proportion of fish returning to the Sultan River that use the upper spawning habitat in 1986 and 1987 compared to pre-project years, the actual escapement of adults to that area has been equivalent or better than pre-project years. In 1978-80 the estimated escapement (based on raw counts adjusted only for visibility) to the upper river was 32, 40, and 76, respectively. In 1986 and 1987 the escapement was 52 and 41, respectively.

Table 1. Summary of chinook spawning surveys in the Sultan River during 1987.

		Chinook			Pink	
Date	Visibility(%)	Live	Dead	Jacks	Live	Dead
		BPA Powerline to River Mouth (reach length = 2.7 miles)				
9/28	75	24	9	0	1,282	68
10/02	75	87	23	0	3,305	212
		Chaplain Gage (reach length = 0.6 miles)				
09/25	75	7	0	0	----[1]	----
10/02	80	15	5	0	-----	----
		Gold Camp (reach length = 0.4 miles)				
09/25	80	1	0	0	----	----
10/02	80	5	2	0	----	----
		Portal to Diversion Dam (reach length = 0.5 miles)				
10/02	80	6	0	0	----	----

[1]Pink salmon use of Sultan River limited to lower reach.

Table 2. Summary of chinook spawner counts, adjusted for visibility, used in pre-project and post-project distribution comparisons.

Year[1]	Above Power-house	Visibility	Above Adjusted	Below Power-house	Visibility	Below Adjusted
1978	30	.95	32	65	.85	76
1979	38	.95	40	60	.75	80
1980	61	.80	76	93	.95	98
1982[2]	35	.90	39	44	.80	55
1983[2]	21	.50	42	53	.50	106
1984	11	.90	12	92	.90	102
1985	4	.80	5	38	.85	45
1986	45	.90/.85	51	139	.90	154
1987	33	.80	41	110	.75	147

[1]Data from 1981 are excluded because the survey occurred sufficiently past the peak in spawning activity and may not be representative of that years' run.

[2]1982 and 1983 data are presented but were not used as pre-project years in the statistical analysis because the river channel (at the powerhouse) was disrupted by construction activity.

STREAMFLOW AND POWER GENERATION

Natural streamflows were unusually low in the Pacific Northwest during the summer-fall, 1987. Consequently, a large proportion of instream flow in the Sultan River was provided by release of reservoir stored water. Project discharges (calculated) to the river at the Diversion Dam averaged 114 cubic feet/second (cfs) in September and 109 cfs in October or roughly 70 percent of total instream flow at the Diversion Dam. At the powerhouse with added direct discharge to meet a higher instream flow requirement the project's flow augmentation share of total stream flow increased to 80 percent. Although natural flows were not calculated, that flow would have been much lower without project discharge since reservoir storage continued to decline steadily during September/October, indicating that withdrawals were exceeding upstream inflows into the reservoir. Project operation (power generation) was limited to and determined totally by meeting the City of Everett municipal and industrial water demand and minimum flow requirements.

During September-October, 1987 the direct discharge to the Sultan River at the powerhouse was either 39 or 53 cfs or 15 to 26 percent of total instream flow. The Pelton turbines operated to provide augmentation flow to meet minimum instream flow requirements. Operation/discharge alternated between the two Pelton units during September and October (Table 3).

Table 3. Jackson Project Pelton turbine operating/water discharge record during September-October 1987.

Day (Month)	Unit No. 1 (cfs)	Unit No. 2 (cfs)	Instream Flow Below Powerhouse[1] (cfs)
(Sept.)			
1-14	39	0	176-197
15-17	39	0	225-260[2]
17-25	53	0	202-225
25-30	0	53	208-247
(Oct.)			
1-8	0	53	214-228
8-14	53	0	225-228
14-19	0	53	225
19-30	53	0	219-225

[1]PUD records. Flow range.
[2]All in-stream flow increase provided initially at Diversion Dam.

APPENDIX B-2

Final report on 1988 chinook spawning survey -
Sultan River, Snohomish County, Washington

FINAL REPORT ON

1988 CHINOOK SPAWNING SURVEY

SULTAN RIVER, SNOHOMISH COUNTY, WASHINGTON

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INTRODUCTION

The Jackson Hydroelectric Project on the Sultan River in northwestern Washington was completed in 1984. The Sultan River and its tributaries are utilized for spawning and rearing by chinook, coho, pink, chum, and steelhead salmon, and sea-run cutthroat trout, and Dolly Varden. These anadromous salmonids utilize the area between the mouth of the Sultan River and the Everett Diversion Dam River Mile (RM) 9.7. The Everett Diversion Dam is the upstream limit of accessible spawning and rearing habitat.

Recognizing that certain flow regimes may create passage problems for adult fish migrating upstream past the powerhouse, the fish management agencies required mitigative steps by the owner/operator Public Utility District No.1 of Snohomish County (District). The key element for this mitigation is a low-head dam, referred to as the fish passage berm, installed at the upstream end of the powerhouse. A study of the berm's ability to facilitate the upstream migration of adult salmonids was initiated in the fall of 1984 (Parametrix, 1987). A portion of this study included comparing pre-project and post-project spawning distributions upstream and downstream from the powerhouse.

Chinook spawning ground surveys have been conducted in 1984, 1985, 1986, and 1987 to determine spawner distribution in the Sultan River for the post-project operation period. The data from those surveys were compared to historical pre-project spawner distribution data (1978-80). Pre-project data were also collected in 1981 through 1983 but the data are not considered to be representative of the actual pre-project conditions. In 1981, the survey was conducted well after the peak in spawning activity and the 1982 and 1983 runs may have been affected by construction activity in the river channel.

The pre- and post-project comparisons have indicated less spawner use of the habitat upstream from the Jackson Project powerhouse during the post-project years (Parametrix, 1987). Surveys were conducted in 1988 to further document the post-project distribution of chinook salmon in the Sultan River.

METHODS

A spawner survey was conducted on September 30, 1988. The survey was a joint effort with the Washington Department of Fisheries. The survey methods followed those used in previous years. Three index areas were surveyed on foot in the section upstream from the powerhouse. These areas included the Diversion Dam reach, Gold Camp reach, and Chaplain Gage reach. One index reach downstream from the powerhouse (BPA powerlines, river mile 2.7 to mouth) was surveyed from a raft.

Of the 9.7 miles available to anadromous fish, slightly less than one-half (4.2 miles) was surveyed. Counts of live chinook, dead chinook, chinook jacks and visible redds were recorded. In addition to maintaining fish and redd counts, estimates of the percent visibility were made for each index area. The numbers of observed fish divided by the corresponding visibility factor for that reach provides an estimate of the fish present on the day of the survey. These adjusted fish numbers are used for comparisons with the numbers from pre-project years.

The ratios of lower river to upper river spawner distributions were used to compare pre-project and post-project years. Since the actual number of fish in a section is affected by run size as well as accessibility, a ratio is more appropriate for comparing distributions from year to year than total counts. The occurrence of similar ratios is indicative of a naturally balanced habitat utilization for spawning as well as juvenile rearing. On the other hand, significant changes in the ratio between pre- and post-project years would indicate that the project is causing an imbalance in habitat utilization between the upstream and downstream reaches.

The number of jacks and redds are reported in this document but are not used for comparative purposes with previous years. This is because of the high variability in the numbers of jacks from year to year, and their inclusion biases the number of spawning pairs toward the high side. This bias occurs because there is not a corresponding number of precocious females in the spawning population to mate with them. Therefore, the male to female ratio is higher than the 1:1 assumption typically used.

As with the jack counts, redd counts are also not used for comparative purposes. Comparing total redd counts above and below the powerhouse is inappropriate because of the problem of differentiating chinook salmon redds from pink salmon redds. Since pink salmon spawn principally in the lower 2.7 river miles below the river crossing of the BPA powerlines this problem would bias only the lower river redd counts. This differentiation problem also makes any year to year comparisons of redd counts impossible because pink salmon spawn only in odd numbered years.

RESULTS

The results of the 1988 survey are summarized in Table 1. There were substantially higher numbers of fish observed in the index areas above the powerhouse compared to previous post-project surveys. Comparisons of the 1988 data with previous years' data were made using the raw counts expanded only for visibility in a chi-square analysis (Table 2).

The post-project years (1984 - 1988) were compared amongst each other to determine if there was significant variation in the distribution of spawners during the post-project years. The result indicated there was significant variation ($p < .0000$) among the post-project years. This is likely due to the fact that in 1984, and 1985 the use of the area upstream from the powerhouse was very minimal compared to other post-project years.

The 1988 distribution was compared against the distribution that occurred during the pre-project years (1978-1980). The result of this comparison indicates a significant difference ($p = .032$) when tested at the $\alpha = .05$ level. Despite the statistically significant difference, the distribution in 1988 was more similar to pre-project conditions than other post-project years. In fact, at a slightly lower alpha level ($\alpha = 0.1$) the difference would not be significant.

Although there has been a significant decrease in the proportion of fish returning to the Sultan River that use the upper spawning habitat in 1986-88 compared to pre-project

years, the total number of adults to that area has been equivalent or better than pre-project years (Table 2). In 1978-80 the estimated number of adults observed in the upper river (based on raw counts adjusted only for visibility) was 32, 40, and 76, respectively. In 1986-88 the numbers were 52, 41, and 108 respectively. The 1988 survey had the highest numbers of fish observed (236) and the highest proportion of fish above the powerhouse (.458) of any previous survey year (either pre- or post-project).

Table 1. Summary of chinook spawning surveys in the Sultan River during 1988.

	Chinook			
Visibility(%)	Live	Dead	Jacks	Redds
	BPA Powerline to River Mouth (reach length = 2.7 miles)			
85	93	16	0	54
	Chaplain Gage (reach length = 0.6 miles)			
85	32	3	2	13
	Gold Camp (reach length = 0.4 miles)			
90	37	3	2	12
	Portal to Diversion Dam (reach length = 0.5 miles)			
75	16	0	1	7

Table 2. Summary of chinook spawner counts, adjusted for visibility, used in pre-project and post-project distribution comparisons.

Year[1]	Above Power-house	Visibility	Above Adjusted	Below Power-house	Visibility	Below Adjusted
1978	30	.95	32	65	.85	76
1979	38	.95	40	60	.75	80
1980	61	.80	76	93	.95	98
1982[2]	35	.90	39	44	.80	55
1983[2]	21	.50	42	53	.50	106
1984	11	.90	12	92	.90	102
1985	4	.80	5	38	.85	45
1986	45	.90/.85	51	139	.90	154
1987	33	.80	41	110	.75	147
1988	92	.90/.85	108	139	.85	128

[1]Data from 1981 are excluded because the survey occurred sufficiently past the peak in spawning activity and may not be representative of that years' run.

[2]1982 and 1983 data are presented but were not used as pre-project years in the statistical analysis because the river channel (at the powerhouse) was disrupted by construction activity.

STREAMFLOW AND POWER GENERATION

During the month of September the powerhouse discharge contribution accounted for 25 percent of the instream flow below the project. This powerhouse contribution increased to 76 percent in October. The mean instream flow below the powerhouse during September and October was 250 and 920 cfs, respectively.

The powerhouse operation provided augmentation flow to meet minimum instream flow requirements. Operation/discharge alternated between the two Pelton turbine units during September with Unit 1 running 80 percent of the time (Table 3). During October, Unit 1 ran 100 percent of the time and Unit 2 only 50 percent (Oct. 15-31).

Higher instream flows in October were due to heavy rainfall. Surface runoff increases and higher power plant releases for reservoir drawdown occurred in the second half of October. Project operation scheduling and Sultan River instream flows were discussed with fishery agencies at that time (See District letter PUD-18033 of October 10,1988 to the agencies).

Table 3. Jackson Project Pelton turbine operating/water discharge record during 1988

Day (Month)	Unit No. 1 (cfs)	Unit No. 2 (cfs)	Average Instream Flow Below Powerhouse[1] (cfs)
(Sept.)			
1-10	69	0	207
11-16	0	61	213
17-30	62	0	289
(Oct.)			
1-14	141	0	331
15-31	588	576	1494

[1]PUD records. Average flow rate.