2004 Evaluation of Juvenile Fall Chinook Salmon Entrapment in the Hanford Reach of the Columbia River

Paul Hoffarth

Washington Department of Fish and Wildlife

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Background

The Hanford Reach stretches from Priest Rapids Dam 82 kilometers downstream to Richland, Washington (Figure 1). The topography, river dynamics, and climate of the area create a unique habitat for wildlife and fish populations. The Hanford Reach supports the larger of the only two remaining healthy naturally spawning fall chinook salmon (*Oncorhynchus tshawytscha*) populations in the Columbia River System (Huntington et al.1996). This population is a primary source of ocean and freshwater sport, commercial, and in-river tribal fisheries (Dauble and Watson 1997) and is a primary component of the Pacific Salmon Treaty between the United States and Canada. River flows for this section of the Columbia River are controlled by discharge from Priest Rapids Dam. Flow fluctuations from Priest Rapids Dam can occur rapidly due to changes in hydroelectric power generation, irrigation, water storage, and flood control. These fluctuations have been observed to cause stranding and entrapment of juvenile fall chinook salmon on gently sloped banks, gravel bars, and in pothole depressions in the Hanford Reach area of the Columbia River (Page 1976, Becker et al. 1981, DeVore 1988, Geist 1989, Wagner 1995, Ocker 1996, Wagner et al. 1999, Nugent et al. 2001a and 2001b).

Stranding of juvenile fall chinook salmon occurs when the fish are trapped on or beneath the unwatered substrate as the river level recedes. Entrapment occurs when the fish are separated from the main river channel in depressions as the river level recedes. Fish mortality in entrapments occurs from stranding, thermal stress, and piscivorous, avian, and mammalian predation.

The impact of river fluctuations due to operation of hydroelectric facilities on rearing salmonids has been assessed on numerous Columbia River tributaries and other river systems (Thompson 1970, Witty and Thompson 1974, Phinney 1974a and 1974b, Bauersfeld 1978, Tipping et al. 1978 and 1979, Becker et al. 1981, Woodin 1984, and Beck 1989) but limited research has been conducted on the Hanford Reach prior to 1997. In 1997, the Washington Department of Fish and Wildlife (WDFW) was contracted through the Bonneville Power Administration (BPA) and the Grant County Public Utility District (GCPUD) to perform an evaluation of juvenile fall chinook salmon stranding on the Hanford Reach. The multi-year study was developed to assess the impacts of water fluctuations from Priest Rapids Dam on rearing juvenile fall chinook salmon, other fishes, and benthic macroinvertebrates of the Hanford Reach and for directing the future management of flows from Priest Rapids Dam.

The Army Corps of Engineers was contracted in August 1998 to collect detailed bathymetry data on 35.1 km^2 of the Hanford Reach from Rkm 571.3 to Rkm 606.9 using Scanning Hydrographic Operational Airborne Lidar Survey (SHOALS). This data was used in conjunction with the Modular Aquatic Simulation System 1D (MASS1) unsteady flow model to provide information on the Hanford Reach at a range of stage discharges. From this information, the extent of area of shoreline exposed by flow fluctuations and the configuration of the river channel could be determined. A sampling plan was designed by Pacific Northwest National Lab (PNNL) and WDFW prior to the 1999 field season to estimate the total number of juvenile fall chinook salmon killed or placed at risk due to flow fluctuations. The study area was confined to the portion of the Hanford Reach defined by the SHOALS bathymetry data at river elevations corresponding to Priest Rapids discharges from 40 kcfs to 400 kcfs.

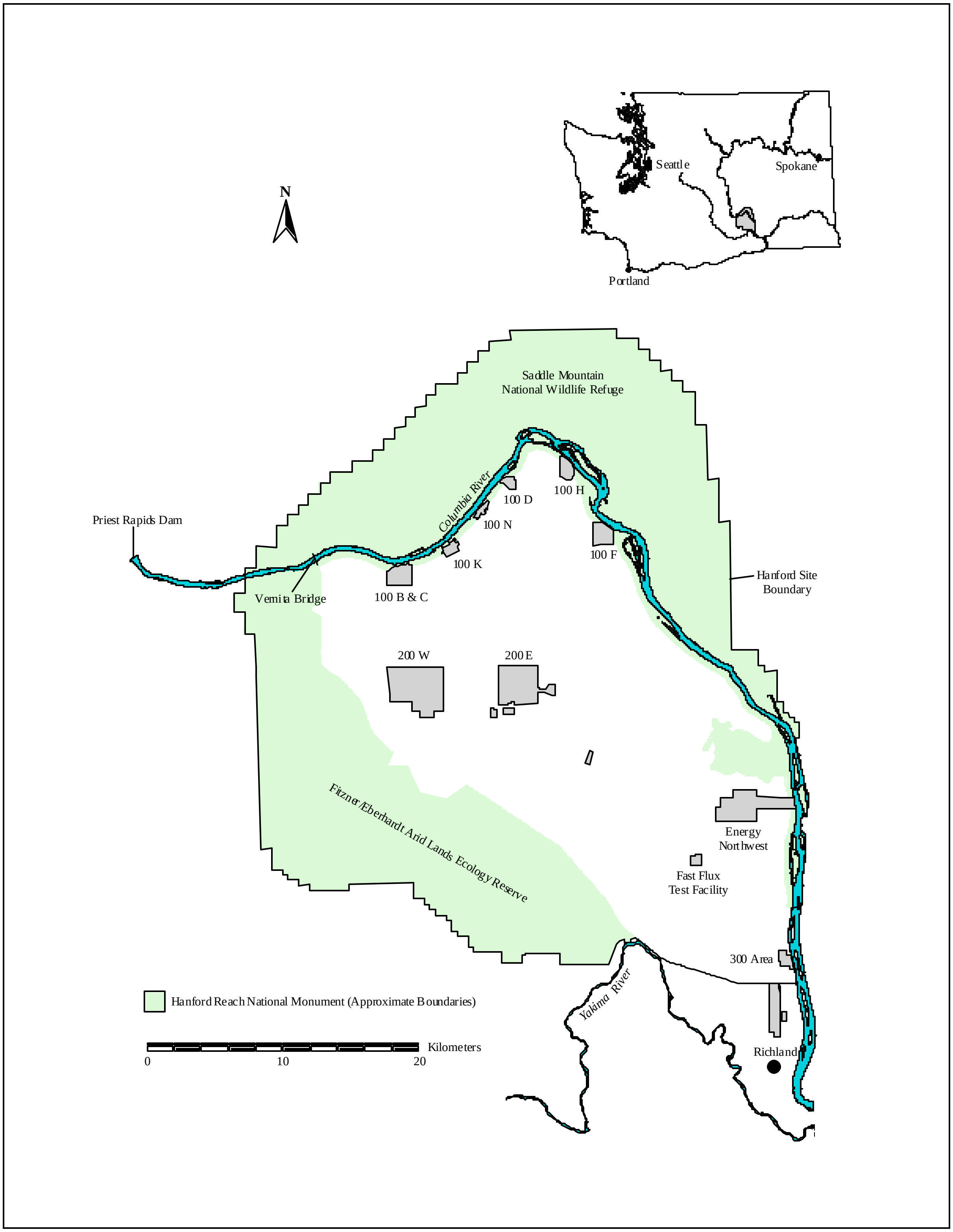

Figure 1. Hanford Reach area of the Columbia River.

The study area was stratified into 40 kcfs flow bands and divided into 3600 ft^2 (344.4 m^2) plots or sampling cells. The sample plot size was based on the mean size of entrapments found in 1998. A list of all cells contained within the study area was compiled and cells were randomly selected to use in daily field sampling activities. Daily sampling targeted random sampling locations within wetted flow bands identified in the previous 48-hour flow history. If entrapments were encountered, an assessment was made to determine the percentage of the entrapment contained within the sample plot. Entrapments with area of 50% or greater within the circle were sampled in their entirety. Entrapments with area of greater than 50% outside of the circle were not surveyed.

Evaluations were conducted within the 21-mile study area for the two following years, 2000 and 2001. In 2002 and 2003, the study area was reduced to an 8-mile section (15.7 km^2) of the Hanford Reach from Rkm 584.5 to Rkm 600.2 (Locke Island to Hanford Townsite). Sampling in the reduced study area would continue to provide in-season monitoring of impacts to juvenile fall chinook and a mortality and at risk estimate could be generated using only one two-person crew. Mean mortality and "at risk"[1] estimates generated though the random sampling method ranged from a low of 45,487 mortalities in 2000 to 2,013,638 mortalities in 2001 (Table 1).

Table 1. Estimated annual impacts (mortality and at risk) to juvenile fall chinook in the Hanford Reach, 1999-2003.

2003	Mean	Mean - 1.96 S.E.	Mean + 1.96 S.E.
Morts	154,853	83,903	225,802
Rev Morts	154,853	83,903	225,802
At Risk	164,643	91,093	238,192
2002	Mean	Mean - 1.96 S.E.	Mean + 1.96 S.E.
Morts	67,409	28,623	106,195
Rev Morts	70,903	31,517	110,288
At Risk	144,249	28,813	259,685
2001	Mean	Mean - 1.96 S.E.	Mean + 1.96 S.E.
Morts	2,013,638	-746,334	4,773,611
Rev Morts	2,013,638	-746,334	4,773,611
At Risk	2,013,638	-746,334	4,773,611
2000	Mean	Mean - 1.96 S.E.	Mean + 1.96 S.E.
Morts	45,487	12,866	78,108
Rev Morts	192,824	-70,865	456,514
At Risk	199,534	-64,234	463,302
1999	Mean	Mean - 1.96 S.E.	Mean + 1.96 S.E.
Morts	93,943	21,393	166,493
Rev Morts	NA	NA	NA
At Risk	320,650	-54,006	695,307

(Chris Murray, Pacific Northwest National Laboratory, July 2003)

[1] Juvenile fall chinook found alive in entrapments were categorized as "at risk" as these entrapments were subject to draining, lethal temperatures, or reflooding.

Comparisons of loss estimates of juvenile fall chinook by river elevation indicate that flow fluctuations at lower flow bands (<120 kcfs) present the highest risk for stranding and entrapment. Hourly flow fluctuations in low flow years such as 2001 have been shown to produce significant mortality impacts on emerging and rearing fall chinook. Large flats or flood terraces exposed at lower flows (40-120 kcfs) pose the greatest threat of stranding and entrapment to juvenile fall chinook on the Hanford Reach (Figure 2). The highest concentrations of stranding and entrapment of juvenile fall chinook salmon observed within the study area occur at island complex areas such as Locke Island/White Bluffs Slough Area (596-602 Rkm) and 100 F Islands (588-593 Rkm). These areas with their large and varied shorelines and diverse shallow water areas appear to provide excellent rearing habitat as well as high stranding potential.

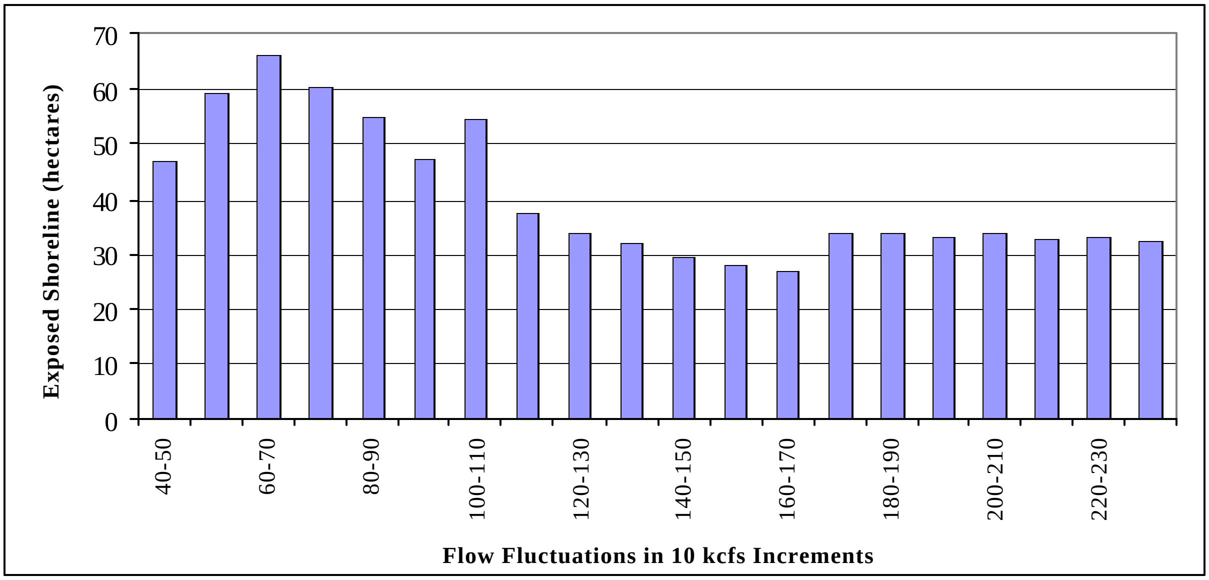

Figure 2. The area of shoreline exposed within 10 kcfs flow bands for a portion of the Hanford Reach of the Columbia River from Rkm 571.3 to 606.9.

These findings have led to the development of a protection plan for emerging and rearing juvenile fall chinook that imposes tighter restrictions on daily flow fluctuations for Priest Rapids Dam at lower flows and allows increased operational flexibility at higher flows. The combination of very high spawning escapements of fall chinook in 2003 and expected low flows in the Columbia River during emergence and rearing in 2004 provided optimum conditions for evaluating entrapment due to fluctuations in discharge from Priest Rapids Dam.

In 2003, a second study was completed focusing directly on mortality resulting from the formation of entrapments along unwatered shorelines. The entrapment evaluation was able to assess impacts throughout the Hanford Reach. The final report for the 2003 Assessment of Losses of Juvenile Fall Chinook in the Hanford Reach has not been completed as of August 2004 but should be available through Columbia River Inter-Tribal Fish Commission by January, 2005.

2004 Monitoring and Evaluation

Funding was made available through Alaskan Fisheries to conduct entrapment monitoring during the 2004 emergence and rearing period for fall chinook in the Hanford Reach. Monitoring did not begin until April 24, well after the estimated start of emergence.

Study Objectives

1. Evaluate impacts to juvenile fall chinook in the Hanford Reach as a result of hydropower operations during the period of emergence and rearing in 2004 for use in in-season management.
2. To collect information on the location, frequency, and number of chinook observed in entrapments for comparison to the 2003 evaluation.
3. To evaluate the effectiveness of the Hanford Juvenile Fall Chinook Protection Plan in improving survival of fall chinook in the Hanford Reach during emergence and rearing.

Methods

The Hanford Reach encompasses the free flowing stretch of the Columbia River from Priest Rapids Dam to Richland, Washington. The magnitude and duration of reductions in discharge from Priest Rapids Dam directly affects river elevations downstream of the Project (Figure 3). Fluctuations in river elevation downstream of Priest Rapids Dam are dampened by channel configuration and bank storage. Translation time of fluctuations downstream is determined by a variety of factors that may include river configuration, bank storage, and magnitude and duration of the fluctuation. Reductions that are of higher magnitude and longer duration will have the largest impacts to fall chinook throughout the Reach. Large reductions in discharge over a short duration will primarily affect areas immediately downstream of the Project. As the river reaches the White Bluffs area, the McNary Dam forebay elevation has increased influence on river elevation and reduces the effects of hydroelectric operations from Priest Rapids Dam.

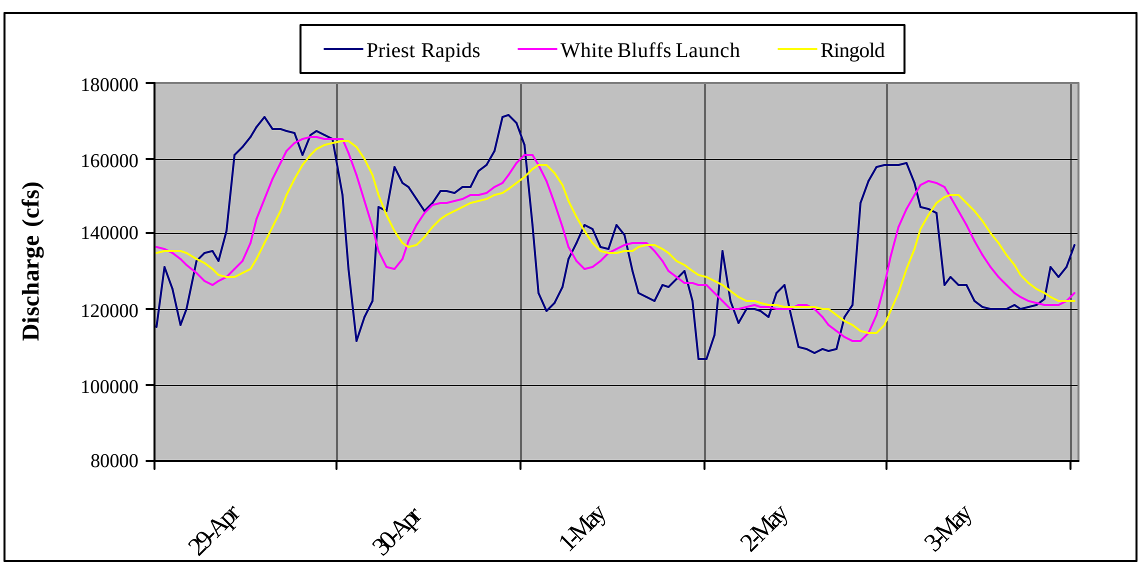

Figure 3. Hourly flow in the Hanford Reach below Priest Rapids Dam, and in the White Bluffs and Ringold areas, April 29 – May 3, 2003.

Previous evaluations of stranding and entrapment mortality were limited to the 21-mile area for which detailed bathymetry was available and focused on dewatered areas that could be sampled between 9:00 am and 3:00 pm. The 21-mile study area was used as an indicator of the effects of hydroelectric operations on the Hanford Reach. In 2003 and 2004, monitoring was conducted from Priest Rapids Dam to Richland to ascertain if impacts in the original study area were representative of impacts Reach-wide. The study focused on impacts to chinook isolated in pools separated from the river during reductions in discharge (entrapments).

All known locations[2] containing large numbers of pools formed by the reduction of discharge from Priest Rapids Dam within the Hanford Reach were designated as part of the study area for this evaluation.

To obtain information on fall chinook entrapment and mortality throughout the Reach under all operational changes in discharge, the study area was stratified into three reaches. Each reach contained sampling sites that would be subject to river elevation changes of similar magnitude and timing.

Vernita - Priest Rapids Dam (RM 397) to Locke Island (RM 373), 27 sampling sites
Hanford[3] - Locke Island to Hanford Slough (RM 363), 24 sampling sites
Richland – Hanford Slough to Howard Amon Park (RM 338), 30 sampling sites

A total of 81 sampling sites were identified prior to the start of field sampling. Using a random number generator, the sites within each reach were randomly ordered and listed at the beginning of the study. The reach sampled on each day was selected based on current flow events and the specific location sampled within the reach was selected from the random list. The location was consequently crossed off the list. Only reaches affected by a given fluctuation event were sampled, thus, sampling may be concentrated in upstream reaches when fluctuations were too small to affect downstream areas or sampling may be distributed among all reaches when events are large.

Staff for sampling in 2004 consisted of two two-man crews working four days per week. One crew per day was scheduled to work from Tuesday to Friday and two crews were scheduled for each weekend day. At the site, field crews recorded the GPS coordinates at the center of each pool sampled and recorded the length, width, and maximum depth. An entrapment was designated as an isolated pool with a minimum wetted surface area of one meter. If no entrapments were present at the designated site, crews moved to the closest adjacent site. Visual observations of fish presence, drainage, and re-inundation by the river were also recorded. Fish were collected from entrapments by beach seining or back pack electrofishing.

[2] Previous stranding/entrapment studies and fall chinook stock assessment surveys had identified areas where large numbers of isolated pools typically formed during reductions in discharge
[3] The Hanford section of the Reach designated in this study is the same study area surveyed for the estimation of mortalities by the Hanford Stranding Study funded through GCPUD. This will allow direct comparison of impacts between studies.

Hanford Reach Fall Chinook Protection Plan

The Vernita Bar Agreement provided protection for incubating and emerging fall chinook in the Hanford Reach by maintaining sufficient discharge from Priest Rapids Dam to prevent desiccation of eggs and hatching fry but did not provide protection or enhance survival of emergent and rearing fry. The Hanford Reach Stranding Policy Group met annually to develop and refine an interim protection plan to protect emergent and rearing juvenile fall chinook salmon in the Hanford Reach area of the Columbia River. In 2004, a comprehensive plan to enhance fall chinook survival was established by Grant County PUD and approved by WDFW and NOAA Fisheries (Hanford Reach Fall Chinook Protection Program, Appendix A).

During the emergence and rearing period, the protection plan sets criteria for the magnitude of daily fluctuations in discharge from Priest Rapids Dam (Table 2). Due to the variability in power demand, water withdrawal (irrigation and urban), and weather events, precise prediction of daily average discharge at Priest Rapids Dam cannot be determined. Flow constraints are based on prior daily inflow[4] to Wanapum Dam and BPA forecasted weekend flows for Chief Joseph including side flows. Under the criteria adopted in 2004, protection of emergent fry would begin at the estimated start of emergence and continue to be in effect until 400 temperature units (°C) had accumulated following the end of emergence. Estimated start of emergence during the last five years has begun as early as February 20 (2003) and as late as April 1 (2001). The period of emergence (start of emergence through end of emergence) has lasted from 40 days (2001 and 2002) to 67 days in 2003 (Table 3). Project operational constraints established through the Plan during the emergence and rearing period were in effect for a period of 76 to 99 days during the past three years (2002 - 2004).

Table 2. Daily operational constraints established for the Hanford Reach Fall Chinook Protection Program.

Wanapum Weekday Inflow/ Chief Joseph Weekend Forecast	**Operational Flow Constraint**[1]
36 kcfs - 80 kcfs	Limit daily flow fluctuation to ? 20 kcfs
80 kcfs - 110 kcfs	Limit daily flow fluctuation to ? 30 kcfs
110 kcfs - 140 kcfs	Limit daily flow fluctuation to ? 40 kcfs
140 kcfs - 170 kcfs	Limit daily flow fluctuation to ? 60 kcfs
Greater than 170 kcfs	150 kcfs minimum hourly discharge at PRD

[1] Daily flow fluctuation (max-min) was calculated during the period from 1:00 am to midnight of each day.

[4] "Previous Day's Average Weekday Wanapum Inflow" – the total volume of water discharged into the Wanapum development measured as a daily average discharge from Rock Island Dam. This measure is used from Monday to Friday to determine the allowable flow fluctuation during the Rearing Period and will be calculated based on data available to Grant that is reported on the Corps of Engineers website [http://nwd-wc.usace.army.mil/report/projdata.htm].

Table 3**.** Summary of emergence timing and chinook presence in nearshore areas and encountered in random sampling, 1999 – 2004.

Year	**Estimated Emergence**		**Protection Plan**	
	Start	End	Start	End
2004	March 21	May 10	March 21	June 12
2003	Feb 20	April 27	Feb 28	June 5
2002	March 17	April 25	March 21	June 4
2001	April 1	May 10	March 26	June 10
2000	March 20	May 2	March 21	June 26
1999	March 8	May 11	March 10	June 30

Fall Chinook Salmon Fry Production Estimate

Fall chinook fry production in the Hanford Reach was calculated to provide a rough estimate of the population affected by flow fluctuations from Priest Rapids Dam. Fall chinook fry production in the Hanford Reach in 2004 was estimated between 17.9 and 60.0 million emergent fry (Table 4). With record numbers of fall chinook returns in 2003, up to 201 million eggs could have potentially been deposited in the Hanford Reach during the fall chinook spawn. The 2004 production estimates were based on 2003 Hanford Reach adult fall chinook escapement, female composition of the escapement, fecundity of hatchery fall chinook salmon at Priest Rapids Hatchery, egg retention of fall chinook salmon in the Hanford Reach, and an egg to emergence survival rate of 30% (Healey 1998). An additional fry estimate was produced using aerial redd counts for fall chinook in the Hanford Reach conducted by PNNL.

Table 4. Calculation of the 1999-2003 fall chinook salmon fry production estimate for the Hanford Reach of the Columbia River.

	Emergence Year				
Method 1	**2004**	**2003**	**2002**	**2001**	**2000**
Adult Fall Chinook Escapement	89,312	69,117	44,140	36,027	27,012
Female (%)	50.9%	40.4%	36.5%	54%	46%
Fecundity	4,422	4,003	4,418	4,794	4,371
# of spawning females	45,460	27,923	16,111	19,455	12,426
Potential eggs	201,023,271	111,776,842	71,178,840	93,265,257	54,311,948
Egg Retention	0.50%	0.50%	0.50%	0.50%	0.50%
Total eggs deposited	200,018,155	111,217,958	70,822,946	92,798,930	54,040,388
Egg to fry survival @ 30%	**60,005,446**	**33,365,387**	**21,246,884**	**27,839,679**	**16,212,116**
Method 2					
PNNL Aerial Redd count	9,465	8,041	6,248	5,507	6,086
Expansion (70% of redds observed)	13,521	11,487	8,926	7,867	8,694
Fecundity	4,422	4,003	4,418	4,794	4,371
Potential eggs	59,791,757	45,983,033	39,433,806	37,715,083	38,002,723
Egg to fry survival @ 30%	**17,937,527**	**13,794,910**	**11,830,142**	**11,314,525**	**11,400,817**
Mean of Two Estimates	**38,971,487**	**23,580,149**	**16,538,513**	**19,577,102**	**13,806,467**

Fall chinook escapement and harvest in the Hanford Reach are calculated annually by WDFW. The total fall chinook escapement for the Hanford Reach in 2003 was estimated at 100,840, with an adult escapement of 89,312 salmon (Appendix B). This was the fourth largest adult escapement recorded dating back to 1964. Of the 1,442 adult chinook sampled during the 2002 Hanford Reach fall chinook sport fishery, the female composition was 40.4%. Fecundity rates have not been determined for naturally spawning fall chinook salmon in the Hanford Reach. For this estimate, fecundity estimates of fall chinook salmon sampled at Priest Rapids Hatchery (PRH) were used. In 2003, fall chinook returning to PRH had an estimated 4,422 eggs per female. No studies have been conducted on egg to emergence/fry/smolt survival for naturally spawning fall chinook salmon in the Hanford Reach. Healey (1998) reported under natural conditions, 30% or less of the potential eggs deposited resulted in emergent fry or fry and fingerling migrants in the systems studied. For purposes of this estimate, an egg to fry survival rate of 30% was used.

A second estimate of fry production was produced using aerial redd counts from PNNL, fecundity from Priest Rapids Hatchery, and an egg to emergent fry survival rate of 30%. Peak redd counts for the Hanford Reach in 2003 was 9,465 (memo, PNNL). For purposes of this estimate the redd count was expanded using an assumed visibility of 70% of the total redd production. Increased escapement of fall chinook into the Hanford Reach in 2003 led to high densities of redds located in the high use areas and redd counts may have been conservative due to superimposition of redds. Expanded redd counts were estimated at 13,521 redds with a fecundity of 4,422 eggs per female, and an egg to fry survival rate of 30%.

Hatchery releases of subyearling chinook into the Hanford Reach and Yakima River for the period from 1999 to 2004 have varied from 10.9 to 12.3 million annually. Subyearling chinook passage indices for McNary Dam for the same years have ranged from 7.6 to 10.8 million. These numbers would indicate significant mortality occurs to fall chinook for both hatchery and wild fish. Hatchery released juvenile fall chinook are typically of sufficient size (>60 mm) that it is unlikely significant mortality would occur from fluctuations from hydroelectric operations at Priest Rapids Dam.

Assessment of Juvenile Fall Chinook Salmon Relative Abundance and Fish Size

Juvenile fall chinook salmon were seined from six nearshore sampling sites within the Hanford Reach once a week during the emergence and rearing period to assess relative abundance and fish size. The six sites were dispersed throughout the Hanford Reach from Vernita Bar (RM 395) to Savage Island (RM 356) (Table 5). Seining techniques were similar to methods described by Key et al. (1994). A beach seine, 21.3 m x 1.8 m with a 1.8 m^2 bag, 4.8 mm diamond mesh, and 15.2 m leads, was used to collect juvenile fall chinook salmon and other fish species from the designated nearshore sampling sites. The 21.3 meter net was deployed parallel to the shoreline at a distance of 15.2 meters. The area sampled in this manner was approximately 320 m^3.

When samples contained less than 100 juvenile fall chinook, all fish were anesthetized with tricaine methanesulfonate (MS 222), measured, and fork lengths recorded. If samples had over

100 chinook, but less than 1,000, all fish were counted and fork lengths on a subsample of 100 chinook were recorded. When seine captures exceeded 1,000 fish, chinook were sub-sampled to estimate total numbers and obtain length frequency information. Sub-sampling was necessary to reduce holding time and stress. Sub-sampling protocol consisted of counting one net of fish removed from the holding pen and returning two nets of fish to the river. The count was then expanded to estimate the total number of fish. All fish were released back into the river after sampling. River temperature, slope, and velocity were recorded for each site.

Table 5. Nearshore sites used to determine relative abundance and length frequency of fall chinook in the Hanford Reach.

Site #	Location	River Mile
1	Vernita Bar	393
2	Coyote Rapids	385
3	Island #2	375
4	DOE ferry landing	370
5	Hanford Townsite	363
6	Savage Island	356

Results

Implementation Timing and Operation of the Hanford Reach Fall Chinook Salmon Protection Program

Emergence timing during the last six years has begun as early as February 20 (2003) and as late as April 1 (2001). The period of emergence for the last six years as calculated under the Vernita Bar Agreement, 1,000 accumulated temperature units Celcius (ATU) from the initiation of spawning to 1,000 ATU from the end of spawning, has varied from 40 days in length (2001 and 2002) to 67 days in 2003 (Table 6). Chinook fry have been found, typically in low numbers, in the nearshore areas prior to the estimated start of emergence for all six years of this study. The annual protection plan has started, based on nearshore presence of chinook, prior to or within four days of the estimated emergence date for the four years prior to 2003.

Emergence of juvenile fall chinook salmon in 2004 as calculated under the terms of the Vernita Bar Settlement Agreement/Hanford Reach Protection Program began March 21 (Figure 4). Under the criteria adopted under the Agreement, operations to improve survival of fall chinook during the emergence and rearing period would coincide with emergence. The criterion for the start of the Protection Plan prior to 2003 was the collection of 50 chinook from six designated index locations. Sampling to assess juvenile fall chinook emergence, abundance, and fish size began on April 28, five weeks after the estimated start of emergence. A total of 3,049 chinook fry ranging in length from 34 mm to 68 mm were collected from six nearshore locations in the Hanford Reach indicating that fall chinook were abundant and had emerged well prior to sampling. Monitoring for entrapment in the Hanford Reach began on April 24, one month after the estimated start of emergence (Table 7).

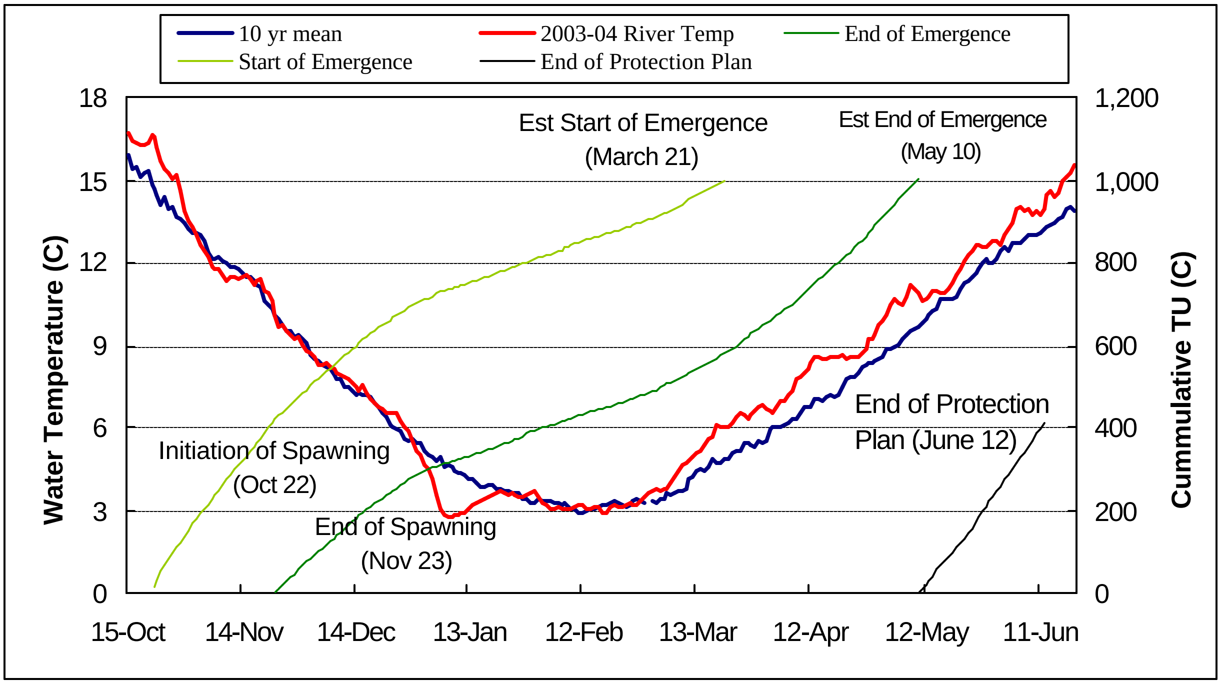

Figure 4. Mean daily river temperatures on the Hanford Reach of the Columbia River and estimated timing of fall chinook salmon emergence based on accumulated temperature units (ATU), 2003-04.

Table 6. Fall chinook spawning and fry emergence timing in the Hanford Reach as established through the Vernita Bar Agreement, 1991 – 2004.

Year	Critical Elevation	Initiation of Spawning		End of Spawning	Start of Emergence	End of Emergence
		<50 kcfs	>50 kcfs			
2003-04	70	10/22/03		11/23/03	3/21/04	5/10/04
2002-03	70	10/23/02	10/30/02	11/24/02	2/20/03	4/27/03
2001-02	50	11/31/01	---	11/18/01	3/17/02	4/25/02
2000-01	65	10/25/00	10/25/00	11/19/00	4/1/01	5/10/01
1999-2000	60	10/27/99	10/27/99	11/21/99	3/20/00	5/2/00
1998-99	60	10/28/98	11/11/98	11/29/98	3/8/99	5/11/99
1997-98	65	10/22/97	10/22/97	11/23/97	3/12/98	5/4/98
1996-97	65	10/23/96	10/23/96	11/24/96	4/30/97	6/4/97
1995-96	65	10/18/95	10/25/95	11/19/95	5/28/96	6/22/96
1994-95	60	10/26/94	11/2/94	11/20/94	5/6/95	5/28/95
1993-94	50	10/27/93	---	11/21/93		
1992-93	55	10/21/92	10/28/92	11/22/92	4/18/93	5/24/93
1991-92	70	10/23/91	10/23/91	11/24/91	2/20/92	4/21/92
1990-91	65	10/24/90	10/24/90	11/18/90	4/13/91	5/23/91
1989-90	70	10/18/89	10/25/89	11/19/89	3/5/90	4/29/90
1988-89	70	10/19/88	10/26/88	11/20/88	4/3/89	5/14/89

Table 7. Summary of chinook fork length and abundance at the end of the protection plan, 1999 – 2004.

Year	2004	2003	2002	2001	2000	1999
Protection Plan End	June 12	June 5	June 4	June 10	June 26	June 30
Index Sample Date	June 9	June 9	June 5[1]	June 13	June 26	June 30
Chinook in Index Sample	1,274	1,253[2]	8	182	26	66
% of Peak Abundance	27.1%	21.5%	0.5%	2.5%	3.0%	3.6%
Mean Fork length	47.2 mm	48.5 mm	49.9 mm	50.4 mm	65.1 mm	73.9 mm
Minimum Fork length	36.0 mm	33.0 mm	37.0 mm	37.0 mm	46.0 mm	46.0 mm

[1] On June 19, 111 chinook were sampled (17.9% of peak abundance)
[2] Nearshore seining was conducted at 15 locations in 2003, only 6 sites were seined in previous years

Monitoring of juvenile fall chinook mortality during the six years of this evaluation has been variable and has typically began after the estimated start of emergence. In all years, except 2001, the first stranded/entrapped chinook was recorded within three days of implementation of monitoring and on the same day in 1999, 2000, 2003, and 2004.

The Hanford Reach Fall Chinook Protection Program ended June 12 in 2004, 400 ATU after the estimated end of emergence. This end date criteria was established and implemented beginning with the 2001 Interim Protection Plan. Length frequency data from nearshore sampling on June 9 showed a reduction in the abundance of chinook in nearshore areas, an increase in mean fork length, and reduced presence of newly emergent fry (<42mm). However, though chinook numbers had decreased by 73% of peak abundance, chinook continued to be found in relatively high numbers along the nearshore areas three days before the end of the Protection Plan. On the June 9 survey, 1,274 chinook were sampled in nearshore surveys, 27% of the peak abundance. Mean fork length had reached 47mm and 18% of the chinook were 42mm or less in length.

Random sampling of entrapments to recover fall chinook mortalities in the Hanford Reach in 2004 concluded June 5. Only one chinook was found in the 20 entrapments sampled. Chinook have continued to be recovered during random sampling in the Reach after the end of the Protection Plan, primarily in entrapments, but they are typically few in number.

Mean Daily Flows and Fluctuations in the Hanford Reach

Hourly discharge from Priest Rapids Dam averaged 110.4 kcfs during the Hanford Reach Fall Chinook Protection Plan, March 21 – June 12 (Figures 5 & 6). Hourly discharge ranged from 70.2 kcfs to 189.3 kcfs. Mean daily flow fluctuation from Priest Rapids Dam during the this period was 28.0 kcfs with 32 days of relatively stable flows (fluctuations < 20 kcfs), 50 days with of flow fluctuations between 20 kcfs and 60 kcfs, and 2 days with flow fluctuations greater than 60 kcfs (Table 8 and Figures 7 & 8). The daily fluctuation was calculated during the period from 1:00 am to midnight of each day. A 17 kcfs fluctuation in discharge equates to a vertical change in river elevation of approximately 0.3 m (1.0 ft). Comparisons of mean daily fluctuations during the annual protection programs is provided in Table 8.

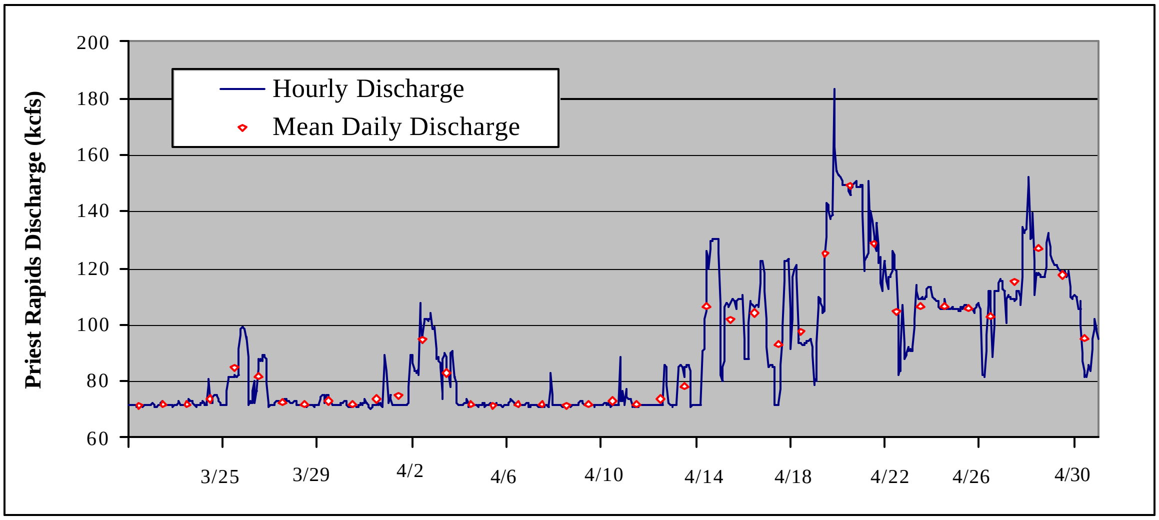

Figure 5. Hourly discharge and average daily flows from Priest Rapids Dam, March 21 – April 30, 2004.

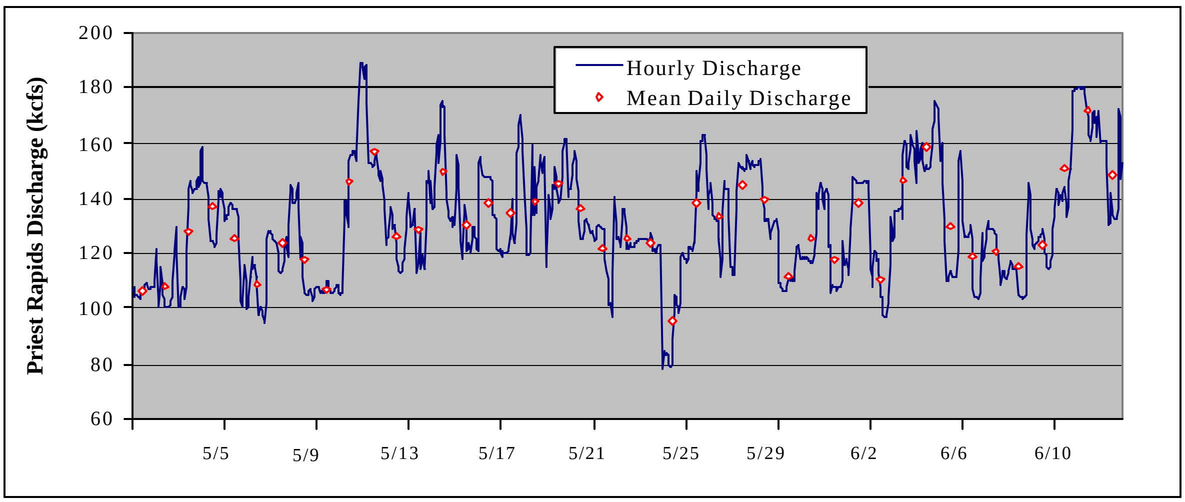

Figure 6. Hourly discharge and average daily flows from Priest Rapids Dam, May 1 – June 12, 2004.

Table 8. Summary of daily fluctuations in discharge from Priest Rapids Dam, during the Interim Protection Plans, 1999 - 2004.

Year	**Protection Plan**	**Total # of Days**	**Mean Fluct.** (kcfs)	**Daily Fluctuation at Priest Rapids Dam** (kcfs)				
				<20	20 to 40	40 to 60	60 to 80	>80
2004	Mar 21 - Jun 12	84	28.0	32	30	20	0	2
2003	Feb 20 - Jun 5	98	33.3	32	28	26	10	2
2002	Mar 21 - Jun 4	76	47.1	19	9	26	11	11
2001	Mar 26-Jun 10	77	23.2	45	11	12	8	1
2000	Mar 21-Jun 26	98	50.0	9	30	34	13	12
1999	Mar 10-Jun 30	113	42.1[1]	13	51	27	12	10

[1] Protection plan called for rewetting of unwateed areas (8 days), average 39.5 with rewetting removed.

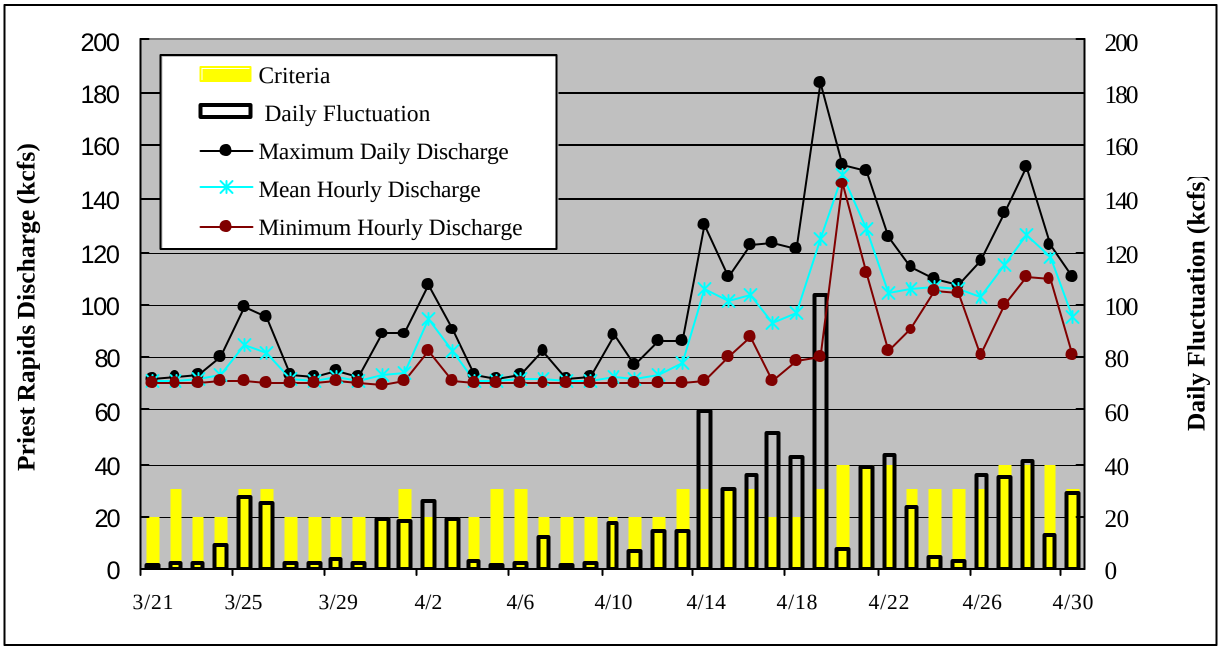

Figure 7. Mean, minimum, maximum hourly discharge, and daily fluctuation from Priest Rapids Dam, March 21 – April 30, 2004.

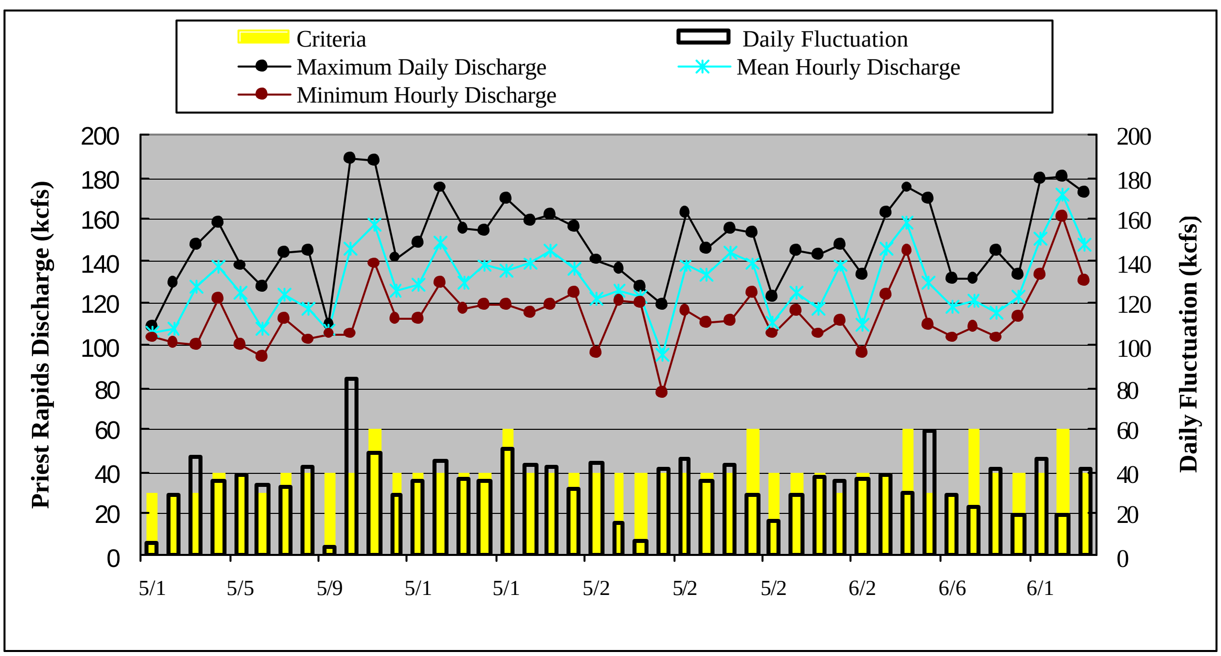

Figure 8. Mean, minimum, maximum hourly discharge, and daily fluctuation from Priest Rapids Dam, May 1 – June 12, 2004.

Random Sampling of Entrapments

A total of 578 isolated pools[5] formed by decreases in discharge from Priest Rapids Dam were surveyed between April 24 and June 5, 2004. Mean surface area and depth of entrapments at the time of sub-sampling was 63 m^2 and 6 cm, respectively. Of the entrapments surveyed, 73 entrapments contained fish (12.6%) and 67 contained juvenile fall chinook (11.6%). A total of 4,088 chinook were collected and sampled from the entrapments containing chinook.

Entrapment sampling began well after the estimated start of fall chinook emergence in 2004. In the first week of sampling (only sampled two days, April 24 - 25) 682 chinook were recovered from the 33 entrapments sampled. The mean number of chinook per entrapment was 20.7 with 6 of the 33 entrapments (18%) containing chinook (Table 9). Chinook presence in entrapments continued to be relatively stable through mid-May. By the third week of May the number of chinook per entrapment decreased in all areas of the Reach but remained slightly elevated in the lower reach (Figure 9 & 10). There was a similar trend in the abundance of chinook in nearshore areas.

The percentage of entrapments with chinook and the number of chinook per entrapment during 2004 had similar trends to 2003 (Table 10). The percent and numbers were lower during the first two weeks of May in 2004 than in 2003. Considering the estimated emergence was roughly double in 2004, having a lower number of entrapments with chinook and lower number of chinook per entrapment would indicate reduced losses from entrapment.

Table 9. Summary of entrapments with chinook by area and week, Hanford Reach, April 24 – June 5, 2004.

Week	Entrapments Sampled				Entrapments w Chinook #)				Number of Chinook			
Ending	Vernita	Hanford	Richland	Total	Vernita	Hanford	Richland	Total	Vernita	Hanford	Richland	Total
Apr 25	11	13	9	33	3	2	1	6	404	272	6	682
May 2	31	24	11	66	3	5	0	8	33	250	0	283
May 9	55	24	21	100	4	8	3	15	62	181	6	249
May 16	63	56	25	144	6	17	1	24	210	1,934	453	2,597
May 23	23	47	70	140	0	3	7	10	0	4	131	135
May 30	9	27	42	78	0	1	2	3	0	2	139	141
Jun 6	0	19	1	20	0	1	0	1	0	1	0	1
Total	192	210	179	581	16	37	14	67	709	2,644	735	4,088

Week	Entrapments w Chinook (%)				Chinook per Entrapment			
Ending	Vernita	Hanford	Richland	Total	Vernita	Hanford	Richland	Total
Apr 25	27%	15%	11%	18%	36.7	20.9	0.7	20.7
May 2	10%	21%	0%	12%	1.1	10.4	0.0	4.3
May 9	7%	33%	14%	15%	1.1	7.5	0.3	2.5
May 16	10%	30%	4%	17%	3.3	34.5	18.1	18.0
May 23	0%	6%	10%	7%	0.0	0.1	1.9	1.0
May 30	0%	4%	5%	4%	0.0	0.1	3.3	1.8
Jun 6	---	5%	0%	5%	---	0.1	0.0	0.1
Total	8%	18%	8%	12%	3.7	12.6	4.1	7.0

[5] Pools isolated from the river and formed by the reduction in discharge will be referred to as entrapments. These isolated pools are potential entrapment areas for fall chinook fry and other fish species.

Table 10. Comparison of entrapments with chinook and mean number of chinook per entrapment in the Hanford Reach, 2003 and 2004.

2004	% Entrapments with Chinook			Chinook per Entrapment	
Week Ending	Entrapments Sampled	Entrapments with Chinook	%	Chinook Sampled	Chinook per Entrapment
Apr 4					
Apr 11					
Apr 18					
Apr 25	33	6	18%	682	20.7
May 2	65	8	12%	283	4.4
May 9	100	15	15%	249	2.5
May 16	143	24	17%	2,597	18.2
May 23	140	10	7%	135	1.0
May 30	78	3	4%	141	1.8
Jun 6	19	1	5%	1	0.1
Jun 13					
Jun 20					
Overall	578	67	12%	4,088	

2003	% Entrapments with Chinook			Chinook per Entrapment	
Week Ending	Entrapments Sampled	Entrapments with Chinook	%	Chinook Sampled	Chinook per Entrapment
Apr 6	47	19	40%	1,682	35.8
Apr 13	71	34	48%	9,204	129.6
Apr 20	52	19	37%	1,066	20.5
Apr 27	101	17	17%	16,832	166.7
May 4	80	26	33%	576	7.2
May 11	65	24	37%	2,446	37.6
May 18	114	9	8%	163	1.4
May 25	115	6	5%	59	0.5
Jun 1	75	5	7%	671	8.9
Jun 8	71	3	4%	455	6.4
Jun 15	75	0	0%	0	0.0
Jun 22	68	2	3%	23	0.3
Overall	934	164		33,177	

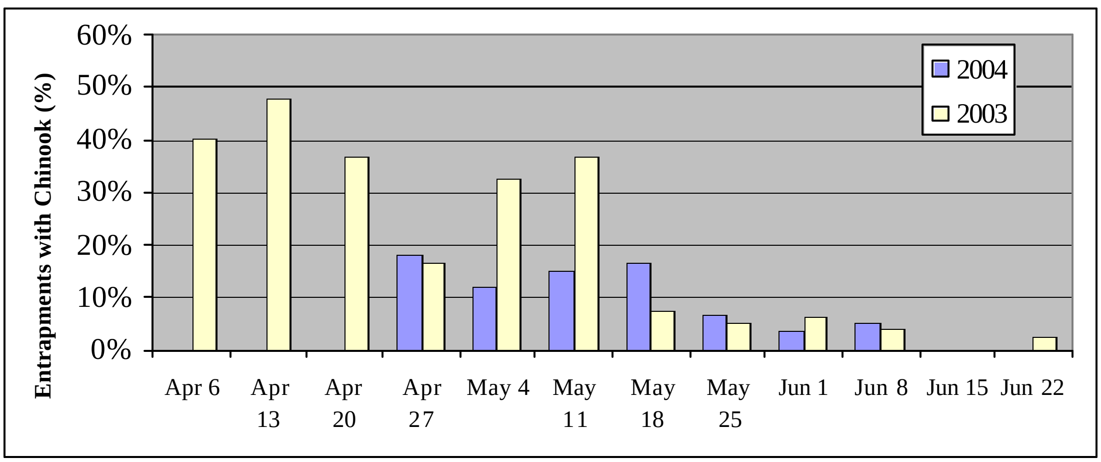

Figure 9. Mean chinook per entrapment by week, 2003 and 2004.

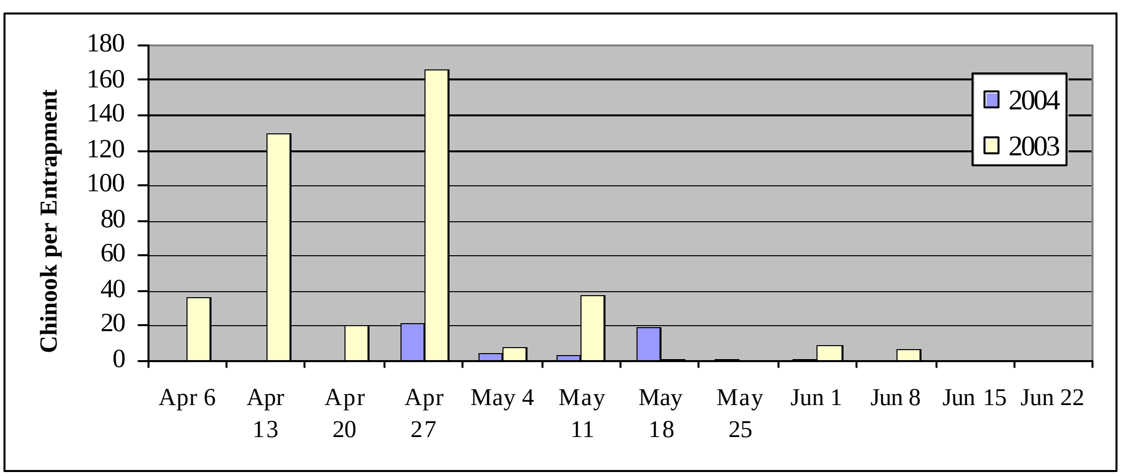

Figure 10. Weekly percentage of entrapments sampled containing chinook, 2003 and 2004.

Assessment of Juvenile Fall Chinook Salmon Relative Abundance and Fish Size

Sampling to assess juvenile fall chinook salmon abundance and fish size began on April 28, five weeks after the estimated start of emergence. The last survey was June 9, three days prior to the end of the Protection Plan. A total of 20,733 juvenile fall chinook salmon were sampled. Chinook fry were already abundant at the start of sampling. Abundance of chinook fry continued to increase through May 19 (Figure 11). One week later, May 26, the number of chinook sampled in nearshore areas had decreased by over 50%. By late May, numbers of chinook fry in the collection at locations in the middle and upper sections of the Reach began to decline and by June 9 had decreased to minimal numbers (Table 11). This was similar to the trend observed in 2003. Though numbers of juvenile fall chinook in the nearshore areas in the middle and upper sections had declined the overall abundance continued to be relatively high (27% of peak collection) on the last day of sampling.

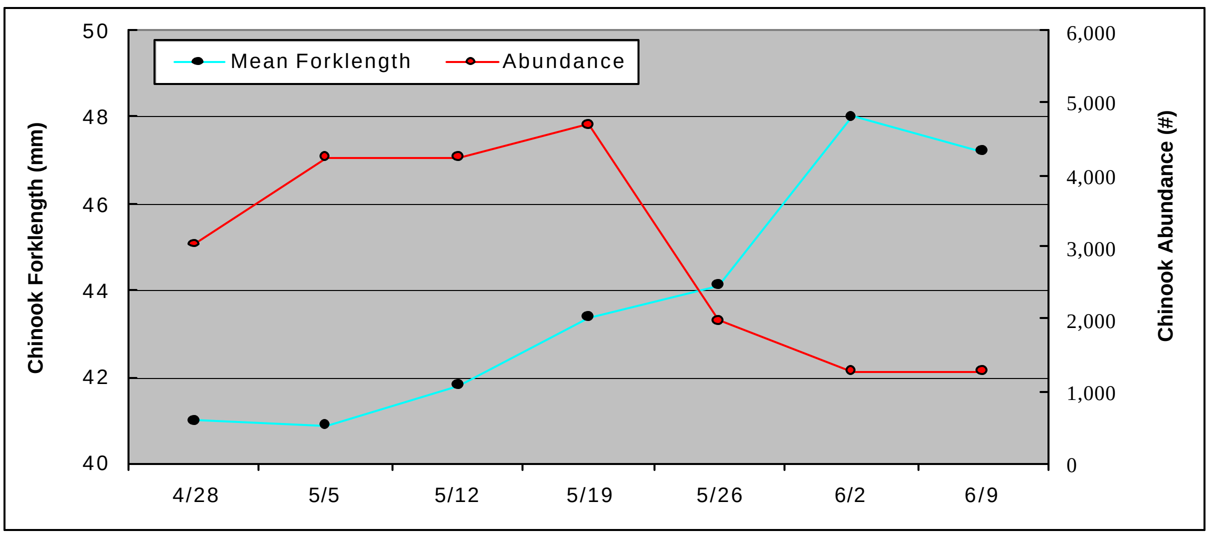

Figure 11. Juvenile fall chinook abundance and mean fork length in nearshore areas of the Hanford Reach, April 28 – June 9, 2004.

Table 11. Fall chinook fry collected in nearshore areas in the Hanford Reach, April 28 - June 9, 2004.

Date	**Vernita Bar**	**Coyote Rapids**	**Island #2**	**Ferry Landing**	**Hanford Townsite**	**Savage Island**	**Total**
Apr 28	221	303		318	1,743	464	3,049
May 5	273	154	525	605	2,047	621	4,225
May 12	274	1,018	134	858	1,137	812	4,233
May 19	38	1,149	220	679	1,641	968	4,695
May 26	100	2	8	840	614	415	1,979
Jun 2	39	17	2	388	796	36	1,278
Jun 9	12	9	1	0	1040	212	1,274
Total	957	2,652	890	3,688	9,018	3,528	20,733

Susceptibility of juvenile fall chinook to stranding/entrapment typically decreases as fork length reaches 50 mm. Mean fork length of chinook were approaching 50 mm (48.0 mm) on June 9 in 2004 just prior to the end of Protection Agreement constraints. Minimum fork length for chinook sampled along nearshore areas in the Reach continued to be less than 40 mm through the final survey, however, the composition of newly emergent fry (<42 mm) in the sample had decrease to 19% of the sample by June 9 (56 of 295).

Conclusions

Juvenile Fall Chinook Protection Plan

The embryonic development and growth of fall chinook salmon is highly dependent on river temperature. Accumulated temperature units (ATU) can be used to predict the rate of development, hatching, and emergence timing of fall chinook salmon. Fall chinook salmon eye at approximately 250°C ATU after spawning, hatch at 500°C ATU, and emerge at 1,000°C ATU.

Implementation and Termination

In 2003, the estimated start of emergence as calculated by the Vernita Bar Agreement was established as the start date for implementation of the annual protection plan for emergence and rearing. This start date appears to correspond well to emergence and increased abundance in the Hanford Reach. In 1999 through 2002, newly emergent fall chinook salmon were first sampled in the nearshore sampling sites 1 to 16 days prior to the estimated start of emergence but typically in low numbers. In 2000 and 2002, presence of juvenile chinook in nearshore areas reached over 50 fish[6] within two days of the estimated start of emergence. In 2001, chinook abundance had begun to increase (>50 chinook) ten days prior to the estimated start of emergence and in 1999 and 2003 abundance of emergent fry did not increase until two weeks after the emergence date. Nearshore sampling was conducted weekly in 1999 and 2003 and probably led to delays in reaching start criteria in these years.

In addition to emergence timing, ATU can be used to predict susceptibility of fall chinook to stranding and entrapment. Based on data from the six years of evaluation and monitoring, juvenile fall chinook salmon susceptiblity to stranding and entrapment appears to decrease substantially by 1400 ATU after the end of spawning. The final chinook found during randomized sampling each year has varied from 344 ATU (2003) to 602 ATU (2001). In years where chinook continue to be abundant and newly emergent fry were present in nearshore areas after 1400 ATU, susceptibility to stranding and entrapment has been low (2000, 2001, and 2003).

Predictive Flows for Establishing Constraints

Due to the variability in power demand, water withdrawal (irrigation and urban), and weather events, precise prediction of daily average discharge at Priest Rapids Dam is not possible.

[6] Criteria for implementation of protection plan in 2000-02 was the presence of 50 or more chinook in six index locations.

Therefore, flow constraints (daily fluctuation limits) are based on prior daily inflow[7] to Wanapum Dam and BPA forecasted weekend flows for Chief Joseph including side flows. The previous weekday inflow to Wanapum Dam was used to predict Priest Rapids discharge and to set constraints for weekdays. Weekend forecasts for Chief Joseph Dam plus side flows were used to predict weekend flows for Priest Rapids Dam and set weekend constraints. Use of previous day flows from Rock Island and weekend forecasts from Chief Joseph were used with the goal of accurrately predicting daily mean discharge for Priest Rapids Dam and thus maintaining flow fluctuations in the Hanford Reach that would reduce stranding and entrapment.

The establishment of protection plan constraints based on upstream discharge and flow forecasts was effective in setting constraints that would reduce the impacts to fall chinook from stranding and entrapment in the Hanford Reach in 2004. The use of prior weekday inflow to Wanapum Dam (discharge from Rock Island Dam) to set weekday constraints was effective in setting constraints that matched or were more restrictive than necessary to reduce stranding/entrapment on 50 of the 60 (83%) weekdays during the 2004 Protection Plan (Table 12). Weekend constraints set using Chief Joseph forecasts were accurate for setting constraints that met or were more restrictive on 12 of the 13 weekends (92%). Accuaracy using these predictive flow indicators was similar to 2003 results. Overall, criteria were identical or more restrictive on 85% of the constraints set in 2004 and 89% in 2003.

Table 12. Summary of Wanapum inflows and Chief Joseph forecasts in predicting constraints for Priest Rapids daily operations, 2003 and 2004.

2004	**Constraints**	**Identical Criteria**	**Constraint More Restrictive**[1]	
			Wanapum Inflow/Forecast	Priest Rapids Daily
Weekday	60	38 (63%)	12 (20%)	10 (17%)
Weekend	13	9 (69%)	3 (23%)	1 (8%)
Overall	73	47 (64%)	15 (21%)	11 (15%)
2003	**Constraints**	**Identical Criteria**	**Constraint More Restrictive**	
			Wanapum Inflow/Forecast	Priest Rapids Daily
Weekday	71	46 (65%)	17 (24%)	8 (11%)
Weekend	14	10 (71%)	3 (21%)	1 (7%)
Overall	85	56 (66%)	20 (24%)	9 (11%)

[1] Constraint was more restrictive when compared to actual mean daily discharge at Priest Rapids Dam

There were a total of 73 flow fluctuation targets established by the Protection Plan in 2004, 60 weekday constraints and 13 weekend constraints. When compared to mean weekday/weekend discharge from Priest Rapids Dam, the targets matched on 47 predictions, were more restrictive on 15 occassions, and were not restrictive enough on 11 occassions. Weekday constraints were accurately predicted on 38 days (63%), with 12 daily constraints were more restrictive (20%), and 10 daily constraints (17%) were not restrictive enough based on Priest Rapids actual mean

[7] "Previous Day's Average Weekday Wanapum Inflow" – the total volume of water discharged into the Wanapum development measured as a daily average discharge from Rock Island Dam. This measure is used from Monday to Friday to determine the allowable flow fluctuation during the Rearing Period and will be calculated based on data available to Grant that is reported on the Corps of Engineers website [http://nwd-wc.usace.army.mil/report/projdata.htm].

daily discharge. Chief Joseph weekend forecasts accurately predicted weekend flows for Priest Rapids on 9 of the weekends (69%), 3 constraints were more restrictive (23%), and 1 constraint was not restrictive enough based on Priest Rapids actual discharge (8%).

Assessment of Flow Fluctuations and Targets

The Hanford Reach Fall Chinook Protection Plan establishes operational criteria to minimize daily fluctuations in river elevations during the period of fall chinook emergence and rearing. There were 73 operational targets set for a period of 85 days in 2004. Of the operational constraints established by the plan, 50 targets were met with daily flow fluctuations below the maximum (Figure 12 and Table 13). This included three days (April 19, May 3, May 10) when fluctuations were above the typical criteria but met Protection Plan allowance for anticipated increasing flows on Mondays (Table 14). There were no major decreases in discharge during these three days. There were 60 weekdays during the protection plan and 13 weekends. Weekday constraints were met on 39 (65%) days and weekend constraints were met on 8 of 14 weekends (62%). Fluctuations were outside of target by less than 5 kcfs on 13 occassions, 10 weekdays and 3 weekends. On April 22 and May 24, flow fluctuations were less than 5 kcfs above the target (< 40 kcfs fluctuation) based on the predicted flows. Actual mean daily flows for each day was 104.7 kcfs and 95.3 kcfs respectively. Ideally, predictive constraints will match Priest Rapids actual, but on these two days the constraint was higher and though the fluctuation was only slightly higher than the target, the fluctuation was over 10 kcfs above the ideal. Similarly, constraints can be more restrictive based on the predicted flows than actual. On May 27, June 1, and June 10, flow fluctuations were higher than targets but actual Priest Rapids mean discharges were above predicted flows and fluctuations would have been within targets. Incidences such as these are typical each year.

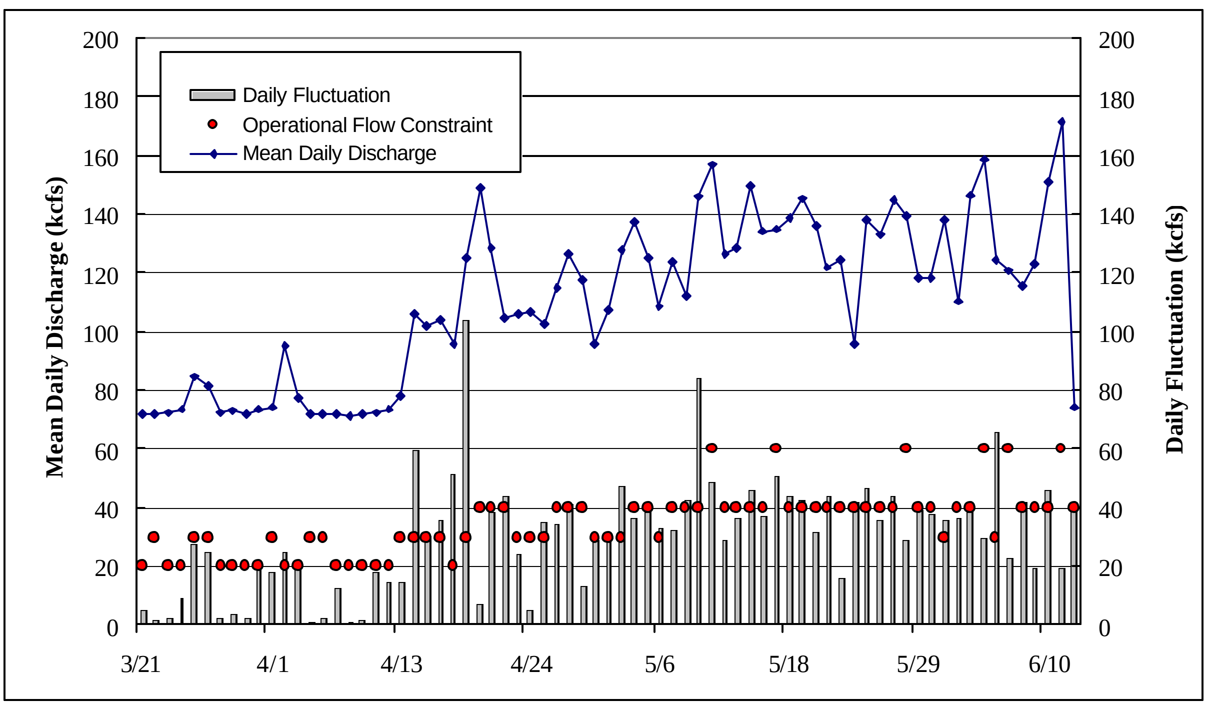

Figure 12. Average daily flows, daily fluctuation, and Protection Plan constraints for Priest Rapids Dam, March 21 – June 12, 2004.

Table 13. Hourly discharge by flow band and compliance with target objective for daily fluctuations below Priest Rapids Dam, March 21 – June 12, 2004.

Flows	Criteria	Targets	PRD Q (mean)	Daily Fluctuation (kcfs)			Fluctuations Outside of Target	Outside of Target <5 k
				Mean	Median	Min		
36-80	<20 kcfs	15	75.6	12.7	9.3	1.4	3	1
80-110	<30 kcfs	20	99.3	31.2	28.8	1.5	7	2
110-140	<40 kcfs	32	126.8	37.8	38.9	7.4	13	10
140-170	<60 kcfs	6	147.0	33.5	29.2	19.6	0	
>170	150 kcfs min	0						
Total		**73**	**110.4**	**30.5**			**23**	**13**

Table 14. Summary of constraints outside of Protection Plan targets, March 21 – June 12, 2004.

Date	Day	PRD (Q)	Fluctuation	Criteria	Out By	Comments
4/2	Fri	94.6	25.4	20	-5.4	
4/3	Weekend	77.2	20.1	20	-0.1	
4/14	Wed	106.0	59.2	30	-29.2	Flows were increasing, dropped 50.7 kcfs from 10pm to 3am
4/15	Thu	101.8	30.4	30	-0.4	
4/16	Fri	103.7	35.4	30	-5.4	
4/17	Weekend	95.2	51.6	20	-31.6	
4/19	Mon	124.9	103.8	30	-73.8	Flows were increasing on a Monday: Meets Criteria
4/22	Thu	104.7	43.7	40	-3.7	
4/26	Mon	102.7	35.0	30	-5.0	
4/28	Wed	126.6	41.3	40	-1.3	
5/3	Mon	127.9	47.3	30	-17.3	Flows were increasing on a Monday: Meets Criteria
5/6	Thu	108.5	33.2	30	-3.2	
5/8	Weekend	112.4	42.6	40	-2.6	
5/10	Mon	145.9	84.1	40	-44.1	Flows were increasing on a Monday: Meets Criteria
5/14	Fri	149.4	45.8	40	-5.8	
5/18	Tue	138.9	43.9	40	-3.9	
5/19	Wed	145.1	42.6	40	-2.6	
5/21	Fri	122.0	44.0	40	-4.0	
5/24	Mon	95.3	41.9	40	-1.9	
5/25	Tue	138.2	46.6	40	-6.6	
5/27	Thu	144.6	43.7	40	-3.7	
6/1	Tue	137.9	35.7	30	-5.7	
6/5	Weekend	124.3	66.1	30	-36.1	
6/8	Tue	115.3	41.8	40	-1.8	
6/10	Thu	150.7	46.0	40	-6.0	
6/12	Weekend	74.1	41.8	40	-1.8	

A large portion of the mortality from reductions in discharge in previous years can be attributed to the reduction in power demands on the weekends and corresponding decline in flow. Additional provisions were included in the Protection Plan in 2004 to reduce fall chinook mortality during the weekends. On the four consecutive Saturdays and Sundays after 800 ATUs from the end of the spawning, Priest Rapids minimum outflow will be maintained at or above the minimum flow calculated as the average of the daily hourly minimum flow from Monday through Thursday of the current week. BPA will provide flows necessary to meet the four weekend minimum flows as provided in the Protection Plan. In 2004, the first year this addition to the Plan has been implemented, the weekday minimum was maintained for one additional weekend. The criteria of 800 ATU after the end of spawning was reached on April 19. The following five weekends, April 24-25 through May 22-23, GCPUD attempted to maintain mean minimum weekday flows. This criteria was met on May 1-2, May 15-16, and May 22-23. Minimum discharges only fell below weekday minimums by 0.8 kcfs on April 24-25 and 1.9 kcfs on May 8-9 (Table 15).

Table 15. Weekend criteria for minimum discharge from Priest Rapids Dam, April 24 - May 23, 2004.

Weekend	Weekday Minimum (Mean of Mon-Thur)	Weekend Minimum	Difference
April 24-25	104.9	104.1	-0.8
May 1-2	100.3	100.6	+0.3
May 8-9	104.4	102.5	-1.9
May 15-16	117.4	117.9	+0.5
May 22-23	119.6	120.2	+0.6

Assessment of Susceptibility of Juvenile Fall Chinook to Stranding and Entrapment

The size of stranded/entrapped juvenile fall chinook salmon and the distribution of stranded/entrapped fish on the Hanford Reach demonstrated similar patterns for the years 1999 through 2003. No fork lengths were recorded during random sampling in 2004. Juvenile fall chinook salmon collected in random plots were relatively small with a mean fork length of 42.2 mm and ranged from 31 mm to 86 mm (Table 16). Individuals greater than 60 mm comprised only 0.7% of the fish measured during these years (Figure 13). Most juvenile fall chinook salmon collected from random plots had fork lengths between 36mm and 45mm. Differences in preferred rearing habitat between size classes of juvenile fall chinook may explain the reduced susceptibility to stranding of fish greater than 60 mm.

Table 16. Mean and range of fork length of stranded and entrapment of juvenile fall chinook salmon found in random plots on the Hanford Reach of the Columbia River from 1999 to 2002.

Year	**Mean Fork Length (mm)**	**Range Fork Length (mm)**	**Number of Chinook Measured**	**Number of Chinook >60 mm**
2003	40.7	35-52	115	0
2002	40.7	32-45	101	0
2001	42.3	31-54	354	0
2000	41.7	33-86	512	4
1999	45.6	36-66	257	6
1999-2003	42.2	31-86	1,339	10

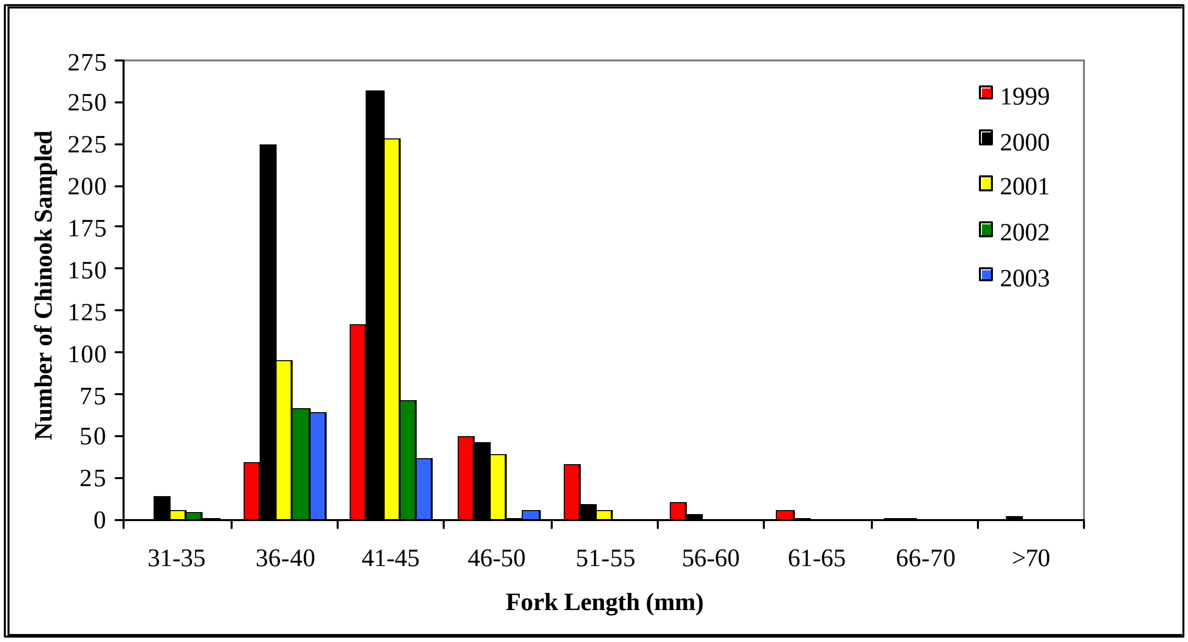

Figure 13. Fork length measurements of juvenile fall chinook salmon collected from random plots on the Hanford Reach of the Columbia River from 1999 to 2003.

Direct mortality of stranded/entrapped juvenile fall chinook most often occurs when entrapments drain or entrapment waters warm to lethal temperatures (≥24ºC). The likelihood of juvenile fall chinook salmon dying within 24 hours of being stranded or entrapped can be high as was seen in 2001 when 97.9% of fish sampled were categorized as direct mortalities at the time of sampling. Thermal stress of juvenile fall chinook salmon subsequently released from entrapments does not, however, appear to have fatal consequences. United States Geological Survey Biological Resources Division (USGS/BRD) performed thermal tolerance tests that showed juvenile fall chinook salmon exposed to entrapment conditions similar to those found on the Hanford Reach had little direct mortality and no increased vulnerability to predation. These fish did, however, show transient increases in plasma concentrations of cortisol, glucose, and lactate, and a dramatic (25-fold higher than controls) and persistent (lasting 2 weeks) increase in levels of liver hsp70. Tests were not conducted to determine the consequences of exposure to multiple, cumulative stressors.

The majority of chinook found entrapped/stranded were recovered during weekend sampling in 2003. The average number of chinook per random plot was 1.7 on the weekends compared to 0.5 chinook per plot on the weekdays. The percentage of samples with chinook was also much higher on the weekends with 35.6% of the samples containing chinook compared to 16.8% on the weekdays. In 2004, the average number of chinook per random plot was 7.4 on the weekends compared to 6.5 chinook per plot on the weekdays. The percentage of samples with chinook was also similar between weekdays and weekends in 2004 with 11.4% of the weekend samples containing chinook compared to 12.0% on the weekdays. This similarity between weekday and weekend impacts observed in 2004 may be due to the added weekend protection criteria established in the 2004 Protection Agreement.

The Hanford Stranding Model developed by PNNL generates an estimate of the shoreline area unwatered from fluctuations in discharge from Priest Rapids within a 35.1 km^2 section of the Hanford Reach from Rkm 571.3 to Rkm 606.9 (Island #1 to Ringold). Based on model outputs for 2004, 1,543 hectares of shoreline were unwatereed during April and May (Table 17 and Figure 14). This was the second least area unwatered in the last six years, only second to the drought year in 2001. Mean daily flow fluctuations during April and May, the primary period of emergence and susceptibility to entrapment and stranding, have decreased considerably compared to pre-Protection Plan operations. The mean daily fluctuation averaged 60% of the mean hourly discharge in 1995 and 1998, whereas, mean daily fluctuation has averaged only 30% of mean hourly discharge from 1999 to 2004.

Table 17. Shoreline area unwatered within the Hanford Reach (Rkm 571.3 to Rkm 606.9) during April and May and mean daily flow fluctuations from Priest Rapids Dam, 1999 - 2004.

Year	**Priest Rapids (Q)**		**Mean Fluctuation**		**Shoreline Area Unwatered**
	April	May	April	May	
1995	101.8	136.5	60.5	78.5	2,018
1998	86.3	175.5	67.6	79.8	2,642
1999	145.4	164.3	36.3	35.2	1,872
2000	160.1	166.4	46.9	55.5	2,564
2001	70.2	64.1	10.7	30.6	1,133
2002	128.3	150.6	48.1	53.5	2,454
2003	115.6	144.6	34.2	47.7	1,977
2004	95.4	128.0	24.6	35.6	1,543

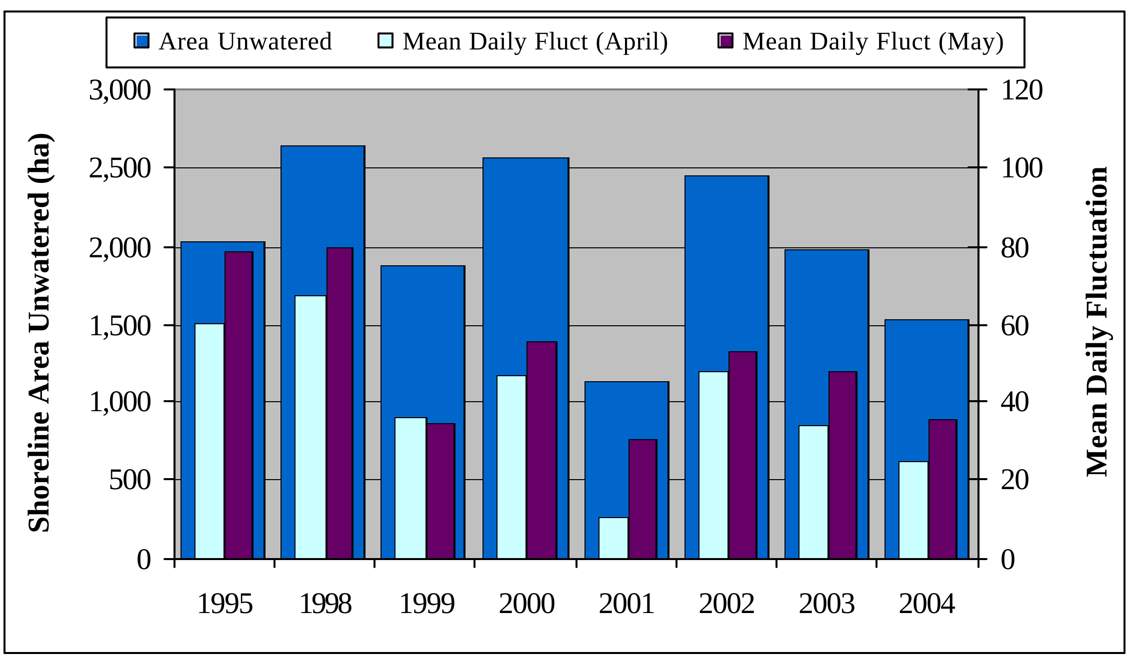

Figure 14. Comparison of shoreline area unwatered and mean daily flow fluctuations for April and May within the Hanford Reach (Rkm 571.3 to Rkm 606.9), 1999 - 2004.

Discussion

Geist and Dauble (1998) noted Hanford Reach fall chinook salmon tend to spawn in areas with complex channel pattern, rather than where the channel is straight and simple. Redd counts, performed by PNNL in 1991, 1994, and 1995, showed that primary fall chinook salmon spawning occurred at Vernita Bar, Locke Island/White Bluffs, and 100 F. According to Healy (1998), upon emergence, fry swim or are displaced downstream. Vernita Bar, Locke Island/White Bluffs, and 100 F Islands provide rearing habitats that are immediately adjacent to or downstream of spawning areas. Island complexes such as Locke Island and 100 F Islands provide irregular shorelines with finer substrates (<32 mm) and lower water velocities. These early rearing areas are generally in close proximity to deeper higher velocity currents containing larger substrates used later in the juvenile fall chinook salmon rearing period. In the Hanford Reach, Dauble et al. (1989) found juvenile fall chinook salmon primarily in shoreline areas of reduced current velocity but were present throughout the river cross section during their early rearing and outmigration period. In a comparable river environment such as the Snake River, Chapman and Bjornn (1969) and Everest and Chapman (1972), reported that juvenile fall chinook salmon were most abundant where substrate particle size was small, velocity was low, and depth was shallow, but were additionally found, at least in small numbers, in virtually every habitat investigated (Healy 1998).

In 1998, first year of the Hanford Reach stranding and entrapment evaluation, juvenile fall chinook salmon were observed stranded and entrapped throughout the 82 kilometers of the Hanford Reach. However, fish were found most often at the island complex areas of Locke Island/White Bluff Slough, 100 F Islands, and Wooded Island (Figure 15). These areas contain good juvenile fall chinook salmon rearing habitat but also provide the highest potential for stranding and entrapment. Based on these initial observations, the 21-mile study area from Island 1 (Rkm 571.3) to Savage Island (Rkm 606.9) was selected as a representative area for determination of impacts from flow fluctuations on fall chinook fry Reach-wide. Evaluation of juvenile fall chinook stranding and entrapment from 1999 to 2002 was primarily limited to this 21-mile area of the Hanford Reach. Impacts to fall chinook determined from these studies cannot be directly applied to other areas within the Hanford Reach. The two studies conducted Reach-wide in 2003 and 2004 have supported observations from the original surveys from 1998 and provided additional insights into the impacts of changes in discharge from Priest Rapids Dam on juvenile fall chinook during emergence and rearing.

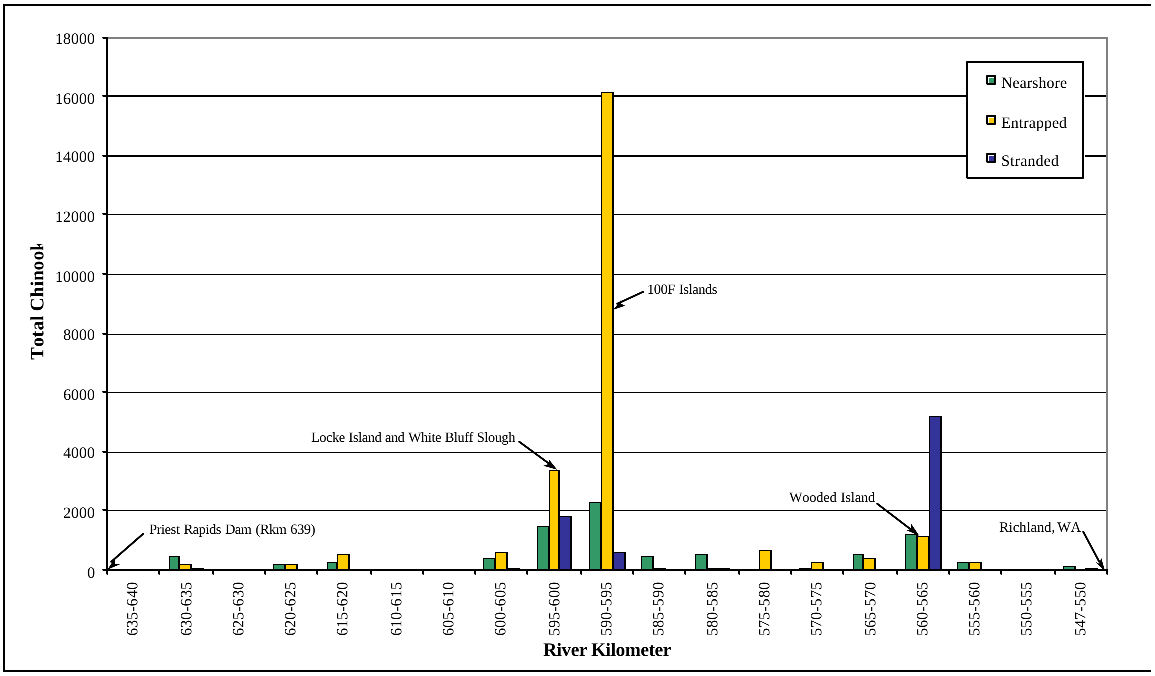

Figure 15. Distribution of juvenile fall chinook salmon observed on the Hanford Reach of the Columbia River in 1998.

Fall chinook fry exhibit a similar temporal and spatial distribution during fall chinook emergence and rearing in the Hanford Reach. During the early portion of the emergence, fall chinook are well dispersed throughout the Reach with slightly higher abundance in the lower areas (Hanford Townsite downstream). As the emergence and rearing period progresses, abundance continues to decline in the upstream regions and increase downstream. Observations of stranding and entrapment tend to follow these distributions with the exception of the central Reach where fall chinook continue to be entrapped in relatively higher numbers than would be expected based on abundance in nearshore areas.

As observed in 1998, the evaluations in 2003 and 2004 reaffirm that Island complex and slough areas have the highest abundance of fall chinook fry and the highest potential for stranding and entrapment. In general, under typical spring flows, the central area of the Hanford Reach from Island 1 to Savage Island has the greater potential for fall chinook mortality resulting from changes in discharge from Priest Rapids Dam.

Currently under the protection plan, the daily average discharge is calculated using the hourly flows from 1am to midnight of each day. Decreases or increases in discharge from midnight to 1am are not reflected in the mean daily flow or fluctuation for either day. This produces a potential for fish mortality from decreases in discharge that is not included under the current Protection Plan. In 2004, flow fluctuations between midnight and 1am that were in excess of 10 kcfs occurred on 14 of the 84 days the Protection Plan was in effect. The maximum increase between midnight and 1:00 am was 15.1 kcfs and the maximum decrease in discharge was 40.7 kcfs (Figure 16).

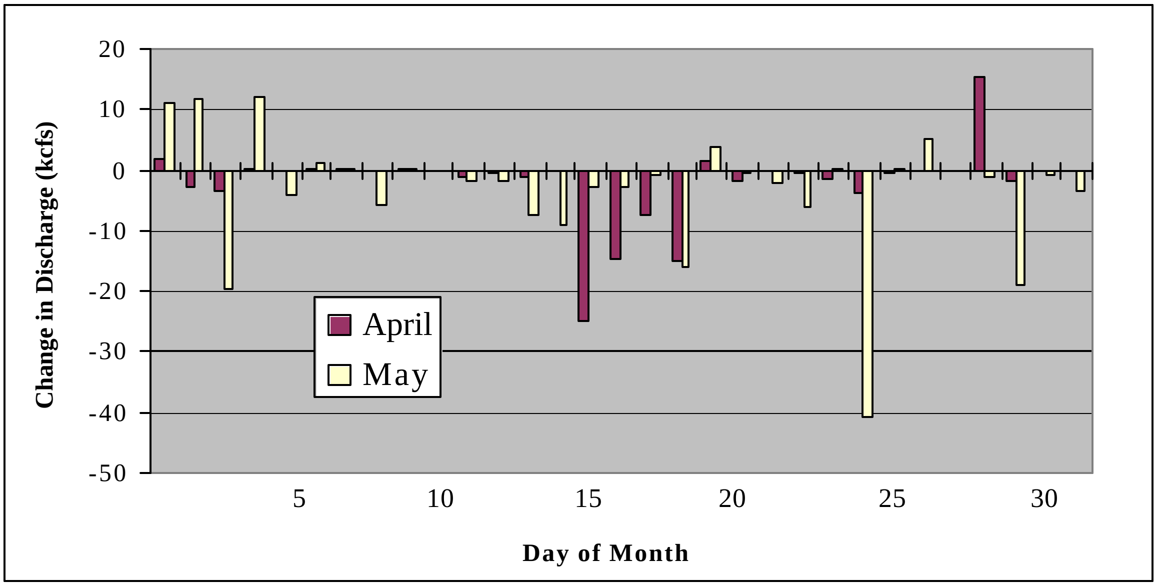

Figure 16. Change in discharge from midnight to 1am at Priest Rapids Dam, April and May 2004.

Incorporating the midnight flows into the calculation for the daily fluctuation does not necessarily increase the total fluctuation for the day (Figure 17). If the calculations for daily average and fluctuation were based on a midnight to midnight time period, 17 of the daily fluctuations for the 84 days of the Protection Plan in 2004 would have increased (Figure 15). On only 3 of these 17 days did daily fluctuations increase by more than 5 kcfs. However, by adding the midnight hour into the calculation the between day changes in discharge could be addressed to some extent under the Protection Plan.

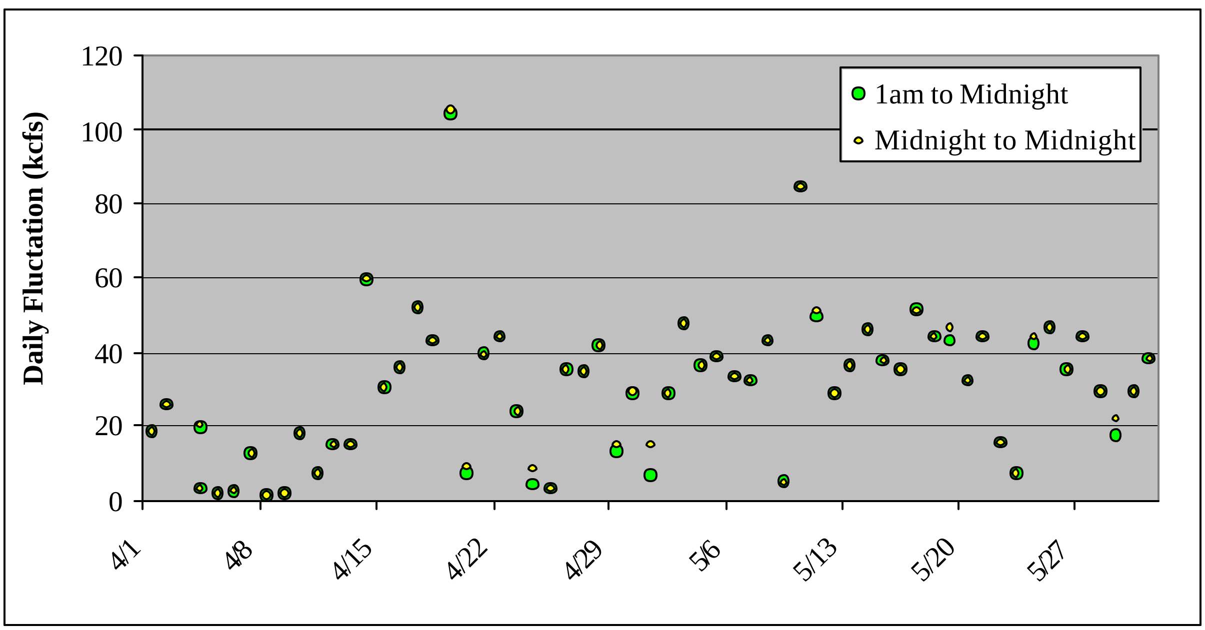

Figure 17. Comparison of daily fluctuations between midnight to midnight and 1am to midnight for Priest Rapids Dam, April and May 2004.

Typical power demands exhibit an increase in demand during daylight hours and decrease in power needs at night. The Upper Columbia Projects typically generate following this pattern as seen in the figure below (Figure 18). As stated previously, the current protocol is to calculate the daily fluctuation and daily average discharge during the period from 1am to midnight. Using this method the nightly decrease in discharge is often split between days in the daily calculations for flow fluctuation as flows typically decrease between 9pm and 4am (Figure 19 & 20). Calculations made on the 1am to midnight protocol may not adequately represent the fluctuation to which fall chinook are actually exposed (Figure 21 & 22). Based on a normal hydrograph, calculating the daily average and fluctuation based on a noon to noon period would better represent the full decrease in discharge. This may also provide better allowance for between day changes in discharge. As seen in the figures below, the typical decrease in discharge from the Project is split between two days when calculating daily fluctuations from 1am to midnight. Whereas, calculating the daily flow fluctuation using noon to noon encompasses the full range of the drop. The calculation of the daily average will typically be similar through either method except possibly during the transition from weekdays to weekends and vice versa.

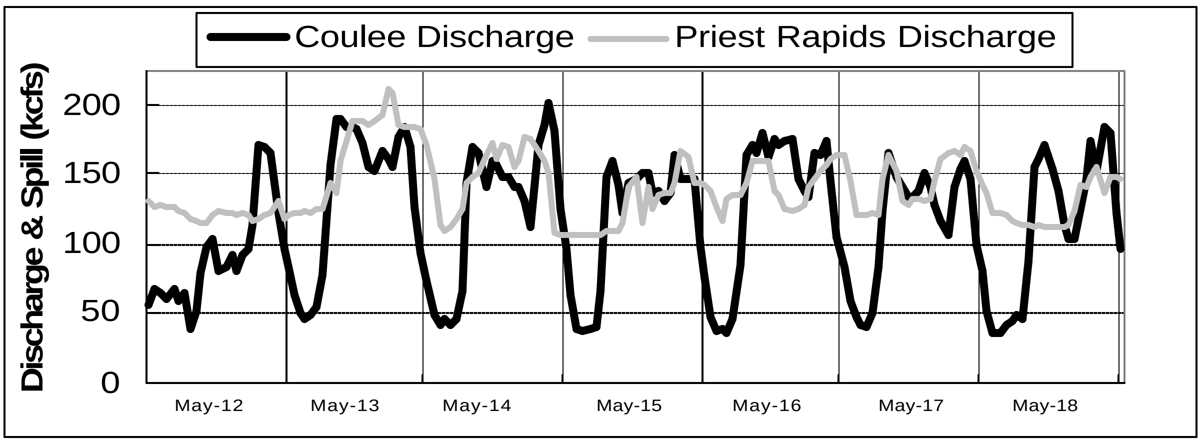

Figure 18. Hourly discharge from Grand Coulee and Priest Rapids Dam, May 12-18, 2002.

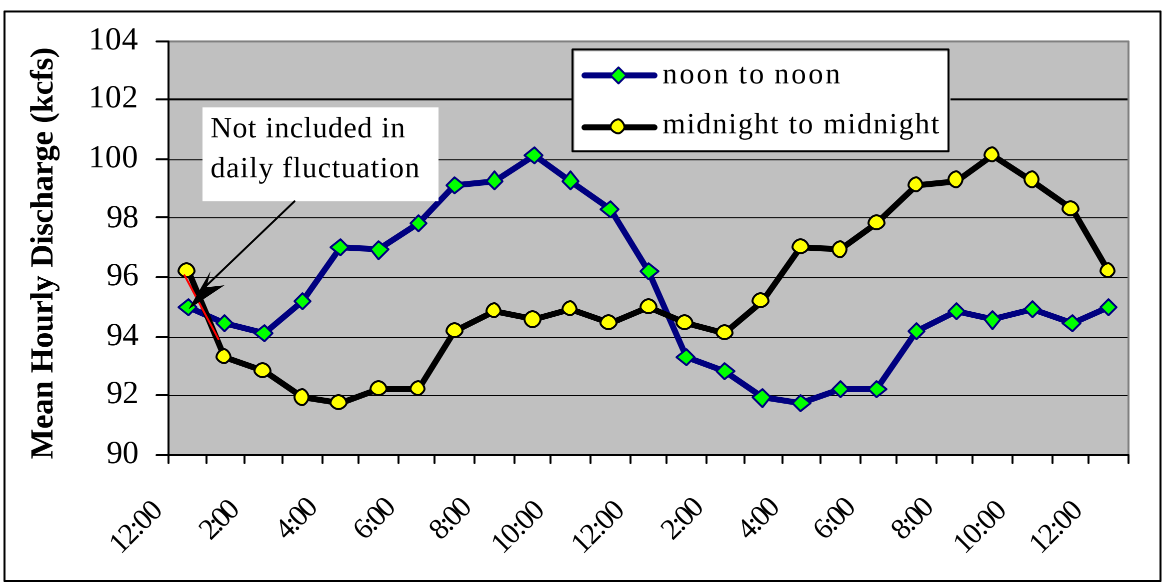

Figure 19. Average hourly discharge from Priest Rapids Dam, April 2004.

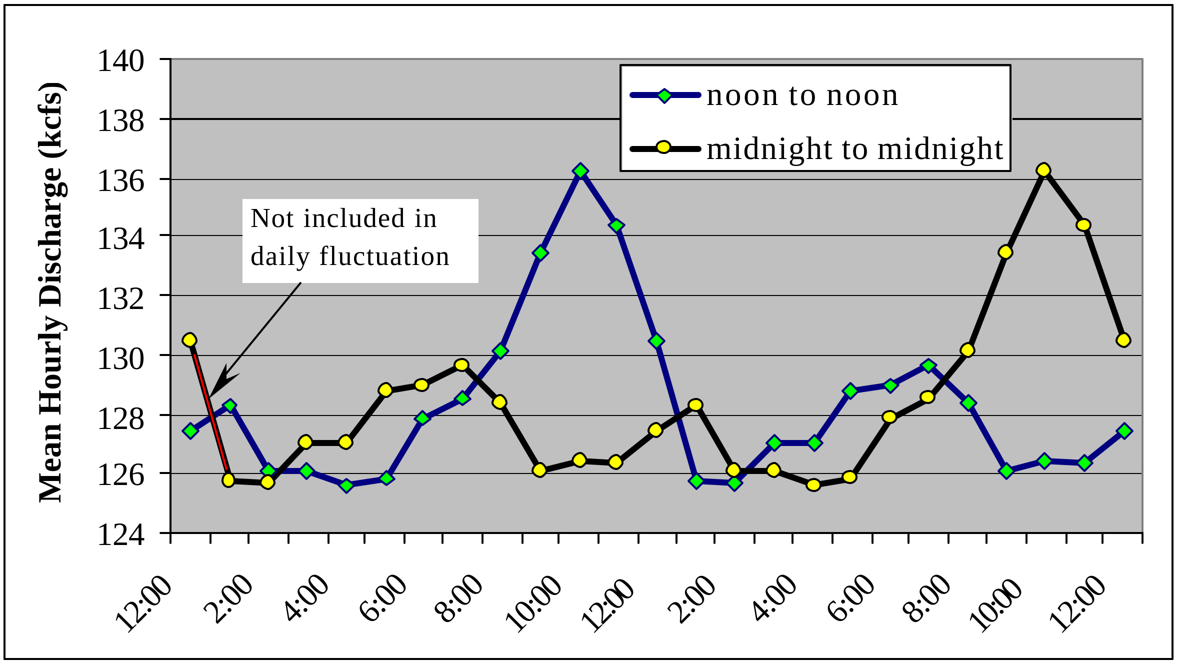

Figure 20. Average hourly discharge from Priest Rapids Dam, May 2004.

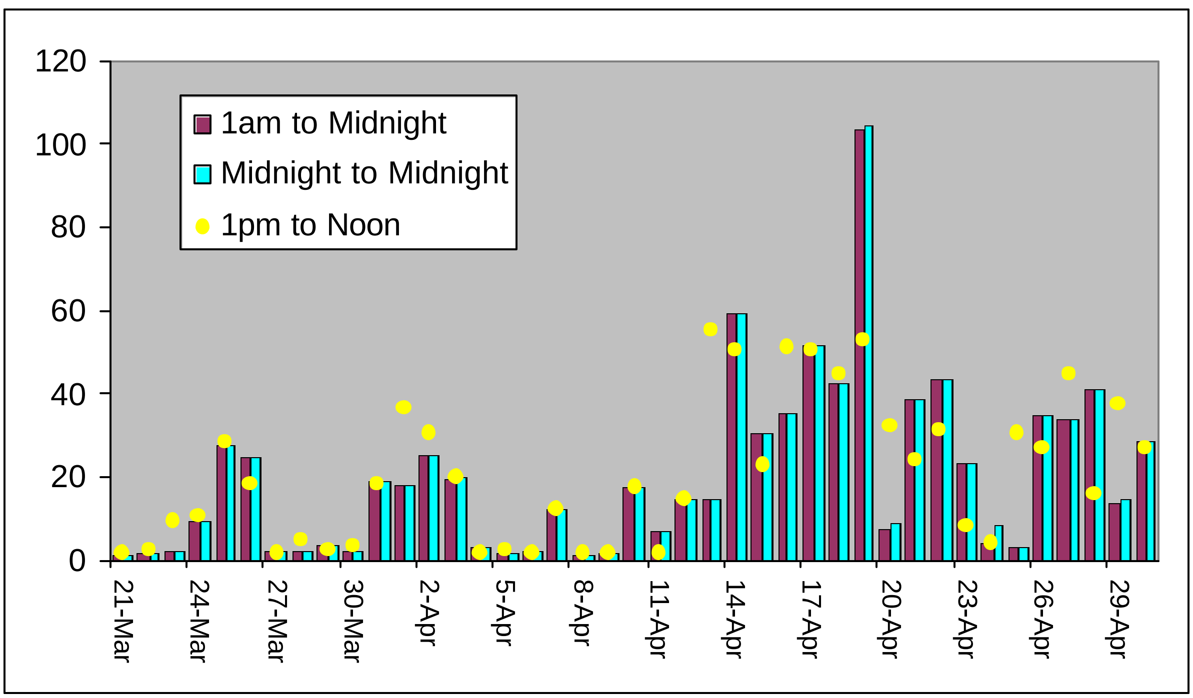

Figure 21. Comparison of mean daily fluctuation from Priest Rapids Dam using three different hourly time frames for calculation, hourly discharge, March 21 - April 30, 2004.

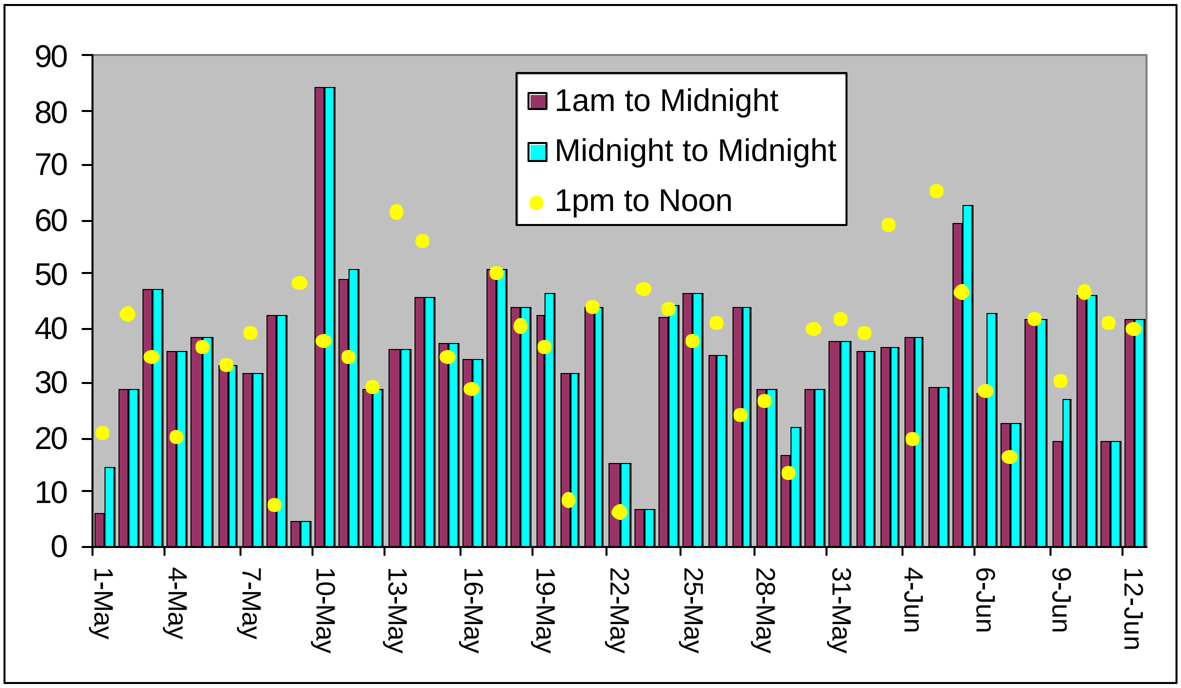

Figure 22. Comparison of mean daily fluctuation from Priest Rapids Dam using three different hourly time frames for calculation, hourly discharge, March 21 - April 30, 2004.

The effects of flow fluctuations on the overall health of the Hanford Reach and to other species of fish is outside the scope of this evaluation. Long-term tests by the University of Idaho and Streamside Programs Consultation on the effects of flow fluctuations show that benthic macroinvertebrates within the river fluctuation zone were severely limited in density and biomass compared to the communities on continually inundated areas (Stark 2001). Total invertebrate density was approximately four times higher on substrates never dewatered than on substrates exposed only 1 to 24 hours. Mean total invertebrate density and biomass from substrates exposed up to 24 hours were reduced by 59% and 65%, respectively, to substrates never dewatered. Effects of short-term exposure scenarios revealed that a dramatic decrease in survival was found with even short duration exposures to air. Artificial exposure tests revealed that survival of macroinvertebrates on substrates exposed to air decreased dramatically with increasing duration of exposure, with only 50% survival after 1 hour of exposure. Changes in discharge and water levels also catastrophically entrained macroinvertebrates into the drift outside of behavioral diel periodicity.

The Hanford Reach Fall Chinook Program limits daily flow fluctuations within a 24-hour period but does not address between day decreases in discharge and will not totally eliminate losses when discharges are reduced during decreased load demands on the weekends. The between day impacts can be substantial if large daily reset operations are needed to meet criteria for the following day. The Hanford Reach Fall Chinook Protection Plan is however a great improvement over pre-Plan operations during the emergence and rearing period for fall chinook in the Hanford Reach.

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Appendix A

Hanford Reach Fall Chinook Protection Program

Hanford Reach Fall Chinook Protection Program

This Agreement is made and entered into this ___ day of ____, 2004, between and among Public Utility District No. 2 of Grant County, Washington ("Grant"), Public Utility District No. 1 of Chelan County, Washington ("Chelan"), Public Utility District No. 1 of Douglas County, Washington ("Douglas"), the United States Department of Energy acting by and through the Bonneville Power Administration ("BPA"), NOAA Fisheries ("NOAAF"), the Washington Department of Fish and Wildlife ("WDFW") and the Confederated Tribes of the Colville Indian Reservation ("CCT"). Each of the above entities may be referred to individually as a "Party" or collectively as the "Parties"; NOAAF, WDFW and CCT may be referred to individually as an "Agency Party" or collectively as the "Agency Parties"; Grant, Chelan, Douglas and BPA may be referred to individually as an "Utility Party" or collectively as the "Utility Parties".

A. DEFINITIONS

"BPA's Friday Priest Rapids Outflow Estimates" – estimate of Priest Rapids Outflow for Saturday and Sunday provided by BPA on Friday afternoon based on expected operations at Chief Joseph Dam plus Side Inflows.

"Chief Joseph" – the Chief Joseph Dam located on the Columbia River System.

"Chief Joseph Uncoordinated Request" – the generation request which BPA determines is the desired output in megawatts of Chief Joseph at any time. Through the operation of Mid-Columbia Hourly Coordination, the Chief Joseph actual generation may be higher or lower than the Chief Joseph Uncoordinated Request. At any time, Chief Joseph Uncoordinated Request plus Chief Joseph bias must equal Chief Joseph actual generation.

"Corps of Engineers" – the United States Army Corps of Engineers.

"Critical Elevation" – the elevation on Vernita Bar at which the Protection Level Flow will be established as provided in subsection C.6.

"Critical Runoff Volume" – the volume of runoff for the January through July period at Grand Coulee for the year 1929 (42.6 million acre feet).

"Daylight Hours" – the time period from one hour before sunrise to sunset at Priest Rapids Dam.

"Emergence" – the point at which the water over eggs in Redds at Vernita Bar or other areas designated in Exhibit A have accumulated 1,000 (°C) Temperature Units after the Initiation of Spawning.

"Emergence Period" – the time period beginning with Emergence and continuing thereafter until 1,000 (°C) Temperature Units have been accumulated at Vernita Bar after the end of the Spawning Period.

“Hanford Reach” – an approximately 50-mile long section of the Columbia River extending from downstream of Priest Rapids Dam to just north of Richland, WA.

"Hatching" – the point at which the water over eggs in redds at Vernita Bar has accumulated 500 (°C) Temperature Units after the Initiation of Spawning.

"Holiday" – means any day designated as a national holiday in the Northwest Power Pool accounting procedures.

"Initiation of Spawning" – the Wednesday before the weekend on which the Monitoring Team first identifies five (5) or more Redds pursuant to subsection C.6. Separate dates for Initiation of Spawning will be set for the 36-50 kcfs zone and for the zone above 50 kcfs within areas identified in Exhibit A and in areas of the Hanford Reach below the 36kcfs level and/or outside the area specified in Exhibit A.

"kcfs" – thousand cubic feet per second.

"kcfs elevation" – the level along Vernita Bar reached by a specific rate of flow measured in kcfs.

"kcfs zone" – the area inundated by a specific rate of flow past Vernita Bar as measured in kcfs.

"kcfsh" – volume of water in thousand cubic feet per second hours.

"Mid-Columbia Hourly Coordination" – the operation of Grand Coulee, Chief Joseph, Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids pursuant to the "Agreement For The Hourly Coordination Of Projects On The Mid-Columbia River", effective July 1, 1997 through June 30, 2017, as such may be amended, extended, or replaced.

"Monitoring Team" – a group of three individuals composed of one fishery biologist designated by each of the following: (1) Grant PUD; (2) Washington Department of Fish and Wildlife; and (3) a signatory fishery agency or tribe.

"Post-Hatch Period" – the time period between Hatching and Emergence.

"Pre-Hatch Period" – the time period between the Initiation of Spawning and Hatching.

“Previous Day’s Average Weekday Wanapum Inflow” – the total volume of water discharged into the Wanapum development measured as a daily average discharge from Rock Island Dam. This measure is used from Monday to Friday to determine the allowable flow fluctuation during the Rearing Period and will be calculated based on data available to Grant that is reported on the Corps of Engineers website [http://nwd-wc.usace.army.mil/report/projdata.htm].

"Priest Rapids Project" – the Priest Rapids and Wanapum hydroelectric developments located on the Columbia River System.

“Priest Rapids” – the Priest Rapids Dam located on the Columbia River System.

"Priest Rapids Outflow" – the total volume of water discharged by Priest Rapids in any hour from all sources, measured in kcfs. For the purposes of the Spawning Period, Pre-Hatch Period, Post-Hatch Period and Emergence Periods, Priest Rapids Outflow shall be measured at the USGS station below Priest Rapids when possible. When USGS station data are not available and for the purposes of the Rearing Period, it will be calculated at Priest Rapids based on data available to Grant that are reported on the Corps of Engineers website [http://www.nwd-wc.usace.army.mil/report/projdata.htm].

"Priest Rapids Weekday Outflow Delta" – this is the difference between minimum Priest Rapids Outflow and maximum Priest Rapids Outflow over a 24 hr period beginning at 0001 hrs and extending to 2400 hrs. Priest Rapids Weekday Outflow Delta will be calculated at Priest Rapids based on data available to Grant that are reported on the Corps of Engineers website [http://www.nwd-wc.usace.army.mil/report/projdata.htm].

"Priest Rapids Weekend Outflow Delta" – this is the difference between minimum Priest Rapids Outflow and maximum Priest Rapids Outflow over a 48-hr period beginning at 0001 hrs on Saturday morning and extending to 2400 hrs on Sunday night. Priest Rapids Weekend Outflow Delta will be calculated at Priest Rapids based on data available to Grant that is reported on the Corps of Engineers website [http://www.nwd-wc.usace.army.mil/report/projdata.htm].

"Protection Level Flow" – the amount of water flowing over Vernita Bar which is needed to provide protection to Redds as specified in subsections C.2 through C.4 of this Agreement.

“Rearing Period” – the time period beginning with the start of the Emergence Period and continuing thereafter until 400 (°C) Temperature Units have been accumulated at Vernita Bar after the end of the Emergence Period.

“Redds” – defined area of riverbed material containing salmon eggs.

"Reverse Load Factoring" – the intentional reduction of power generation during Daylight Hours and the corresponding increase in power generation during hours of darkness for the purpose of influencing the location of Redds on Vernita Bar. Reverse Load Factoring does not include spilling at night to allow lower daytime flows.

"Rocky Reach" – the Rocky Reach Dam located on the Columbia River System.

"Side Inflows" – the algebraic sum of the flow rates of water entering or leaving the Columbia River from all sources between Chief Joseph and Priest Rapids as calculated by the method presently specified by Mid-Columbia Hourly Coordination.

"Spawning Period" – the time period beginning with the Initiation of Spawning and continuing until 2400 hours on the last Sunday prior to Thanksgiving.

"Temperature Unit" – one degree Celsius of water temperature above freezing (0°C) for 24 hours.

"Vernita Bar" – the gravel bar located in the Columbia River approximately four miles downstream from Priest Rapids.

"Wanapum" – the Wanapum Dam located on the Columbia River System.

"Wanapum Inflow" – the daily average flow rate for water flowing into the Wanapum reservoir calculated at Rock Island based on data available to Chelan.

"Wells" – the Wells Dam located on the Columbia River System.

B. SCOPE AND DURATION

1. Purpose of Agreement and Relationship to Prior Agreement

This Agreement establishes the obligations of the Parties with respect to the protection of fall Chinook in the Hanford Reach of the Columbia River. The Parties agree that during the term of the Agreement these flow regimes address all issues in the Hanford Reach with respect to fall Chinook protection and the impact of operation of the seven dams operating under Mid-Columbia Hourly Coordination, including the obligations of Grant, Chelan, and Douglas under any new licenses issued by the Federal Energy Regulatory Commission (FERC).
It is the intent of the Parties that this Agreement replaces and supersedes the original **June 16, 1988** Vernita Bar Agreement.

2. Term, Effectiveness, and Regulatory Approvals

(a) This Agreement shall become effective on the date of execution of this Agreement by all Parties and shall continue for a period equal to the remainder of the current license for Priest Rapids Project No. 2114, plus the term(s) of any annual license(s) and the next new Priest Rapids Project license which may be issued thereafter.

(b) By signing this Agreement, the Agency Parties represent that they have assembled and reviewed substantial evidence, and that based on that substantial evidence, they will recommend to FERC that this Agreement be approved in its entirety.

(c) Promptly after the execution of this Agreement, Grant shall file it with the FERC and request that FERC include appropriate conditions in the new license for the Priest Rapids Project reflecting the terms and conditions of this Agreement. All Parties agree to submit a statement of support of this Agreement to FERC within a reasonable time of Grant's filing. The Parties, however, shall, without limitation or qualification, commence implementation of this Agreement at the beginning of the 2004 Rearing period.

(d) In the event that FERC shall issue an order which makes any material modification to the terms of this Agreement, either by additions to or omissions from its terms, any Party may, within 60 days following the issuance of a FERC order denying a request for rehearing, withdraw from this Agreement after giving the other Parties 30 days written notice of its intention to do so and of the reasons for its decision to withdraw.

(e) The Agency Parties represent and stipulate that this Agreement shall constitute the agency Parties terms, conditions and recommendations for any FERC licensing process of the Utility Parties; including any such necessary filings with the Washington Department of Ecology Section 401 certification process with respect to protection of fall Chinook in the Hanford Reach of the Columbia River.

(f) The Parties represent and stipulate that all submittals and recommendations to FERC, including those to Washington Department of Ecology, for inclusion in the new licenses for the Priest Rapids Project, the Rocky Reach Project and the Wells Project will in all respects be consistent with the terms and conditions of this Agreement.

(g) An Utility Party may, upon 30-days notice, withdraw from this Agreement and be relieved of all obligations under this Agreement in the event FERC, the Washington Department of Ecology, or other regulatory authority imposes on such Party any measure inconsistent with this Agreement or additional obligations with respect to the protection of fall Chinook and other aquatic resources in the Hanford Reach of the Columbia River.

(h) Nothing in this Agreement will limit or prohibit any action by any Party based on non-compliance with this Agreement.

3. Reopener Limitation/Withdrawal

(a) No Party may petition the FERC directly, or through the Washington Department of Ecology, to modify any provision of this Agreement or request any flows, minimum flows or other operation that is inconsistent with this Agreement, until ten years from the effective date of this Agreement, unless such modification is jointly requested by all Parties.

(b) Ten years following the effective date of this Agreement, a Party may:

> (1) Request reopening of this Agreement and the imposition by the FERC of different, additional or modified fall Chinook protection measures for the Hanford Reach;
>
> (2) Bring any cause of action, raise any defense (including exhaustion of administrative remedies at the FERC) or claim, or rely on any theory in any appropriate forum;
>
> (3) Petition any other appropriate administrative agency or political body for relief, including the deletion of one or more measures otherwise in effect under this Agreement, or;
>
> (4) Take other appropriate action relating to any issue or matter addressed by this Agreement that could have been addressed by this Agreement or the Parties with respect to protection of aquatic resources in the Hanford Reach.

(c) In any action under this subsection B.3(b) the petitioning Party shall have the burden of proof. The Parties will continue to implement this Agreement until the relief sought becomes effective by operation of law, unless otherwise agreed.

(d) With respect to any petition or suit filed pursuant to this subsection B.3(b) and any subsequent judicial review thereof, nothing in this Agreement shall bar, limit or restrict any Party from raising any relevant issue of fact or law, regardless of whether such issue is or could have been addressed by this Agreement.

(e) Notwithstanding any other provisions of this subsection B.3(b) any Party may participate in any legislative or administrative proceeding dealing with fish protection or compensation issues; provided that no Party may contend on its own behalf, or support any contention by other persons in any proceeding or forum, including the Northwest Power and Conservation Council, the Washington Department of Ecology Section 401 certification process, and/or Congress, that additional or different measures for protection of fall Chinook salmon in the Hanford Reach should be imposed on any Party until a period of ten years following the effective date of this Agreement has passed.

4. Stipulation of Adequacy

For ten years from the effective date of this Agreement, the Parties stipulate as follows:

(a) Performance of the requirements of Grant, Chelan, Douglas and BPA under this Agreement shall constitute acceptable protection of fall Chinook in the Hanford Reach, taking into account both hydropower and fishery needs.

(b) Performance by any Utility Party of its obligations under this Agreement satisfies the obligations of such Party with respect to protection of fall Chinook salmon in the Hanford Reach arising under applicable laws and regulations, including but not limited to the Endangered Species Act, the Federal Power Act as amended by the Electric Consumers Protection Act of 1986, the Pacific Northwest Electric Power Planning and Conservation Act, the Fish and Wildlife Coordination Act and the Magnuson-Stevens Fisheries Conservation and Management Act. In any and all disputes, proceedings and hearings under the above applicable laws and regulations, the Parties will support the adequacy of protection for fall Chinook salmon in the Hanford Reach pursuant to this Agreement.

(c) Performance by any Party of its obligations under this Agreement shall constitute compliance with the applicable provisions of the Northwest Power and Conservation Council's Fish and Wildlife Program as currently written.

C. HANFORD REACH FALL CHINOOK PROTECTION

Subject to the limitations and conditions set out in this Agreement, Grant, Chelan, Douglas and BPA shall provide the following flow regimes for the Spawning through Rearing Period for Hanford Reach fall Chinook salmon in the Hanford Reach of the Columbia River.

1. Spawning Period

(a) All Parties agree that flows maintained during the Spawning Period and escapement levels are factors influencing the placement of Redds. The flow manipulation under this subsection C.1 is directed to minimize formation of Redds above the 70 kcfs elevation. Minimizing formation of Redds above the 70 kcfs elevation in turn is a key factor influencing the success of the flow regime under subsection C.4 during the Emergence Period.

(b) During the Spawning Period(s) of 2005 and 2006, Grant will experiment with alternative operations for flow manipulation. The requirement of the alternative operations will be to ensure that Priest Rapids Outflows are not higher than 70 kcfs and not lower than 55 kcfs for a continuous period of at least 12 hours out of each day during the Spawning Period. Grant will provide continuous monitoring of Redd formation during these tests and report the results weekly. These experiments may continue as long as no more than 31 Redds are located above the 65 kcfs elevation on Vernita Bar. If Redd counts reveal that more than 31 Redds are located above the 65 kcfs elevation, Spawning Period operations will default to the procedures of C.1(c) below. If Redd counts show that alternative Spawning Period operations can limit the formation of Redds above 70 kcfs, then Grant shall be allowed to choose between use of C.1(b) or C.1(c) as guidelines for operational parameters during the Spawning Period of future years.

(c) If the experimental operations testing during C.1(b) above are unsuccessful in minimizing formation of Redds above the 70 kcfs elevation, Grant's operations will revert to the default operation specified in this paragraph. During the Spawning Period, Grant will operate Priest Rapids Project No. 2114 to the extent feasible through use of the Mid-Columbia Hourly Coordination and Reverse Load Factoring to produce a Priest Rapids Outflow during Daylight Hours that can range from 55 to 70 kcfs. The goal during the Spawning Period is to limit spawning to the area below the 70 kcfs elevation on Vernita Bar. In the event physical changes are made at the Priest Rapids Project which affect Grant's ability to provide Reverse Load Factoring, Grant agrees to meet with the Parties to this Agreement to determine what adjustments to Grant's obligation under this subsection C.1(c) shall be made, notwithstanding the provisions of subsections B.4 and B.5.

(d) The Parties agree that BPA has no obligation under this Agreement to limit fall flows to influence Redd location. This is, however, without prejudice to the rights of any Party to assert, except before the FERC prior to ten years from the effective date of this Agreement, that BPA may have an obligation apart from this Agreement to limit such flows and the rights of any Party to request cooperation of BPA, the Bureau of Reclamation and the Corps of Engineers to limit such flows. The Parties agree to work together to obtain the cooperation of BPA, the Bureau of Reclamation and the Corps of Engineers to achieve the desired flow regime.

2. Pre-Hatch Period

During the Pre-Hatch Period the Priest Rapids Outflow may be reduced to 36 kcfs for up to 8 hours on weekdays and 12 hours on weekends (with no two consecutive minimum periods). All Parties recognize that utilization of the 36 kcfs minimum may have to be limited to achieve the Priest Rapids Outflow goal during the Spawning Period.

3. Post-Hatch Period

(a) After Hatching has occurred at Redds located in the 36 to 50 kcfs zone, the Protection Level Flow shall be maintained over Vernita Bar so that the intergravel water level is no less than 15 cm below the 50 kcfs elevation.

(b) After Hatching has occurred at Redds located in the zone above the 50 kcfs elevation, the Protection Level Flow shall be maintained over Vernita Bar through the Post Hatch Period so that the intergravel water level is no less than 15 cm below the Critical Elevation.

4. Emergence Period

(a) During the Emergence Period, after Emergence has occurred in the 36 to 50 kcfs zone, the Protection Level Flow shall not be less than necessary to maintain water over Vernita Bar at the 50 kcfs elevation.

(b) During the Emergence Period, after Emergence has occurred above the 50 kcfs elevation, the Protection Level Flow shall be maintained at or above the Critical Elevation.

5. Rearing Period

(a) All Parties recognize that flow fluctuations during the Rearing Period may impact juvenile Hanford Reach fall Chinook. The Parties also recognize that elimination of all flow fluctuations is not physically possible without severely impacting the ability of Mid-Columbia Operators to produce a reliable supply of electricity. The goal during the Rearing Period is to provide a high level of protection for juvenile Hanford Reach fall Chinook rearing in the Hanford Reach by limiting flow fluctuations while retaining operational flexibility at each of the seven dams on the Mid-Columbia River.

(b) During the Rearing Period, Grant will operate Priest Rapids Project No. 2114 to the extent feasible through use of the Mid-Columbia Hourly Coordination to produce a Priest Rapids Outflow that limits flow fluctuations according to the following criteria:

> (1) When the Previous Day's Average Weekday Wanapum Inflow is between 36 and 80 kcfs limit Priest Rapids Weekday Outflow Delta to no more than 20 kcfs. When the average of BPA's Friday Chief Joseph Outflow Estimates plus side flow estimates for Saturday and Sunday is between 36 and 80 kcfs limit the Priest Rapids Weekend Outflow Delta to no more than 20 kcfs.

(2) When Previous Day's Average Weekday Wanapum Inflow is between 80 and 110 kcfs limit Priest Rapids Weekday Outflow Delta to no more than 30 kcfs. When the average of BPA's Friday Chief Joseph Outflow Estimates plus side flow estimates for Saturday and Sunday is between 80 and 110 kcfs limit the Priest Rapids Weekend Outflow Delta to no more than 30 kcfs.

(3) When Previous Day's Average Weekday Wanapum Inflow is between 110 and 140 kcfs limit Priest Rapids Weekday Outflow Delta to no more than 40 kcfs. When the average of BPA's Friday Chief Joseph Outflow Estimates plus side flow estimates for Saturday and Sunday is between 110 and 140 kcfs limit the Priest Rapids Weekend Outflow Delta to no more than 40 kcfs.

(4) When Previous Day's Average Weekday Wanapum Inflow is between 140 and 170 kcfs limit Priest Rapids Weekday Outflow Delta to no more than 60 kcfs. When the average of BPA's Friday Chief Joseph Outflow Estimates plus side flow estimates for Saturday and Sunday is between 140 and 170 kcfs limit the Priest Rapids Weekend Outflow Delta to no more than 60 kcfs.

(5) When Previous Day's Average Weekday Wanapum Inflow is greater than 170 kcfs Priest Rapids Outflow for the following weekday will be at least 150 kcfs. When the average of BPA's Friday Chief Joseph Outflow Estimates plus side flow estimates for Saturday and Sunday is greater than 170 kcfs, Priest Rapids Outflow for Saturday and Sunday will be at least 150 kcfs.

(6) On four consecutive Saturdays and Sundays that occur after 800 TUs have accumulated after the end of the Spawning Period, Priest Rapids Outflow will be maintained to at least a minimum flow calculated as the average of the daily hourly minimum flow from Monday through Thursday of the current week.

(c) All Parties agree that perfect compliance with the flow constraints of C.5(b) is not possible. Conditions related to inflow, reservoir elevation, accuracy of BPA estimates, emergencies and human error can contribute to exceeding the Priest Rapids Outflow Delta or Priest Rapids Outflow dropping below minimums specified. Grant will make every effort to meet the operating constraints.

On Monday, following lower flows from the weekend it is not considered a violation of the provisions in C.5(b) when Monday inflows require increasing the Priest Rapids discharge above the upper limit established at midnight on Sunday. If the upper limit is raised on Monday, the lower limit must be raised to allow the difference between the maximum and new minimum flow to remain within the applicable Priest Rapids Weekday Outflow Delta limit.

Problems can be expected from time to time. Grant will detail the circumstances associated with its inability to meet these constraints in the annual report described under C.6(c). In addition to annual reporting, the Parties agree to use the dispute resolution process described under E.9 whenever any Party claims excessive non-compliance.

6. Monitoring Team

For purposes of determining the Protection Level Flow during the Post Hatch and Emergence Periods, a Critical Elevation shall be determined each year as follows:

(a) The Monitoring Team will survey Redds on Vernita Bar in the area specified on Exhibit A for the purpose of determining the Initiation of Spawning, the location of Redds and the extent of spawning. The Monitoring Team will also provide a concurrent aerial survey of the Hanford Reach on the same weekend(s). The aerial survey(s) will be utilized to determine if Initiation of Spawning in areas of the Hanford Reach below the 36 kcfs level and/or outside the area specified on Exhibit A occurs prior to Initiation of Spawning within the Exhibit A area above the 36 kcfs level. Once an initiation of Spawning date has been determined, based upon the presence of 5 or more redds in an individual survey, the aerial surveys maybe discontinued for that year. The surveys will be conducted on weekends beginning on the weekend prior to October 15 of each year.

(b) The Monitoring Team will make a final Redd survey the weekend prior to Thanksgiving to determine the Critical Elevation. The Monitoring Team may also make a supplemental Redd survey the weekend after Thanksgiving to determine if additional Redds are present above the 50 kcfs elevation. A preliminary estimate of the Critical Elevation will be made following the final Redd survey and will be confirmed or adjusted based on the supplemental survey. The Critical Elevation will be set as follows: (Elevations must be in 5 kcfs increments beginning at the 40 kcfs elevation.)

(1) If 31 or more Redds are located above the 65 kcfs elevation, the Critical Elevation will be the 70 kcfs elevation.

(2) If there are 15 to 30 Redds above the 65 kcfs elevation, the Critical Elevation will be the 65 kcfs elevation.

(3) If there are fewer than 15 Redds above the 65 kcfs elevation, then the Critical Elevation will be the first 5 kcfs elevation above the elevation containing the 16th highest Redd within the survey area on Vernita Bar (see Table 1 below for examples of the application of these counts).

Table 1. Examples illustrating theoretical final Vernita Bar Redd counts and the resulting Critical Elevations, elevations are provided in kcfs ranges.

	36-50 kcfs	50-55 kcfs	55-60 kcfs	60-65 kcfs	65-70 kcfs	70+ kcfs	Resulting Critical Elevation
Example 1	836	418	148	71	48	34	70
Example 2	283	94	65	28	16	4	65
Example 3	105	35	10	3	1	0	55

(c) Additional activities of the Monitoring Team will include calculation of Temperature Units, determination of the dates of Initiation of Spawning, Hatching, Emergence, the end of the Emergence Period and the end of the Rearing Period. The Monitoring Team may also make non-binding recommendations to any of the Parties to this Agreement, including non-binding recommendations to protect Redds above the Critical Elevation or to address special circumstances. By September 1 of the following year, Grant will submit an annual report to the Monitoring Team and BPA. The annual report will include, but not be limited to: 1) Vernita Bar Redd Counts, 2) dates on which the Hatching, Emergence, End of Emergence and End of Rearing Periods occurred, 3) a record of Columbia River flows through the Hanford Reach based on Priest Rapids discharges, and 4) a description of the actual flow regimes from the Initiation of Spawning through the Rearing Period based on available data. During the rearing period, Grant will provide a weekly operations report to the Parties. After review by the Monitoring Team, the final report will be sent to all Parties. During the Rearing Periods of 2011, 2012 and 2013, the Parties will also meet to develop a follow-up monitoring program to estimate fry losses. This monitoring program will be designed according to protocols developed from 1999 to 2003 or alternatively with different methods developed by the Parties.

(d) If from time to time, disputes arise regarding activities of the Monitoring Team, the Parties agree to use the dispute resolution process described under E.9 below.

7. Redds Above Critical Elevation

This Agreement is not intended either to preclude or require protection of Redds above the Critical Elevation. The Parties shall meet annually to determine if there are measures that, in the joint discretion of Grant, Chelan, Douglas and BPA, can be taken to protect any Redds located above the Critical Elevation.

D. RIVER OPERATIONS

In order to achieve the required Protection Level Flows during the Post Hatch and Emergence Periods and to provide the desired flow regimes during the Rearing Period, Grant, Chelan, Douglas and BPA agree to the following:

1. Weekday Request

On any day other than a Saturday, Sunday or Holiday, BPA shall provide a Chief Joseph Uncoordinated Request that will, on a daily average basis and when converted from megawatts to Chief Joseph discharge, be not less than the Protection Level Flow minus Side Inflows. For example, if the Critical Elevation is established at 65 kcfs, BPA shall be required to submit a Chief Joseph Uncoordinated Request during the periods described in subsections C.3(b) and C.4(b) which is not less than (but nothing in this Agreement shall require the request to be greater than) 65 kcfs minus Side Inflows on a daily average basis. For Saturdays, Sundays, and Holidays, the Chief Joseph Uncoordinated Request shall not be less than the amounts set out in subsections D.2 and D.3 below.

2. Saturday Request

Beginning 0000 hours on any Saturday, BPA may reduce the Chief Joseph Uncoordinated Request so long as the Saturday midnight accumulation of the difference between the resulting Chief Joseph discharge and the Protection Level Flow minus the Side Inflows does not exceed 925 kcfsh. The accumulated difference calculated above will be identified as the Chief Joseph Accumulated Deficiency (CJAD).

3. Sunday or Holiday Request

On any Sunday or Holiday, BPA may reduce the Chief Joseph Uncoordinated Request so long as the midnight CJAD does not exceed 854 kcfsh.

4. Post-Sunday or Holiday Deficiency

Following any Sunday or Holiday, BPA shall provide a Chief Joseph Uncoordinated Request so that CJAD does not exceed at midnight on any day the CJAD of the preceding midnight. On any weekend or holiday weekend when CJAD exceeds 0, BPA shall provide Chief Joseph Uncoordinated Requests such that CJAD will return to zero by 1200 hours on Wednesday of the following week.

5. Weekends During the Rearing Period

(a) BPA will provide flows necessary to meet the four weekend minimum flows as provided in C.5(b)(6). However, on any Saturday and Sunday of the prescribed four weekends BPA may reduce the Chief Joseph Uncoordinated Request so long as the resultant Sunday midnight accumulation of the difference between the resulting Chief Joseph discharge and the established weekend minimum flow minus the side inflows does not exceed the following criteria: 1) 925 kcfsh on Saturday at midnight, 2) 854 kcfsh on Sunday or any holiday at midnight.

(b) The accumulated difference calculated above will be identified as the Chief Joseph Accumulated Deficiency – II (CJAD-II). On all four designated weekends when CJAD-II exceeds 0, BPA shall provide Chief Joseph Uncoordinated Requests such that CJAD-II will return to zero by 1200 hours on Wednesday of the following week.

6. Grant, Chelan, Douglas and BPA Drafts and Refill

(a) Spawning through Emergence Period provisions are as follows:

(i) Grant, Chelan and Douglas shall utilize the actual discharges from the Chief Joseph Project and Side Inflows to meet the required Protection Level Flow. To the extent that actual discharges from the Chief Joseph Project, together with Side Inflows, are insufficient to meet the Protection Level Flow, Grant, Chelan and Douglas shall make up the deficiency by drafting their reservoirs in the following order and quantities to the extent required to comply with the flow regimes specified in this Agreement: 1) Grant will draft up to 3 feet from Priest Rapids, 2) Grant will draft up to 2 feet from Wanapum,

3) Chelan will draft up to 1 foot from Rocky Reach, (4) Douglas will draft up to 1 foot from Wells, and 5) Grant will draft up to 0.7 feet from Priest Rapids; provided, that in lieu of so drafting their reservoirs, Grant, Chelan and Douglas may, upon their agreement, draft their reservoirs in any alternative manner which provides the equivalent amount of total draft. Subsequent refill of the reservoirs shall be accomplished in the reverse order of draft (i.e., 0.7 feet at Priest Rapids, 1 foot at Wells, 1 foot at Rocky Reach, 2 feet at Wanapum and 3 feet at Priest Rapids) or in an alternative manner by agreement of Grant, Chelan and Douglas.

(ii) After BPA has met its Chief Joseph Uncoordinated Request obligations, and after Grant, Chelan and Douglas have provided the drafts described above, additional water may still be required from time to time on a short-term basis to meet the flow regimes specified in this Agreement. Such additional water may be required to the extent that: 1) actual discharges from the Chief Joseph Project differ from Chief Joseph discharges which would have resulted from Chief Joseph Uncoordinated Requests, and/or 2) the CJAD exceeds, from time to time, 925 kcfsh. Whenever such additional water is required on a short-term basis, it will be provided by the draft of all seven dams associated with the operation of Mid-Columbia Hourly Coordination in proportion to 50% Federal and 50% Non-Federal contribution on a content basis.

(b) During the Rearing Period prescribed in C.5 Grant will operate Priest Rapids Project No. 2114 to limit flow fluctuations and maintain a minimum flow for the four designated weekends as described in C.5(b) through the following provisions:

(i) After drafts of 1 foot from each of Wanapum and Priest Rapids (or combination thereof) have been provided, Chelan and Douglas will provide drafts of up to 1 foot from Rocky Reach and Wells Projects. All drafts will be measured from a pre-determined baseline.

(ii) After conditions under (i) above have been provided, Grant will draft Wanapum and/or Priest Rapids beyond 1 foot each as necessary to meet the rearing requirements under C.5., limited to a total equivalent draft of 3.7 feet at Priest Rapids and 2 feet at Wanapum.

(iii) Chelan, Douglas and Grant, upon their agreement may draft their reservoirs in any alternative manner, which provides an equivalent amount of total draft.

(iv) After BPA has met its Chief Joseph Uncoordinated Request obligations, and after Grant, Chelan and Douglas have provided the drafts described above, additional water may still be required from time to time on a short-term basis to meet the flow regimes of C.5. Such additional water may be required to the extent that: 1) actual discharges from the Chief Joseph Project differ from Chief Joseph discharges which would have resulted from Chief Joseph Uncoordinated Requests, and/or 2) the CJAD-II exceeds, from time to time, 925 kcfsh. Whenever such additional water is required on a short-term basis, it will be provided by the draft of all seven dams associated with the operation of Mid-Columbia Hourly Coordination in proportion to 50% Federal and 50% Non-Federal contribution on a content basis.

7. BPA Request Requirements

BPA shall provide sufficient generation requests and hourly coordination operating parameters for Grand Coulee and Chief Joseph via Mid-Columbia Hourly Coordination such that the discharge from Chief Joseph, which would result absent modification by non-Federal generation requests via Mid-Columbia Hourly Coordination, would not be less than the flows required in subsections D.1 through D.5 above.

8. Relationship to Section C

Nothing in the foregoing subsections D.1 through D.7 shall limit or diminish the obligations of the Parties under Section C.

9. Draft at Mid-Columbia Projects

Notwithstanding any other provision of this Agreement, Grant, Chelan and Douglas shall not be required to draft their respective reservoirs in a manner which would be inconsistent with the requirements of any applicable FERC license or to a level less than one (1) foot above the applicable FERC license minimum reservoir elevation. At any time that a reservoir is within one (1) foot above the applicable FERC license minimum reservoir elevation, that project shall have no further obligation under this Agreement except to pass the inflow entering that project's reservoir.

Whenever the sum of the remaining pondage in Priest Rapids, Wanapum, Rocky Reach, and Wells is less than 1500 kcfsh, Grant, Chelan, Douglas and BPA shall confer to coordinate operations regarding the maintenance of the Protection Level Flow or operations necessary to meet Priest Rapids Weekday and Weekend Outflow Delta limits during the Rearing Period.

10. Excuse of Performance

In the event any performance by any Party is rendered impossible by an act of the Bureau of Reclamation or the Corps of Engineers which is beyond the control of such Party, such performance shall be excused until the cause of such impossibility is removed or eliminated.

11. Adverse Water Conditions

When the National Weather Service/Soil Conservation Service Joint official March 1, January-July volume of runoff forecast at Grand Coulee is less than the Critical Runoff Volume, the Parties will meet prior to any reductions and discuss an allocation of available flows between power interests, fishery interests at the Hanford Reach and other nonpower interests. After such discussions, BPA may reduce its flow requests below those required under Section D resulting in a proportional reduction in the Protection Level Flow and Critical Elevation, provided that such reductions are approximately proportional to the adverse impact on Columbia River firm hydropower generation from the reduced flow volume, and provided that failure to refill shall not be the determining factor in measuring such adverse impacts. In no event shall the effect of this paragraph result in a reduction in the Protection Level Flow of greater than 15% or below 50 kcfs, whichever provides for a higher Protection Level Flow.

12. Instantaneous Minimum Flow for the Hanford Reach

The Parties further agree that a minimum instantaneous release of 36 kcfs from Priest Rapids Dam as measured at USGS gauge No. 12472800 will be maintained during all time periods except for those times when maintenance of the Protection Level Flow and Rearing Period operation constraints require a higher instantaneous minimum flow. The Parties agree that this minimum flow was historically intended to provide general protection for aquatic resources, water quality, recreation, and operation of water intakes of the Hanford Reservation and other beneficial uses of the Hanford Reach of the Columbia River.

E. MISCELLANEOUS

1. No Prejudice

All Parties stipulate that, except as expressly provided herein neither FERC approval nor any Party's execution of this Agreement shall constitute approval or admission of, or precedent regarding, any principle, fact or issue in any FERC or in any other administrative or judicial proceeding, including subsequent modification proceedings under Section B of this Agreement.

2. Waiver of Default

Any waiver at any time by any Party hereto of any right with respect to any other Party or with respect to any matter arising in connection with this Agreement shall not be considered a waiver with respect to any subsequent default or matter.

3. Entire Agreement—Modifications

All previous communications between the Parties hereto, either verbal or written, with reference to the subject matter of this Agreement are hereby abrogated, and this Agreement duly accepted and approved, constitutes the entire Agreement between the Parties hereto, and no modifications of this Agreement shall be binding upon any Party unless executed or approved in accordance with the procedures set forth in Section B.

4. Benefit

This Agreement shall be binding upon and inure to the benefit of the Parties hereto and their successor and assigns.

5. Force Majeure

No Party shall be liable for failure to perform or for delay in performance due to any cause beyond its control. This may include, but is not limited to, fire, flood, terrorism, strike or other labor disruption, act of God or riot. The Party whose performance is affected by a force majeure will make all reasonable efforts to promptly resume performance once the force majeure is eliminated.

6. Execution

This Agreement may be executed in counterparts. A copy with all original executed signature pages affixed shall constitute the original Agreement. The date of execution shall be the date of the final Party's signature.

7. Authority

Each Party to this Agreement hereby represents and acknowledges that it has full legal authority to execute this Agreement and shall be fully bound by the terms hereof.

8. Captions

Captions and titles used to identify sections of this Agreement are for the convenience of the Parties and shall not have any substantive meaning.

9. Dispute Resolution

(a) Disputes covering issues associated with the implementation of this Hanford Reach fall Chinook Protection Program shall be subject to the dispute resolution procedures.

(b) In the event that a dispute arises over an issue associated with the implementation of the Hanford Reach fall Chinook Protection Program, the Party raising the issue shall provide written notice of the issue and the supporting rationale to each Party to the Agreement. Within five days of receipt of such notice, the Parties shall develop a subcommittee to review the disputed issue(s). The subcommittee shall be composed of one (1) representative of each Party. Within twenty (20) days of receipt of notice of a dispute, the subcommittee shall seek to resolve the dispute. Parties shall endeavor in good faith to reach a resolution of the dispute using the best available information.

(c) At the end of the twenty (20) day period, the appropriate subcommittee shall provide a report to the Parties describing the outcome of their efforts under Section C.8(b), above. In the event that the subcommittee has identified a proposed resolution that is consistent with terms of the Hanford Reach fall Chinook Protection Program, the report shall describe the proposed resolution, the basis for the proposed resolution, and such additional information as may be necessary to support the proposed resolution. In the event that the subcommittee was unable to resolve the dispute, the report shall describe the remaining issues in dispute, the efforts to resolve them, and any additional information pertinent to resolving the outstanding issues in a timely manner.

(d) Upon receipt of a report described above, the Parties, within thirty (30) days, will approve or disapprove the proposed resolution. In the event that it approves the proposal, the Parties will implement the resolution as accepted. In the event that the resolution requires the regulatory approval of FERC or another regulatory entity, Grant PUD, with the support of the Parties, shall seek prompt approval of the resolution by FERC or the relevant regulatory authority, and the appropriate Party or Parties shall proceed with its implementation upon receipt of the required approval. In the event that the report identifies unresolved issues, the Parties shall undertake to resolve the matter according to procedures identified in the Alternative Dispute Resolution section below.

(e) Alternative Dispute Resolution: The Parties may use non-binding alternative dispute resolution (ADR) procedures involving a third-party mediator and in cooperation with FERC representatives to seek a resolution of an outstanding dispute that could not be resolved by the designated subcommittee. The Parties shall cooperate in good faith to promptly schedule, attend and participate in the ADR, and to devote the time, resources and attention to the ADR as may be necessary to attempt to resolve the dispute as promptly as possible.

(f) Final Action: If, by the end of the thirty (30) day period (or the period otherwise agreed to), the Parties have not resolved the dispute, any Party may petition FERC for a remedy.

10. Relationship to Mid-Columbia Hourly Coordination

This Agreement is not intended to prohibit Grant, Chelan, Douglas or BPA from exercising their rights to give notice of termination of the Agreement for Hourly Coordination of Projects on the Mid-Columbia River according to its terms. The termination of that agreement shall not relieve any Party from its obligations under this Agreement.

IN WITNESS WHEREOF, the Parties have executed this Agreement the day and year first written above.

Appendix B

Hanford Reach Fall Chinook Protection Program

Fall Chinook Escapement for the Hanford Reach, 1964-2003.

Year	Adult	Jack	Total
2003	89,312	11,196	100,840
2002	69,342	15,167	84,509
2001	44,140	15,708	59,848
2000	36,027	11,993	48,020
1999	27,012	2,800	29,812
1998	29,410	5,983	35,393
1997	34,007	9,486	43,493
1996	37,548	5,701	43,249
1995	38,381	16,827	55,208
1994	48,857	14,246	63,103
1993	30,650	6,697	37,347
1992	29,449	12,503	41,952
1991	31,971	20,225	52,196
1990	40,117	17,034	57,151
1989	65,913		
1988	74,034		
1987	88,762		
1986	72,559		
1985	65,796		
1984	41,982		
1983	36,022		
1982	20,543		
1981	15,115		
1980	21,861		
1979	23,558		
1978	20,578		
1977	31,527		
1976	21,140		
1975	22,242		
1974	25,847		
1973	33,044		
1972	26,749		
1971	31,398		
1970	26,730		
1969	34,939		
1968	24,067		
1967	23,188		
1966	28,079		
1965	24,360		
1964	24,048		