Public Workshop Comments
Issue 8. River Flows: San Joaquin River at Airport Way Bridge, Vernalis:
February – April 14 and May 16 – June

Triennial Review of the 1995 Water Quality Control Plan
For the San Francisco Bay/Sacramento-San Joaquin Delta Estuary

State Water Resources Control Board
March 21-23, 2005

Comments of the California Department of Fish & Game

The Department appreciates the opportunity to provide input to the State Water Resources Control Board's (Board) Triennial Review Workshop regarding assessment of water quality standards established by the Board for the benefit of protecting fish and wildlife species dependent on the Delta. The Board is seeking input regarding the adequacy of river flows in the San Joaquin River at Airport Way Bridge, Vernalis from February – April 14 and May 16 – June (e.g., Issue 8) to protect fish and wildlife beneficial uses. The Board's specific Issue #8 questions are:

Question #1: Should the SWRCB amend flow objectives for the San Joaquin River at Airport Way Bridge, Vernalis, for February through April 14 and May 16 through June in the Water Quality Objectives for Fish and Wildlife Beneficial Uses (Table 3 of the 1995 Plan)[1]?

Question #2: Should the SWRCB change the methodology for determining the applicable San Joaquin River flow objectives that currently are determined by reference to the required Delta Inflow objective? How should the methodology for determining required flows be modified and what are the scientific and legal arguments in support of and against modification?

The Department offers the following information, comments, and recommendations in response to the Board's Workshop Issue #8.

Issue 8, Question #1: Should the SWRCB amend flow objectives for the San Joaquin River at Airport Way Bridge, Vernalis, for February through April 14 and May 16 through June in the Water Quality Objectives for Fish and Wildlife Beneficial Uses (Table 3 of the 1995 Plan)?

1. Status of SJR Fall-run Chinook Salmon:

Fall-run Chinook salmon populations in the SJR tributaries are in recent years less than the 1967-1991 average upon which the narrative doubling goal was developed (Table 1). The Department is concerned that even with the flow objectives in the 1995 Plan, SJR salmon populations are showing a declining trend. This trend causes the Department to believe that in-river and in-Delta production losses maybe controlling production of fall-run Chinook salmon in the SJR. This result raises the question of whether the existing February through June flow objectives, before, during or after the VAMP period, are providing adequate protection for salmon beneficial use in the SJR.

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[1] State Water Resources Control Board Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (May 1995) Salmon Protection Table 3 Water Quality Objectives for Fish and Wildlife Beneficial Uses:

Dissolved Oxygen: San Joaquin River between Turner Cut & Stockton (6 mg/l)

Salmon Protection: Water quality conditions shall be maintained together with other measures in the watershed, sufficient to achieve a doubling of natural production of chinook salmon from the average production of 1967-1991, consistent with the provisions for State and Federal law.

San Joaquin River Salinity: San Joaquin River at and between Jersey Point and Prisoners Point, measured as Electrical Conductivity at maximum 14-day running average of mean daily level of 0.44.

Table 1. San Joaquin River Fall-run Chinook Salmon Escapement Population Status

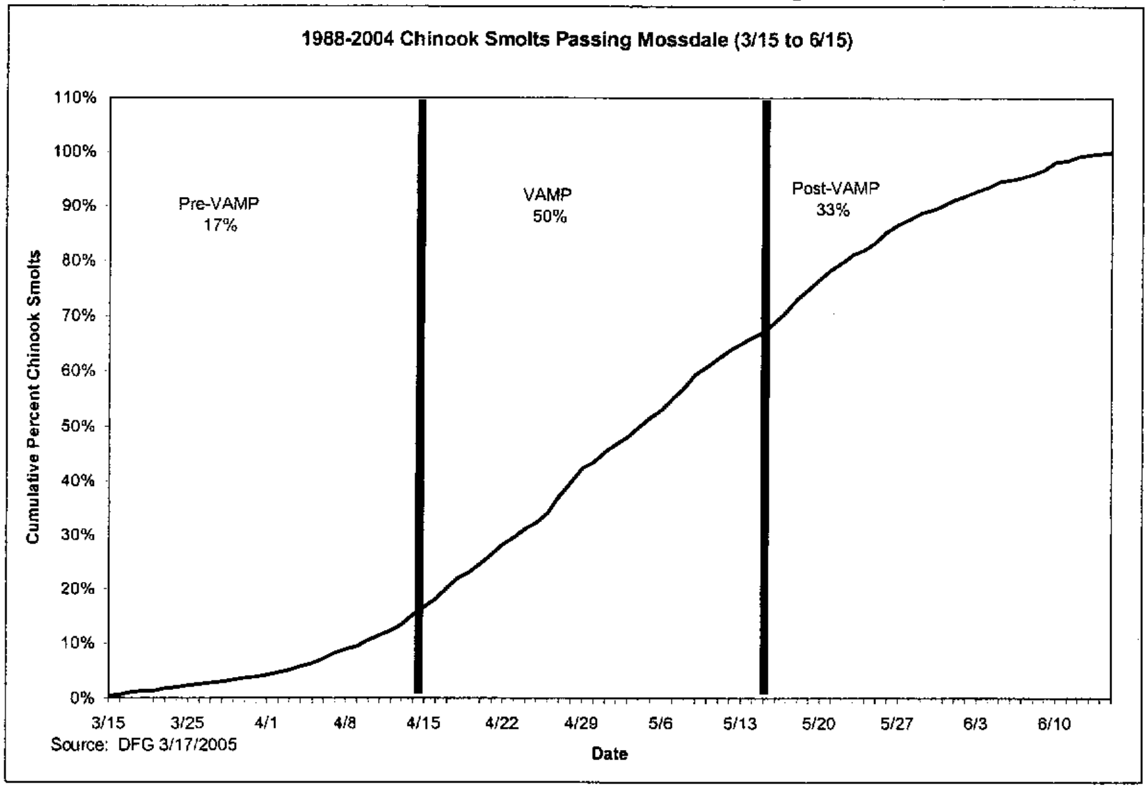
Time Frame	Average Escapement	Doubling Goal
1967-1991	18, 211	36,000
1992-2004	13,855	

2. Duration of Vernalis Target Flow Temporally Too Narrow to Protect Salmon Beneficial Use:

In establishing VAMP, the Board recognized that the smolt life history stage was the predominate life history stage contributing to adult escapement and established SJR Vernalis flow objectives (e.g., magnitude, duration, and seasonal window) to protect this key salmon life history stage. SJR fall-run Chinook salmon smolt out-migration from the east-side tributaries through the south Delta begins in mid-March and extends to mid-June, a period of about 90 days. The prime out-migration salmon smolt time frame remains April 1 through May 31, a period of about 60 days. In establishing VAMP, and the April 15th to May 15th time window for increased flows at Vernalis the Board expected to be affording protection for 66% to 75% of SJR basin out-migrating salmon smolts. However, based on more current information from the Department's Kodiak Trawl sampling on the San Joaquin River at Mossdale (1988-2004) the 31-day VAMP window is affording increased protection for only about 50% of SJR out-migrating salmon smolts (Figure 1). This temporally narrow window of protection for out-migrating salmon smolts relative to the typical out-migration period is of great concern to the Department given the continued declining trend of the SJR salmon populations. Figure 1 shows that 17% of out-migrating smolts pass Mossdale prior to the VAMP protection window (e.g., Apr. 1 thru Apr. 14), and 33% of smolts pass Mossdale after the VAMP window (e.g., May 16 to June 30).

If the Delta Inflow Standard Target Flows as measured at Vernalis were to be expanded from the current VAMP time period to Apr. 1 thru May 31, the percentage of salmon smolts afforded protection would rise from about 50% to 85%.

Figure 1. SJR Cumulative Percent Salmon Smolt Catch Passing Mossdale (1988-2004).



3. Influence of Delta Inflow Magnitude, Duration, and Frequency of Minimum Flow Standard, as measured at Vernalis and Adult SJR Salmon Production

Introduction:

SJR salmon populations appear to rise and fall generally in response to wet and dry year cycles and the amount of water flowing into the south Delta from the SJR. South Delta SJR inflow is strongly correlated with subsequent adult salmon production (Figures 2 and 3). This relationship and the declining trend in populations of SJR salmon, combined with the less than conclusive results to date from VAMP studies, prompted the Department to suggest to the Board at the workshop in January that there is a need now for a comprehensive review to:

(i) evaluate the adequacy and efficacy of the water provided in protecting migrating salmon;

(ii) assess the likelihood that the VAMP studies as presently designed will enable us to differentiate the impacts of Delta inflow from Delta diversions with a temporary, and eventually a permanent, barrier operated at the head of Old River;

(iii) enable timely consideration of needed changes and the sources of water which might be used to affect needed changes in the study design as effectively and efficiently as possible.

Figure 2. Vernalis Flow Level and Escapement 2.5 Years Later

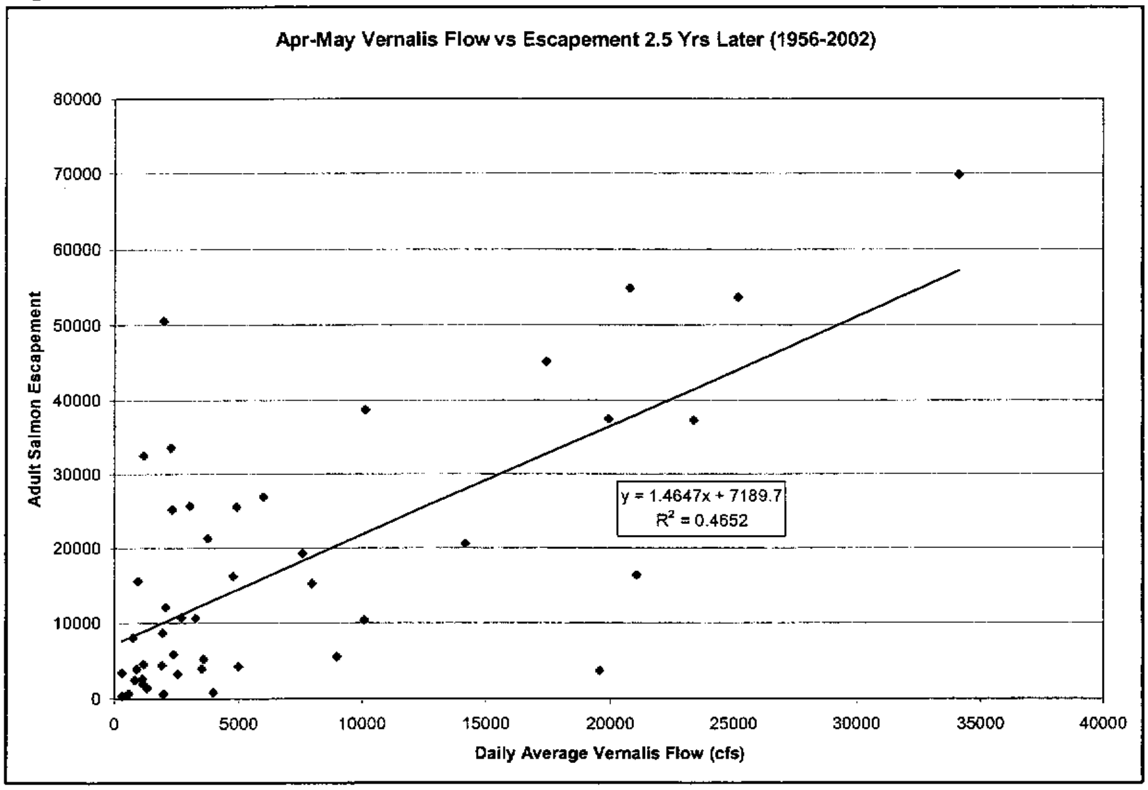
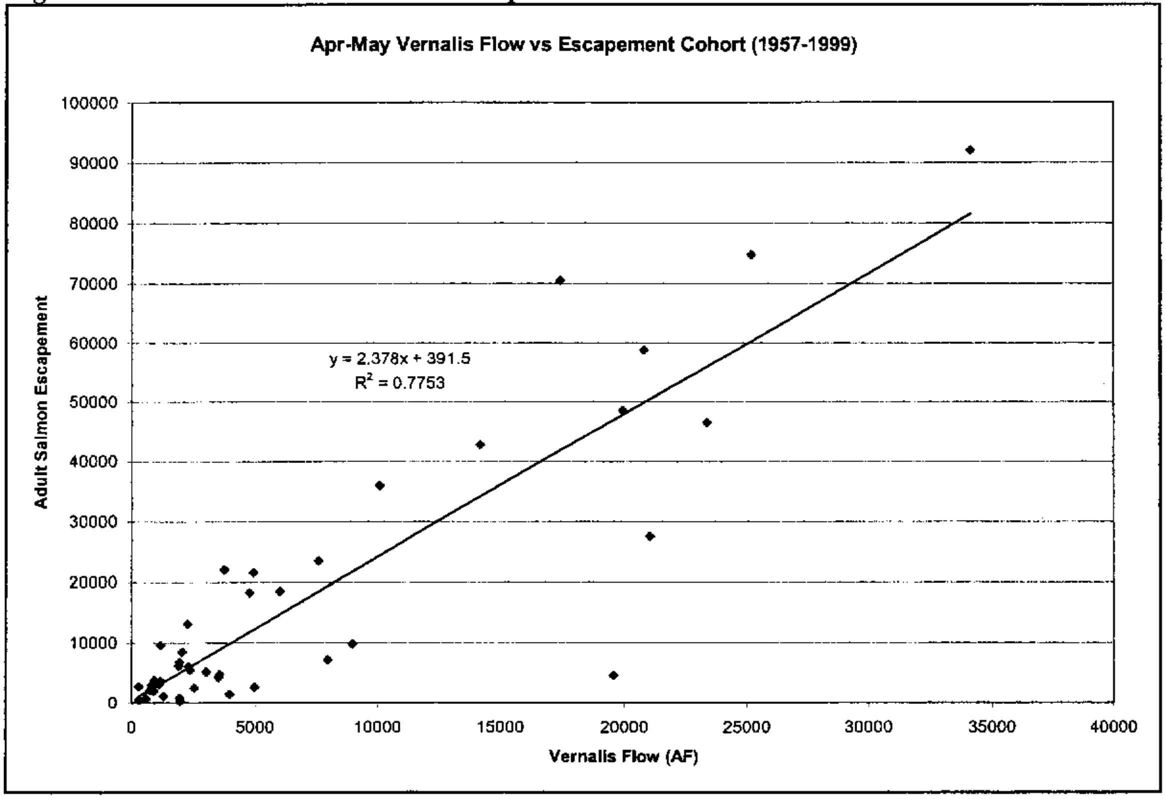


Figure 2. SJR Delta Inflow vs SJR Escapement Cohort 1957-1999.



Note: Flow data from USGS gage at Vernalis

The Department believes that salmon production in the SJR basin is largely influenced by flow magnitude, flow duration, and frequency of suitable flow levels in the SJR at Vernalis and the SJR east-side tributaries, during the salmon smolt life history stage, especially in the drier years. Based on monitoring in recent years, about 50% of salmon smolts out-migrate before Mid-April or after mid-May and thus do not receive protection from conditions provided during the VAMP window (Figure 1). The Department believes that increasing the Delta Inflow Standard Target Flows, prolonging the VAMP window of protection from April 1 to May 31, and changing the frequency of Standard minimum flow levels, that substantial gains in adult salmon escapement are possible. To evaluate this hypothesis the Department conducted a simple assessment, for the 1988 thru 2004 time period[2]. This assessment is based upon: (i) empirical relationships between Delta Inflow as measured at Vernalis; (ii) salmon smolt abundance per the Department's Mossdale Kodiak Trawl (1988 thru 2004); (iii) salmon smolt survival thru the south Delta from Mossdale to Chipp's Island; (iv) the abundance of SJR salmon smolts passing Chipp's Island; and (v) eventual adult escapement. Flow and exports were assumed to be held at VAMP levels for all of the following analyzes. The purpose of conducting this analysis was to examine potential changes in SJR adult salmon escapement that might be expected if changes were made in the magnitude, duration, and frequency of minimum Standard flows at Vernalis. Results of these analyses are pertinent to the issue and question before the Board (e.g., Issue#8:Questions #1) and suggest that substantive changes in SJR adult salmon escapement could occur with substantial changes in the Standard or Target Flow. The following south Delta Inflow changes were evaluated:

<u>Delta Inflow Magnitude (Apr. 15 thru May 15):</u>

Years1988 thru 2004 were used to predict what the salmon escapement might have been if the Delta inflow target minimum flow was incrementally increased from 3200 to 4450, from 3200 to 5700, from 3200 to 7000, and from 3200 to 10000[3] cfs. Table 2 shows the actual VAMP time period average flows for years 1988 thru 2004.

To predict adult salmon escapement resulting from the fraction of salmon smolts out-migrating through the South Delta during the VAMP time period (e.g., Apr. 15 thru May 15) for the years 1988 through 2004 the following computations were performed: (i) calculated average daily Delta Inflow level as measured at Vernalis; (ii) identified number of salmon smolts passing Mossdale during the VAMP time period; (iii) estimated salmon smolt survival rate to Chipp's Island from Mossdale using the survival to flow regression relationship equation identified for the "Head of Old River Barrier in Place"

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[2] 1988-2004 time frame represents the duration of DFG's Kodiak Trawl survey at Mossdale on the SJR.

[3] The 10,000 cfs flow level was added as the 1995 Water Quality Control Plan, and subsequent VAMP experiment, realized that the current SJR Delta Inflow Standard maximum inflow level of 7,000 cfs was an artificial ceiling created by flow limitations associated with the temporary Head of Old River Barrier. The Department in its D-1621 Phase 8 testimony identified flows in excess of 7,000 being needed to adequately protect salmon beneficial uses in the south Delta, and needing to be evaluated as part of the VAMP experiment once a permanent HORB was constructed.

from data obtained in 2000 to 2004 VAMP Annual Reports (Figures 4 and 5)[4], (iv) estimated number of smolts surviving to Chipp's Island; and (v) estimated number of returning adult salmon based upon the regression relationship of number of SJR smolts at Chipp's island and numbers of returning adult salmon (Figures 6[5] & 7[6]). The increased number of returning adults estimated to occur by increasing flow level is not compounded from year to year (i.e., no additional smolt production as adult abundance increases) is this assessment (see later section).

Table 2: Delta Inflow as Measured at Vernalis (USGS)

	Vernalis Daily Average Flow (cfs)		
Year	Pre-VAMP 4/1 – 4/14	VAMP 4/15 – 5/15	Post-VAMP 5/16 - 5/31
1988	1,865	2,093	1,484
1989	1,704	2,168	1,726
1990	1,239	1,280	1,273
1991	1,355	1,048	988
1992	1,616	1,250	712
1993	3,292	3,915	2,836
1994	1,631	2,110	1,780
1995	21,503	19,636	23,125
1996	7,946	6,501	10,165
1997	4,101	5,314	3,887
1998	22,087	19,381	18,627
1999	5,624	6,892	4,327
2000	4,811	5,873	4,085
2001	2,280	4,049	2,945
2002	1,822	3,300	2,319
2003	2,031	3,223	2,170
2004	2,270	3,157	2,159

[4] Note: Original Mossdale to Chipp's Survival Relationship (Figure 4) resulted in survival estimates greater than 100%. By forcing the Y-intercept thru zero (Figure 5) survival estimates >100% were eliminated. The regression relationship depicted in Figure 5 is the one used in these assessments.

[5] The regression relationship depicted in Figure 6 is derived by taking the Mossdale Smolt Production Index (e.g., estimated number of out-migrating smolts for any given year), applying the smolt survival relationship between Mossdale and Chipp's Island to estimate the number of smolts out-migrating past Chipp's Island then regressing smolt numbers against adult salmon cohort escapement (e.g., that number of overall adults (recruits), comprised of the multi-age groups of 2, 3, 4, and 5 year old adult salmon that return over a four year period post smolt out-migration year). The reconstructed adult cohort data was provided by Dr. Carl Messick (Carl Messick Consultants) upon request by the Department, and consists of reconstructing SJR adult escaping cohorts by applying coded wire tagged salmon return data from the Sacramento River basin.

[6] Figure 7 uses the same data depicted in Figure 6, but the regression relationship is forced thru zero to prevent adult estimates that are greater than the number of smolts producing the estimate.

Figure 4. Mossdale to Chipp's Island Flow vs. Survival Regression (*y intercept <0*)

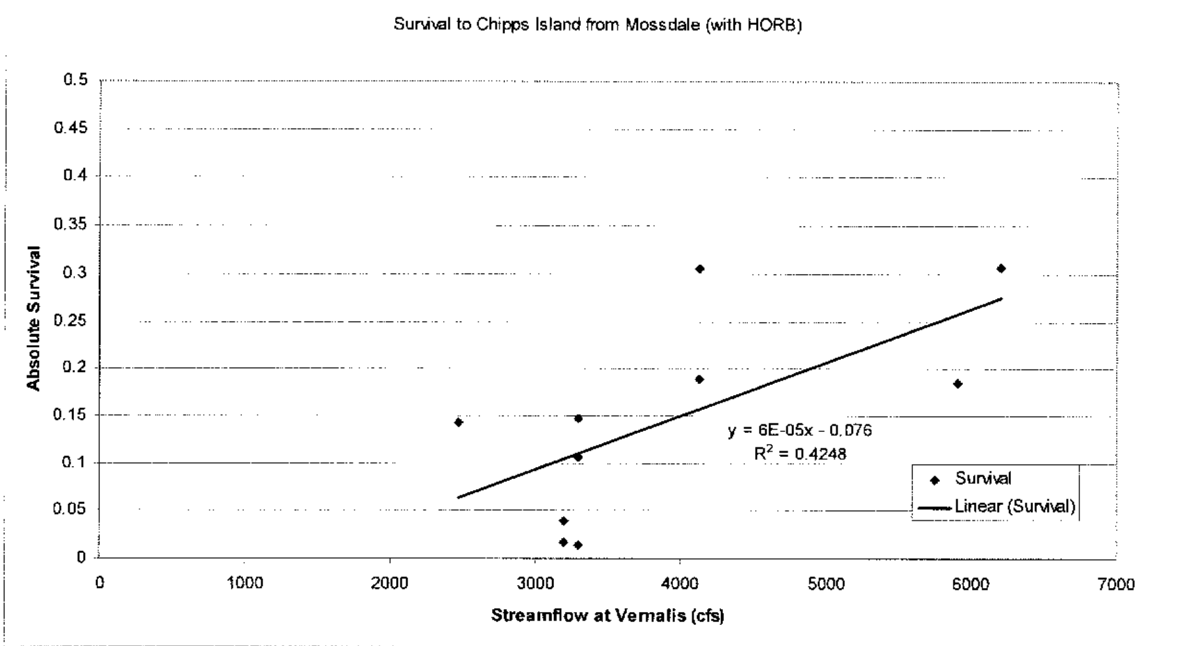


Figure 5. Mossdale to Chipp's Island Flow vs. Survival Regression (*with zero Y intercept*)

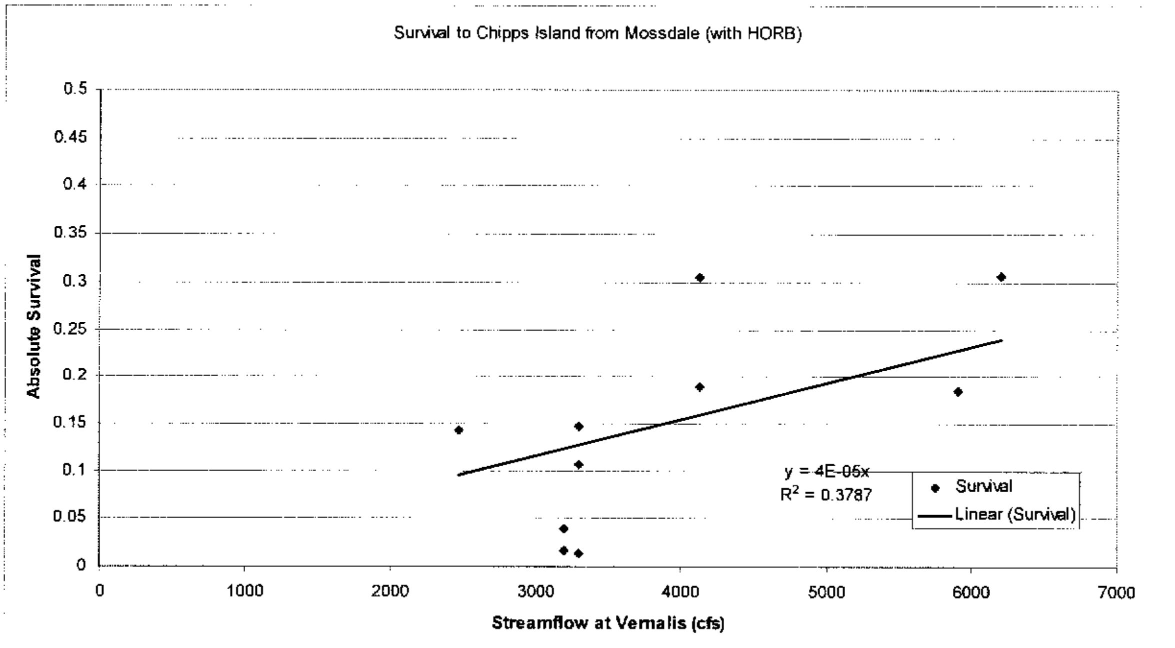


Figure 6. Chipp's Island Smolt Abundance vs. Escaping Adult Salmon (*y intercept >0*)

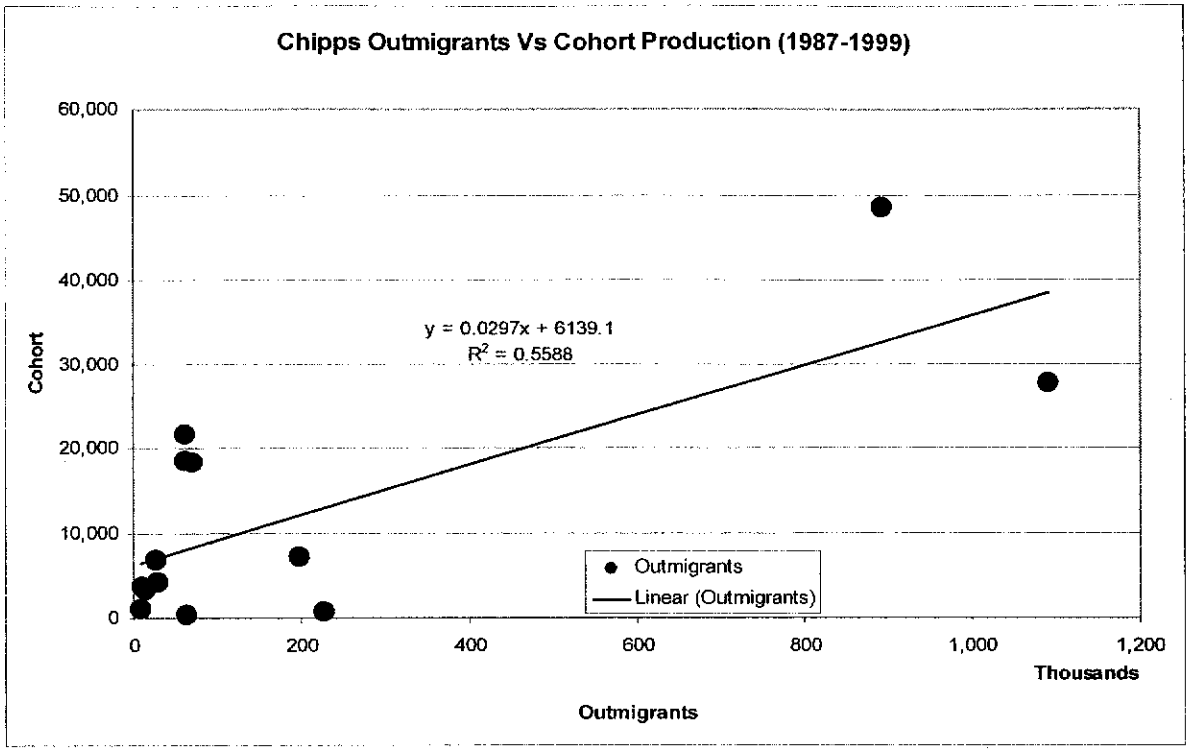
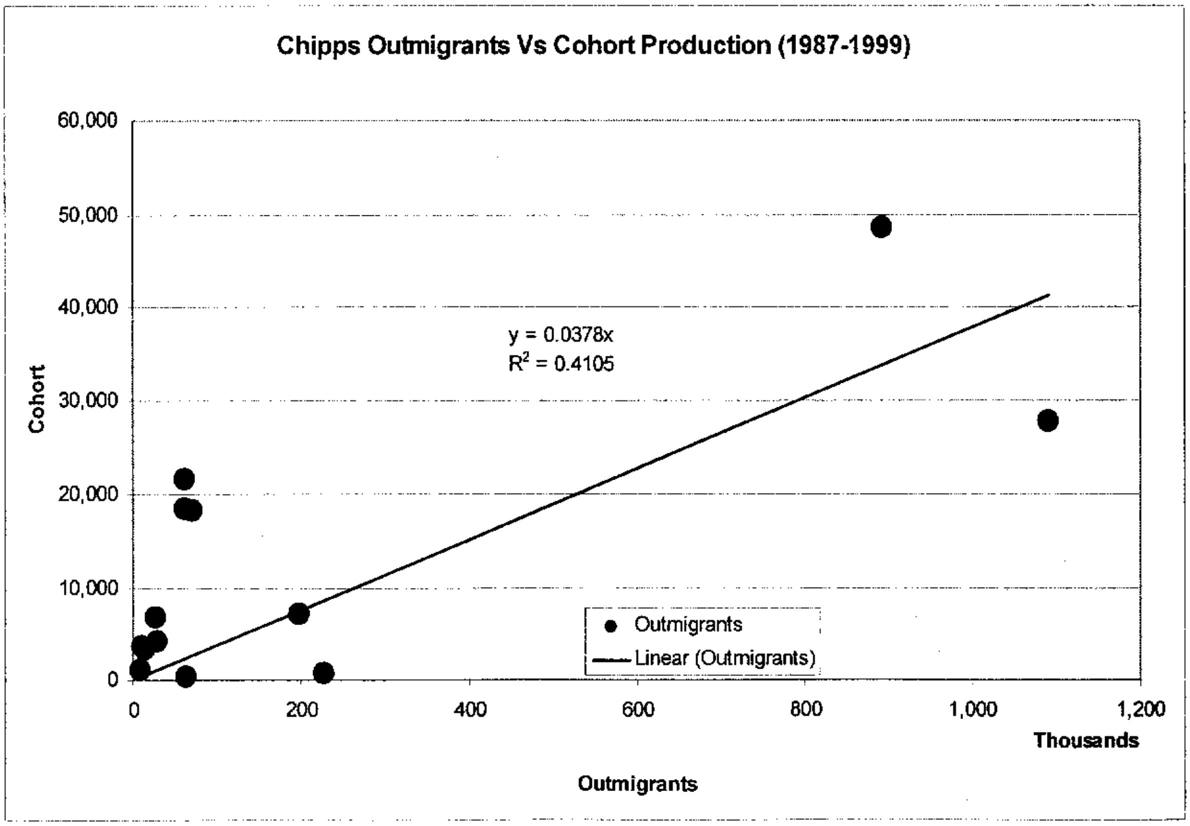


Figure 7. Chipp's Island Smolt Abundance vs. Escaping Adult Salmon (*zero y intercept*)



Results of this simple assessment are provided in Table 3. By adjusting historical flows up to VAMP Standard flow levels (e.g., 3200, 4450, 5700, 7000 etc), comparisons between Delta Inflow Standard Target Flows, as compared to the historical production, could be made. An example of the calculation used in preparing the estimates used for comparison is provided below. Results for the Delta Inflow minimum target flow level of 3200 cfs are provided in Table 4. Estimates for other VAMP flow level targets (e.g., 4450, 5700, & 7000) were also prepared but are not shown in detail. Table 5 shows the combined results of these analyzes. These results show a conservative estimate of the gains in adult salmon escapement, that could be achieved by evaluating the Delta Inflow Standard Target Flows by different amounts during the VAMP time period, and suggest that by incrementally increasing the Delta Inflow Standard Target Flows during the VAMP time period substantial gains in adult escapement are possible. History tends to confirm this as well.

Table 3. Predicted Salmon Escapement 1988 thru 2004 Based on the Estimated Number of Smolts passing Mossdale during VAMP Time Period

VAMP Time Period Historical Base Adult Salmon Escapement Production					
Year	Estimated Smolt Outmigrant Production	Vernalis Flow	Mossdale to Chipp's Island Survival Index	Smolts Surviving to Chipp's Island[7]	Predicted Subsequent Escapement
1988	816,852	2,093	8.37%	67703	2,559
1989	2,926,014	2,168	8.67%	251,207	9,496
1990	188,887	1,280	5.12%	9,574	362
1991	433,493	1,048	4.19%	17,990	680
1992	198,320	1,250	5.00%	9,817	371
1993	197,964	3,915	15.66%	30,691	1,160
1994	344,196	2,110	8.44%	28,760	1,087
1995	85,138	19,636	78.54%	66,202	2,502
1996	674,512	6,501	26.00%	173,646	6,564
1997	221,361	5,314	21.26%	46,582	1,761
1998	720,286	19,381	77.52%	552,811	20,896
1999	122,857	6,892	27.57%	33,530	1,267
2000	163,654	5,873	23.49%	38,061	1,439
2001	477,803	4,049	16.20%	76,111	2,896
2002	565,248	3,300	13.20%	73,867	2,792
2003	429,976	3,223	12.89%	54,878	2,074
2004	269,568	3,157	12.63%	53,754	2,032
				Average	**3,526**

Note: Vernalis Flow Years 2000 thru 2004 were official VAMP Years (e.g., 2000 (5700 cfs), 2001 (4450 cfs), 2002-4 (3200 cfs).

[7] Estimated number of smolts surviving to Chipp's Island are a function of multiplying the Mossdale salmon smolt outmigrant production estimate by 0.99 to account for loss of smolts thru the HORB (per data reported in VAMP Annual Reports), then multiplying the result by the Mossdale to Chipp's Island Survival Index.

Predicted VAMP Time Period Escapement Prediction Equation:
*(Annual Mossdale Outmigrant Production Estimate[8] - HORB Loss (1%)) * (Mossdale to Chipp's Island Vernalis Flow vs. Survival Index) * Chipp's Island Outmigrant to Future Year Cohort Regression) = Predicted Escapement*

Table 3 VAMP Time Period Example (1988):
*((816,852-8169) * 8.3720%) * (0.0378) = 2,559*

Table 4. Estimated Salmon Escapement Based on Number of Smolts Passing Mossdale during VAMP Time Period and Adjusting Historical VAMP Period Flows at Vernalis to a Minimum of 3200 cfs from 1988 thru 2004.

VAMP Time Period Historical Vernalis Flows Modified to VAMP Target Flow Levels and Predicted Subsequent Escapement Estimates					
Year	Mossdale Outmigrant Production	Vernalis Flow[9]	Mossdale to Chipp's Island Survival Index	Smolts Surviving to Chipp's	Predicted Subsequent Escapement
1988	816,852	3,200	12.80%	103511	3,913
1989	2,926,014	3,200	12.80%	370,785	14,016
1990	188,887	3,200	12.80%	23,936	905
1991	433,493	3,200	12.80%	54,932	2,076
1992	198,320	3,200	12.80%	25,131	950
1993	197,964	4,450	17.80%	34,885	1,319
1994	344,196	3,200	12.80%	43,617	1,649
1995	85,138	19,636	78.54%	66,202	2,502
1996	674,512	7,000	28.00%	186,975	7,068
1997	221,361	5,700	22.80%	49,966	1,889
1998	720,286	19,381	77.52%	552,811	20,896
1999	122,857	7,000	28.00%	34,056	1,287
2000	163,654	**5,873**	23.49%	38,061	1,439
2001	477,803	**4,049**	16.20%	76,111	2,896
2002	565,248	**3,300**	13.20%	73,867	2,792
2003	429,976	**3,223**	12.89%	54,878	2,074
2004	269,568	**3,157**	12.63%	53,754	2,032
				Average	**4,100**

[8] For time period of consideration. Here is that portion of the smolts estimated to have passed Mossdale from April 1 thru May 31.
[9] Years in bold (2000 thru 2004) were official VAMP Vernalis flow years therefore, flows for these years were not adjusted to exactly the VAMP flow target levels for these years but were left as they occurred.

Table 5. Comparison of Estimated Adult Salmon Escapement Increase with Flow Increase During the VAMP Period.

1988-2004 Estimated Adult Salmon Production Comparison without VAMP, with VAMP, and With Higher VAMP Minimum Vernalis Flow Targets (Apr. 15 thru May 15)					
Without VAMP Production Average	Vernalis Flow Targets				
	3200	4450	5700	7000	10000
3,526	4,100 (+14%)	4,826 (+27%)	5,597 (+37%)	6,425 (+45%)	8,589 (+59%)

<u>Delta Inflow Duration (Apr. 1 to 14 and May 16 to 31):</u>

The Department evaluated the potential effect on adult salmon escapement with increasing the duration when the Delta Inflow target flows are provided. The years 1988 thru 2004 were analyzed to determine what the predicted salmon escapement estimate might be if the Delta Inflow Standard Target Flows duration were extended from the 31-day VAMP time period to the 61-day period from Apr. 1 thru May 31. Following the same procedure outlined above for assessing the effects of Delta Inflow Magnitude, daily average flow data for the Apr. 1 to Apr. 14 and May 16 to May 31 time periods were calculated (Table 6) and referred to as the base case in terms of estimated adult salmon production for the Apr. 1 to Apr. 14 and May 16 to May 31 time periods. When flow in the pre and post-VAMP time periods was below 3200 cfs, flows were increased to 3200 cfs (Table 7). Pre and post-VAMP time period minimum flow increases above 3200 were made by changing the pre & post-VAMP time period flows to 4450, 5700, 7000, and 10,000 (not shown). An example of the pre and post-VAMP flow extension calculations are provided below.

<u>Predicted Pre-VAMP Flow Extension Escapement Prediction Equation:</u>
*(Annual Mossdale Outmigrant Production Estimate for Pre-VAMP time period - HORB Loss (1%)) * (Mossdale to Chipp's Island Vernalis Flow vs. Survival Index) * Chipp's Island Outmigrant to Future Year Cohort Regression) = Predicted Escapement*

Pre-VAMP Extension Prediction Example (1988):
*(((114,656-1147) * (7.46%)) * (0.0378)) = 320*

<u>Predicted Post-VAMP Flow Extension Escapement Prediction Equation:</u>
*(Annual Mossdale Outmigrant Production Estimate for Post-VAMP time period - HORB Loss (1%)) * (Mossdale to Chipp's Island Vernalis Flow vs. Survival Index) * Chipp's Island Outmigrant to Future Year Cohort Regression) = Predicted Escapement*

Post-VAMP Extension Prediction Example (1988):
*(((151,041-1,510) * 5.94 %)) * (0.0378)) = 336*

Table 6. 1988 to 2004 Historical Vernalis Flows for Pre (4/1-4/14) & Post (5/16-5/31) VAMP Time Periods

Estimated Adult Salmon Production without Expanding VAMP Flow Protection Levels into Pre (4/1-4/14) & Post (5/16-5/31) VAMP Time Periods										
Year	Mossdale Out-migrant Production		Vernalis Flow		Mossdale to Chipp's % Survival		Projected #Smolts to Chipp's		Projected Escapement Cohort Production	
	Pre-VAMP 4/1 - 4/14	Post-VAMP 5/16 - 5/31	Pre-VAMP 4/1 – 4/14	Post-VAMP 5/16 – 5/31	Pre-VAMP 4/1 - 4/14	Post-VAMP 5/16 - 5/31	Pre-VAMP 4/1 - 4/14	Post-VAMP 5/16 - 5/31	Pre-VAMP 4/1 - 4/14	Post-VAMP 5/16 - 5/31
1988	114,656	151,041	**1,865**	**1,484**	7.46%	5.94%	8,468	8,876	320	336
1989	366,741	1,005,536	**1,704**	**1,726**	6.82%	6.90%	24,747	68,728	935	2,598
1990	11,049	65,737	**1,239**	**1,273**	4.96%	5.09%	542	3,314	20	125
1991	89,853	57,537	**1,355**	**988**	5.42%	3.95%	4,821	2,251	182	85
1992	71,990	12,411	**1,616**	**712**	6.46%	2.85%	4,607	350	174	13
1993	23,970	22,367	**3,292**	**2,836**	13.17%	11.34%	3,125	2,512	118	95
1994	85,712	29,659	**1,631**	**1,780**	6.52%	7.12%	5,536	2,091	209	79
1995	0	933,344	**21,503**	**23,125**	86.01%	92.50%	0	854,709	0	32,308
1996	92,062	151,379	**7,946**	**10,165**	31.78%	40.66%	28,968	60,935	1,095	2,303
1997	147,249	162,634	**4,101**	**3,887**	16.40%	15.55%	23,913	25,034	904	946
1998	109,456	423,177	**22,087**	**18,627**	88.35%	74.51%	95,735	312,147	3,619	11,799
1999	28,028	117,175	**5,624**	**4,327**	22.50%	17.31%	6,242	20,078	236	759
2000	102,670	156,792	**4,811**	**4,085**	19.24%	16.34%	19,560	25,364	739	959
2001	67,300	231,636	**2,280**	**2,945**	9.12%	11.78%	6,076	27,014	230	1,021
2002	52,408	90,574	**1,822**	**2,319**	7.29%	9.28%	3,781	8,318	143	314
2003	39,558	64,732	**2,031**	**2,170**	8.12%	8.68%	3,182	5,563	120	210
2004	23,570	31,651	**2,270**	**2,159**	9.08%	8.64%	3,556	5,534	134	209
								Average	**540**	**1,366**

Table 7. 1988 to 2004 Modified (to 3200 base minimum) Vernalis Flows for Pre (4/1-4/14) & Post (5/16-5/31) VAMP Time Periods

Estimated Adult Salmon Production By Expanding VAMP Target Minimum Flow Protection Levels (up to 3200) into Pre (4/1-4/14) & Post (5/16-5/31) VAMP Time Periods										
	Mossdale Outmigrant Production		Vernalis Flow		Mossdale to Chipp's % Survival		Projected #Smolts to Chipp's		Projected Escapement Cohort Production	
Year	Pre-VAMP 4/1 - 4/14	Post-VAMP 5/16 - 5/31	Pre-VAMP 4/1 - 4/14	Post-VAMP 5/16 – 5/31	Pre-VAMP 4/1 - 4/14	Post-VAMP 5/16 - 5/31	Pre-VAMP 4/1 - 4/14	Post-VAMP 5/16 - 5/31	Pre-VAMP 4/1 - 4/14	Post-VAMP 5/16 - 5/31
1988	114,656	151,041	**3,200**	**3,200**	12.80%	12.80%	14,529	19,140	549	723
1989	366,741	1,005,536	**3,200**	**3,200**	12.80%	12.80%	46,473	127,422	1,757	4,817
1990	11,049	65,737	**3,200**	**3,200**	12.80%	12.80%	1,400	8,330	53	315
1991	89,853	57,537	**3,200**	**3,200**	12.80%	12.80%	11,386	7,291	430	276
1992	71,990	12,411	**3,200**	**3,200**	12.80%	12.80%	9,123	1,573	345	59
1993	23,970	22,367	**3,292**	**3,200**	13.17%	12.80%	3,125	2,834	118	107
1994	85,712	29,659	**3,200**	**3,200**	12.80%	12.80%	10,861	3,758	411	142
1995	0	933,344	**21,503**	**23,125**	86.01%	92.50%	0	854,709	0	32,308
1996	92,062	151,379	**7,946**	**10,165**	31.78%	40.66%	28,968	60,935	1,095	2,303
1997	147,249	162,634	**4,101**	**3,887**	16.40%	15.55%	23,913	25,034	904	946
1998	109,456	423,177	**22,087**	**18,627**	88.35%	74.51%	95,735	312,147	3,619	11,799
1999	28,028	117,175	**5,624**	**4,327**	22.50%	17.31%	6,242	20,078	236	759
2000	102,670	156,792	**4,811**	**4,085**	19.24%	16.34%	19,560	25,364	739	959
2001	67,300	231,636	**3,200**	**3,200**	12.80%	12.80%	8,528	29,353	322	1,110
2002	52,408	90,574	**3,200**	**3,200**	12.80%	12.80%	6,641	11,478	251	434
2003	39,558	64,732	**3,200**	**3,200**	12.80%	12.80%	5,013	8,203	189	310
2004	23,570	31,651	**3,200**	**3,200**	12.80%	12.80%	5,013	8,203	189	310
								Average	**659**	**1,586**

Table 8. Comparison of Estimated Increase in Salmon Escapement with Duration of the Delta Inflow Standard Extended to the Pre-VAMP Time Period.

1988-2004 Estimated Adult Salmon Production Comparison Pre-VAMP Window (Apr. 1 thru Apr. 14) Extended					
Without Pre-VAMP Window Protection Production Average	Vernalis Flow Targets				
	3200	4450	5700	7000	10000
540	659 (+18%)	770 (+30%)	900 (+40%)	1,042 (+48%)	1,386 (+61%)

Table 9. Comparison of Estimated Increase in Salmon Escapement with Duration of the Delta Inflow Standard Extended to the Post-VAMP Time Period.

1988-2004 Estimated Adult Salmon Production Comparison Post-VAMP Window (May 16 thru May 31)					
Without Post-VAMP Window Protection Production Average	Vernalis Flow Targets				
	3200	4450	5700	7000	10000
1,366	1,586 (+14%)	1,811 (+25%)	2,072 (+34%)	2,343 (+42%)	2,916 (+53%)

Note: 1995 removed as >90% outmigrated after May 15 with an average flow of >20,000 cfs and the results of this one year (32,000) swamp improvements made by much smaller flow incremental changes in other years.

Based upon the estimated number of out-migrating smolts passing Mossdale each year during the pre- and post-VAMP periods, adult salmon escapement predictions were computed for each of the 17-year flow data sets with minimum Delta Inflow target flow levels (e.g., 3200, 4450, 5700, & 7000 cfs). Extending the Delta Standard into the Apr. 1 to Apr. 14, and May 16 to May 31, time frames for the Vernalis south Delta inflow Standard flow levels of 3200, 4450, 5700, 7000, and a 10000 cfs show that substantial gains in adult salmon escapement are possible from improving migration conditions for smolts in these periods (Tables 8 (Pre-VAMP) and 9 (Post-VAMP)). Table 10 shows the combined Pre & Post VAMP Delta Inflow target flow duration extension, with predicted salmon escapement, for 3200, 4450, 5700, 7000, and 10,000 cfs minimum flow levels.

Table 10. Comparison of Estimated Increase in Salmon Escapement with Duration of the Delta Inflow Standard Extended to the Pre & Post-VAMP Time Periods.

1988-2004 Estimated Adult Salmon Production Comparison Post-VAMP Window (Apr. 1 thru Apr .14 & May 16 thru May 31)					
Without Pre & Post-VAMP Window Protection Production Average	Vernalis Flow Targets				
	3200	4450	5700	7000	10000
1,906	2,245 (+15%)	2,581 (+26%)	2,972 (+36%)	3,385 (+44%)	4,302 (+56%)

Combined VAMP Magnitude and Duration Flow Increase Escapement Estimate Comparison

Combining the predicted increases for the VAMP and both pre and post VAMP time frame target flow increases (Table 11) suggests that substantial cumulative increases in adult salmon escapement are possible by extending the VAMP time period and by increasing the VAMP target flow level.

Table 11. Combined VAMP Magnitude, and both Pre & Post VAMP Delta Inflow Standard Target Flow Duration Estimated Average Salmon Escapement

1988-2004 Estimated Adult Salmon Production Comparison Post-VAMP Window (Apr. 1 thru May 31)					
Without VAMP & Pre/Post-VAMP Window Protection Production Average	Vernalis Flow Targets				
	3200	4450	5700	7000	10000
5,432	6,345 (+14%)	7,407 (+27%)	8,569 (+37%)	9,810 (+45%)	12,891 (+58%)

Change in Lowest Delta Inflow Standard Frequency Occurrence Interval:

The Department evaluated the potential effect on adult salmon escapement connected with the frequency of occurrence of the lowest Delta Inflow. The years 1988 thru 2004 were analyzed to determine what the predicted salmon escapement estimate might be if the Delta Inflow minimum Standard level frequency of re-occurrence was changed from the historical base case condition. Table 12 shows the occurrence frequency for the Delta Inflow Standard Target Flows as superimposed upon the years 1988 through 2004.

Table 12. 1988 to 2004 Delta Inflow Standard Target Flows Frequency of Occurence

1988 to 2004 Delta Inflow Standard Target Flows Frequency of Occurrence					
Years	3200	4450	5700	7000	>10000
17	9 (53%)	2 (12%)	1 (6%)	3 (18%)	2 (12%)

It is interesting to note, from the VAMP Time Period Vernalis Flow Exceedence graph (Figure 8) that the flow levels identified for study in the VAMP experiment test flows are in the 35 to 50% exceedence range. This is a narrow part of the overall range. By VAMP's design and purpose, the highest 50% of flows (e.g., at or below 3200 cfs) have been adjusted to the 3200 level during the VAMP experiment time frame (e.g., thru 2012). This essentially means that the flow range has gone from a range of 290 to 34,110 cfs to 3200 to 34,110 cfs. Thus, the VAMP Target flow range leaves a significant portion of the total flow range untested particularly the higher ranges when salmon production is known to exhibit dramatic increases. The Department believes that it will be difficult to tease out differences in flow versus survival from the results of the VAMP experiment, because the ranges of flows being tested is too small. This problem has occurred in the Stanislaus, where a narrow range of flows in being tested (e.g., 700 to 1500); whereas, on the Tuolumne and Merced Rivers much wider ranges in flows have been tested (Figure 9).

Figure 8. Vernalis VAMP Time Period Daily Average Historical Flow Exceedence (1923-2004). Data from USGS.

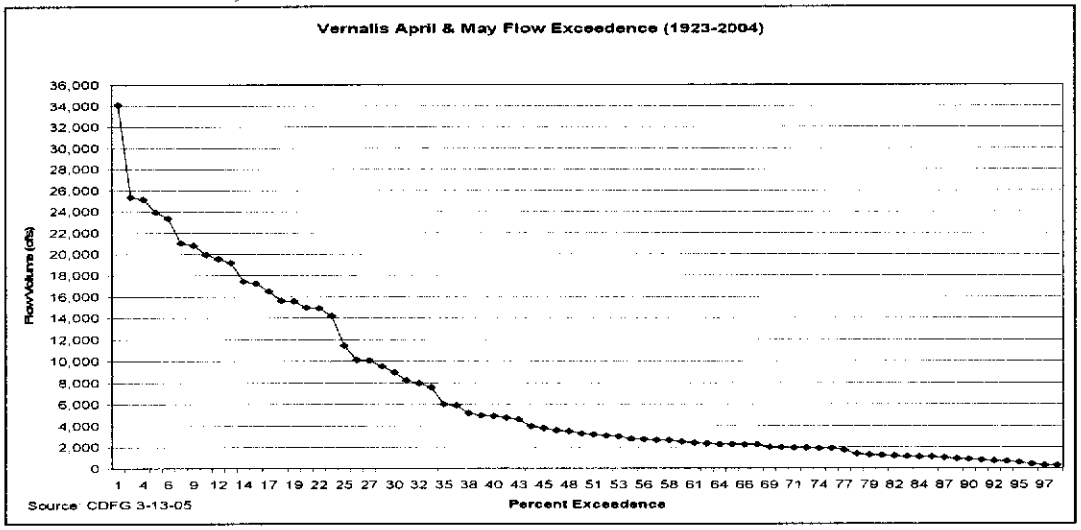
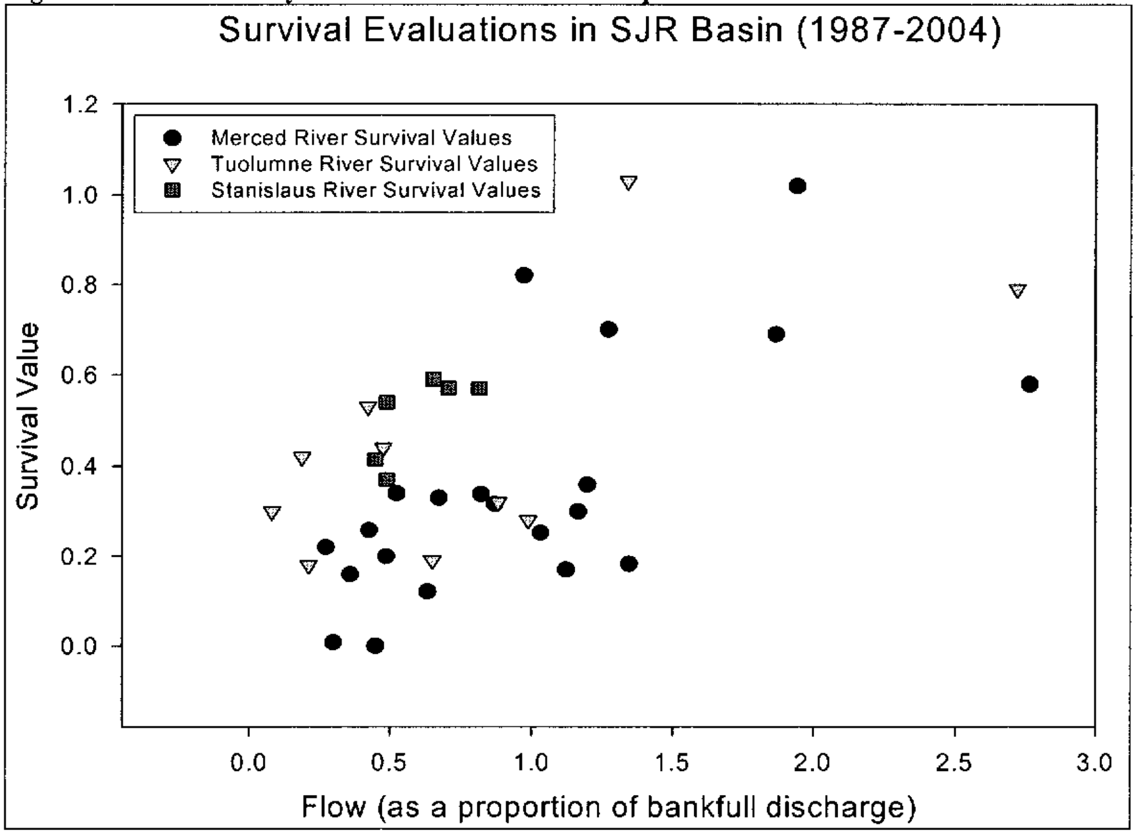


Figure 9. SJR Tributary Flow vs Survival Relationship



By changing the frequency of occurrence (Table 12) during the VAMP, and both pre and post-VAMP time frames, substantial gains in adult salmon escapement are possible. The base case, with historical frequency of occurrence (Table 12) produced 7,252 adult salmon and the altered frequency of occurrence of Delta Inflow (Table 13) produced 10,279 adult salmon, an estimated 29% increase.

Table 13. Altered 1988 to 2004 Delta Inflow Standard Target Flows Frequency of Occurence

Altered 1988 to 2004 Delta Inflow Standard Target Flows Frequency of Occurrence					
Years	3200	4450	5700	7000	>10000
17	0 (0%)	2 (12%)	7 (41%)	6 (35%)	2 (12%)

Note: Frequency changes made by alternating Delta Inflow Standard Target Flows levels of 5700 and 7000. 4450 levels were chosen by taking the first year (1988) and the 10th year (1998). The >7,000 levels were left as they occurred (e.g., 1995 & 1998).

Compounding Escapements:

The above estimates of increased escapements should be viewed as conservative. In reality if adult escapement increased, as indicated by the above results, there is likely to be an increased number of smolts produced, greater survival of these smolts to Mossdale thence Chipp's Island, and an even larger increase in the numbers of returning adult salmon, as Delta Inflow levels (largely driven by east-side tributaries) increase during the salmon smolt out-migrant time frame. Although this is a relatively simple analysis, the Department believes this hypothesis to be true based upon the multi-correlation relationship between SJR fall spawning escapement, following spring Vernalis flow level during the Apr. 15 to May 15 time frame, smolt production at Mossdale, and future year adult salmon escapement cohort size (Table 14). The multiple regression correlation for this comparison is fairly strong with an adjusted r-squared value of 0.77 (e.g., Equation = ((SJR fall spawning escapement*0.4348)+(4/15 to 5/15 Daily Average Vernalis Flow*1.8976)+(Mossdale Smolt Production*-0.0035)+406.1482).

Table 14. Numbers of SJR Adult Salmon Returning to Spawn Based upon Cohort Year Spawning Escapement, Delta Inflow and Smolt Production at Mossdale.

Relationship of SJR Salmon Spawning Escapement and Vernalis Flow (Period & Magnitude) and Number of Smolts at Estimated at Mossdale to Adult Salmon Cohort Returns				
SJR Escapement Year	SJR Spawning Escapement	Apr. 15 to May 15 Avg. Flow at Vernalis[10]	Mossdale Smolt Out-migrant Estimate[11]	SJR Returning Adult Escapement Cohort[12]
1987	25,169	2,111	1,216,662	344
1988	20,583	2,178	4,341,856	765
1989	3,212	1,282	282,125	1,098
1990	658	1,058	580,882	3,267
1991	590	1,266	296,027	3,677
1992	1,373	3,926	251,530	4,221
1993	2,603	2,123	459,567	6,722
1994	4,557	19,636	1,798,052	27,594
1995	3,895	6,483	978,113	7,164
1996	8,691	5,314	593,279	18,221
1997	16,359	19,435	1,629,784	48,491
1998	15,216	6,877	390,760	18,452
1999	16,232	5,892	441,367	21,608

[10] Vernalis flow level is the following spring from the SJR Escapement Year (1987 Escapement Year goes with 1988 Vernalis flow year).

[11] Mossdale smolt out-migrant estimate for entire Mossdale Trawl time period (typically 4/1 thru 6/15).

[12] The reconstructed adult cohort data was obtained upon from Dr. Carl Messick (Carl Messick Consultants) upon request by the Department, and consists of reconstructing SJR adult escaping cohorts by applying coded wire tagged salmon return data from the Sacramento River basin.

If this hypothesis is true, and modifying Delta Inflow target levels (e.g., magnitude, duration, and frequency) as measured at Vernalis produces more escaping adult salmon, then increasing numbers of adult salmon escaping into the SJR basin could result in large, compounding, increases in adult salmon production due to increased numbers of eggs, fry, and out-migrating smolts reaching Mossdale thence Chipp's Island if a change in the Delta Inflow Standard target flow levels were to occur. The Department believes that if the Delta Inflow Standard target flow levels to protect SJR salmon beneficial uses were changed in terms of increased magnitude, prolonged duration, and reduction in re-occurrence interval of the lowest Standard year type, then substantial gains in SJR adult salmon are possible. Table 15 illustrates this point, with the estimated results for the 10,000 level particularly eye catching (31,840) as the estimated average is near that targeted to achieve the 1995 Water Quality Control Plan's Narrative Doubling Goal of 36,000 SJR adult fall-run Chinook salmon. With this simple prediction model underestimating the average number of adult salmon produced, the actual number of adult salmon produced could be higher.

Table 15. Compounding Annual Escapement Increases

1988-2004 Estimated Accumulated Adult Salmon Production Comparison with Increased VAMP Window Target Flows					
No Vernalis Target Overlay on Historical Record	Vernalis Flow Targets Added to Historical Flow Years				
	3200	4450	5700	7000	10000
11,414	12,506 (+9%)	13,777 (+18%)	15,967 (+29%)	19,412 (+41%)	31,840 (+64%)

Tables 16 and 17 provide a detailed tabular representation of the products of the calculations used in the compounding escapement increase estimate comparison. Table 16 shows the baseline compounding escapement estimate for the historical baseline time frame (e.g., without VAMP flows except for years 2000 thru 2004 which were formal VAMP years). Table 17 shows the compounding escapement increase if VAMP target minimum flows were changed to 3200 cfs (e.g., VAMP flow values which were below 3200 cfs were raised to the 3200 cfs level). Table 18 shows a comparison of the results provided in Table 16 (baseline estimate prediction) to the actual SJR escapement estimates for the years 1992 thru 2004. The simplified model used underpredicts slightly the overall average. The Department believes this is due to using Mossdale to Chipp's Island Survival and Chipp's Island to Adult Escapement Cohort regression relationships that are forced thru zero, which overestimates in smaller escapement years and underestimates in larger escapement years. Following Tables 16 thru 18, is a description of the calculations used in this simplified compounding escapement prediction model.

Table 16. Compounding Escapement Prediction Estimates for Vernalis Flows at 3200 Apr. 1 thru May 31

Baseline Estimate for Compounding Adult Escapement Comparison Between Vernalis Flow Targets										
SJR Escapement Year	Estimated Fall Spawning Escapement[13]	Vernalis Flow (4/1-5/31)[14]	Estimated Mossdale Outmigrants	Smolt Survival Index	Estimated Chipp's Smolt Outmigrants	Estimated Escapement Cohort	Age Cohorts[15]			
							2	3	4	5
							(24.8%)	(55.2%)	19.4%)	(0.6%)
1987	25,169	1,881	1,962,646	7.5%	147,690	5,583	n/a	n/a	n/a	**36**
1988	20,583	1,946	1,663,949	7.8%	129,517	4,896	n/a	n/a	**948**	31
1989	3,212	1,268	508,699	5.1%	25,811	976	n/a	**538**	189	6
1990	658	1,103	337,138	4.4%	14,871	562	**139**	310	109	4
1991	590	1,193	335,014	4.8%	15,986	604	150	333	117	4
1992	**1,662**[16]	3,489	464,548	14.0%	64,830	2,451	608	1,352	475	16
1993	**680**	1,918	359,667	7.7%	27,593	1,043	259	576	202	7
1994	**1,056**	21,008	877,591	84.0%	737,468	27,876	6,911	15,381	5,400	179
1995	**1,731**	7,794	580,337	31.2%	180,915	6,839	1,695	3,773	1,325	44
1996	**7,965**	4,661	907,699	18.6%	169,247	6,398	1,586	3,530	1,239	41
1997	**17,294**	19,804	1,910,033	79.2%	1,513,084	57,195	14,180	31,558	11,080	366
1998	**10,766**	5,928	1,123,896	23.7%	266,505	10,074	2,498	5,558	1,952	65
1999	**19,213**	5,700	1,671,235	22.8%	381,042	14,403	3,571	7,947	2,790	92
2000	**35,339**	4,450	2,695,102	17.8%	479,728	18,134	4,496	10,006	3,513	116
2001	**20,250**	3,200	1,674,564	12.8%	214,344	8,102	2,009	4,471	1,570	52
2002	**14,761**	3,200	1,315,032	12.8%	168,324	6,363	1,577	3,511	1,233	41
2003	**14,869**	3,200	1,322,112	12.8%	169,230	6,397	1,586	3,530	1,239	41
2004	**9,653**	5,700	1,045,089	22.8%	238,280	9,007	2,233	4,970	1,745	58
11,414		**Average Escapement**								

[13] Estimated Fall Spawning Escapement for Years 1987 thru 1991 are actual escapement estimates (not predicted estimates) and therefore do not include age cohort summations (as do years 1992 thru 2004).

[14] Vernalis Flow is the flow at Vernalis the spring following the SJR Escapement Year (e.g., 1988 Vernalis Flow goes with SJR Escapement Year 1987).

[15] Age Cohort percentages are averages from reconstructed SJR fall-run Chinook salmon cohorts for years 1957-1999.

[16] Annual Fall Spawning Escapement made up of mult-age cohorts and is the sum of the age 2 thru 5 age cohort columns (shaded calls). Any differences between hand calculating the numbers in the Age Cohort columns and the number listed in the Fall Spawning Escapement columne is due to significant figure rounding).

Table 17. Compounding Escapement Prediction Estimates for Vernalis Flows at 3200 Apr. 1 thru May 31

3200 Vernalis Flow Target Compounding Adult Escapement Estimate										
							Age Cohorts[19]			
SJR Escapement Year	Estimated Fall Spawning Escapement[17]	VAMP Period Flows (4/1-5/31)[18]	Estimated Mossdale Outmigrants	Smolt Survival Index	Estimated Chipp's Smolt Outmigrants	Estimated Escapement Cohort	2 (24.8%)	3 (55.2%)	4 19.4%)	5 (0.6%)
1987	25,169	3,200	1,996,724	12.8%	255,581	9,661	n/a	n/a	n/a	**62**
1988	20,583	3,200	1,696,356	12.8%	217,134	8,208	n/a	n/a	**1,590**	53
1989	3,212	3,200	558,612	12.8%	71,502	2,703	n/a	**1,491**	524	17
1990	658	3,200	391,333	12.8%	50,091	1,893	**469**	1,045	367	12
1991	590	3,200	386,879	12.8%	49,521	1,872	464	1,033	363	12
1992	**3,613**[20]	3,348	588,668	13.4%	78,827	2,980	739	1,644	577	19
1993	**2,085**	3,200	484,795	12.8%	62,054	2,346	582	1,294	454	15
1994	**2,156**	21,421	960,282	85.7%	822,821	31,103	7,711	17,161	6,025	199
1995	**2,600**	8,204	647,859	32.8%	212,601	8,036	1,992	4,434	1,557	51
1996	**9,594**	4,434	1,008,531	17.7%	178,873	6,761	1,676	3,731	1,310	43
1997	**19,627**	20,032	2,068,699	80.1%	1,657,580	62,657	15,534	34,572	12,138	401
1998	**12,151**	5,614	1,206,464	22.5%	270,940	10,242	2,539	5,651	1,984	66
1999	**21,021**	5,700	1,789,628	22.8%	408,035	15,424	3,824	8,510	2,988	99
2000	**38,472**	4,450	2,900,331	17.8%	516,259	19,515	4,838	10,767	3,780	125
2001	**21,656**	3,200	1,766,645	12.8%	226,131	8,548	2,119	4,716	1,656	55
2002	**15,734**	3,200	1,378,748	12.8%	176,480	6,671	1,654	3,681	1,292	43
2003	**15,940**	3,200	1,392,266	12.8%	178,210	6,736	1,670	3,717	1,305	43
2004	**10,249**	5,700	1,084,145	22.8%	247,185	9,344	2,316	5,155	1,810	60
12,506		**Average Escapement**								

[17] Estimated Fall Spawning Escapement for Years 1987 thru 1991 are actual escapement estimates (not predicted estimates) and therefore do not include age cohort summations (as do years 1992 thru 2004).
[18] Vernalis Flow is the flow at Vernalis the spring following the SJR Escapement Year (e.g., 1988 Vernalis Flow goes with SJR Escapement Year 1987).
[19] Age Cohort percentages are averages from reconstructed SJR fall-run Chinook salmon cohorts for years 1957-1999.
[20] Annual Fall Spawning Escapement made up of mult-age cohorts and is the sum of the age 2 thru 5 age cohort columns (e.g., differences between hand calculating the numbers in the Age Cohort columns and the number listed in the Fall Spawning Escapement columne due to rounding)

Table 18. Comparison Between Predicted and Actual SJR Salmon Escapement

Escapement Comparison		
Year	Predicted	Actual
1992	1,662	1,373
1993	680	2,603
1994	1,056	4,557
1995	1,731	3,895
1996	7,965	8,691
1997	17,294	16,359
1998	10,766	15,216
1999	19,213	16,232
2000	35,339	37,407
2001	20,250	26,916
2002	14,761	25,529
2003	14,869	10,631
2004	9,653	10,700
Average	11,942	13,855

Note: Predicted = Baseline Estimated from Table #16

Compounding Escapement Increase Over Time Model Equation:

Example of Estimate Equation for 1993[21] (Table 16):

1. 1992 Mossdale Outmigrant Estimate **(464,548)** = 1992 Fall Spawning Escapement (**1662** = 1990 Age 2 (139)+ 1989 Age 3 (538) + 1988 Age 4 (948) + 1987 Age 5 (36)) * **65.49675**)) + 1993 Vernalis Flow Level**(3,489)* 25.84094)** + y-intercept **(265,545);**

2. 1992 Chipp's Island Smolt Outmigrant Estimate (**64,830**) = Mossdale Outmigrants(**464,548)** * Mossdale to Chipp's Island Smolt Survival Regression Index (**14%**);

3. 1992 Escapement Cohort Estimate (**2,451**) = Chipp's Island Smolt Outmigrant Estimate **(64,830)** * Chipp's Island Smolt Outmigrant Estimate to SJR Escapement Cohort Regression Coefficient (**0.0378**);

4. 1993 Escapement Estimate **(680)** = Spawning Escapement 1991 Age 2 Cohort **(150)**, + Spawining Escapement 1990 Age 3 Cohort **(310)**, + Spawning Escapement 1989 Age 4 Cohort **(189)**, + and Spawning Escapement 1988 Age 5 Cohort (**31**).

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[21] The numbers calculated in the example are slightly off those calculated in the reference table due to rounding of numbers used in the example calculation

Compounding Escapement Model Term Definitions:

The following parameters are needed to estimate adult salmon escapement as a function of Vernalis Flow and are listed in order of estimate calculation progression:

Current Year Annual Escapement Estimate:
--determined by amount of 2, 3, 4, & 5 year old salmon cohorts contributing to current year annual escapement

Vernalis Flow:
--calculated daily average flow for period (4/1 to 5/31)

Mossdale Outmigrant Estimate:
--calculated by regression relationship[22] between fall adult salmon escapement and following spring Vernalis daily average flow level

Mossdale to Chipp's Smolt Survival Index
--Determined by flow level per the VAMP flow vs salmon smolt survival relationship (with HORB in)

Chipp's Island Outmigrant Estimate:
--calculated by applying the Mossdale to Chipp's smolt survival index to the Mossdale smolt outmigrant estimate

Escapement Cohort:
--calculated by applying the Chipp's Island smolt abundance to escapement cohort regression relationship

Adult Salmon Escapement Cohort Fraction
--Calculated by multiplying the Project Salmon Escapement value by the 2, 3, 4, and 5 year old year age class percentages[23]

Future Year Escapement
--calculated by summing the number of 2, 3, 4, and 5 year age cohorts that contribute to the present year escapement

Conclusion:

The above analyzes suggest that potentially large increases in adult salmon escapement are theoretically possible if: (i) the SJR Delta Inflow flow target window was increased from Apr. 15 to May 15, to Apr. 1 to May 31; (ii) the minimum flow target level was increased above 3200 cfs; and (iii) the frequency of the minimum flow target level was substantially decreased.

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[22] Regression Equation=(Fall Escapement*65.49)+(Vernalis Flow*25.84)+(y intercept of 265545). The 1988 thru 1999 (period of Mossdale Trawl and adult escapement data exist) multiple regression adjusted R-squared value for this equation is 0.14. The multiple regression adjusted R-squared value can be improved to 0.84 by removing 1988 (a year with a large outlier with respect to adult escapement and subsequent Mossdale Outmigrant Production Estimate), but results in very low escapement estimates as compared to those which actually occurred. Therefore, the regression with the lower Adjusted R-squared was used in the model.

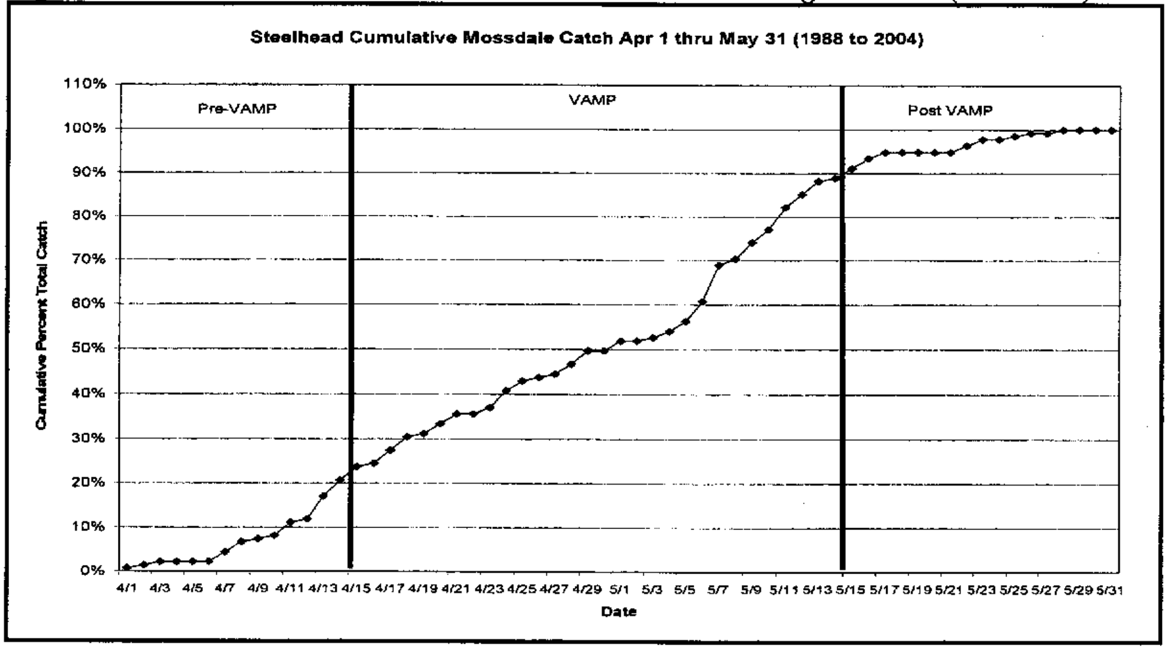
[23] Cohort age class percentages = 24.8 (2yr), 55.2 (3yr), 19.4 (4yr), and 0.6 (5yr)

The Department recognizes that these predictions, though based on empirical relationships, are somewhat oversimplified and we do not include confidence limits for these estimates. The Department believes that the assessment is sufficiently robust to demonstrate, with reasonable certainty that one of the main reasons SJR tributary salmon populations remain below target levels, and in fact are declining, is poor habitat conditions for out-migrating salmon and that improving these conditions will translate into healthier salmon runs in the SJR tributaries.

4. VAMP Target Flow Duration Temporally Too Narrow for Steelhead:

Data from the Department's Mossdale Trawl from 1988 through 2004 indicates that the out-migration window for Steelhead Rainbow Trout yearling smolts also occurs primarily between April 1 and mid-May, a time period matching that of salmon smolts. Data from rotary screw traps in SJR east-side tributaries suggests that steelhead movement may occur from January through May. **Steelhead smolts are <u>much larger in size</u> than salmon smolts (e.g., 300 mm vs 90 mm) therefore, they can more easily evade capture in either trawl nets or rotary screw traps meaning that trawl and screw trap surveys are capturing only a small percentage of the overall population of steelhead present in the SJR basin.** Based on the Department's Mossdale Trawl data, the VAMP window protects about 70 % of out-migrating steelhead yearling smolts (Figure 8), with the greatest percentage of steelhead smolts not being protected by the current standard present at Mossdale during the pre-VAMP time period. This contrasts with salmon which have the greatest percentage of non-VAMP smolt protected fraction occurring post-VAMP. If the VAMP window were extended from 31 to 61 days (e.g., April 1 through May 31) then not only would a larger proportion of out-migrating salmon benefit, but virtually all out-migrating steelhead would be afforded some level of increased protection.

<u>Figure 9. Cumulative Percent Steelhead Rainbow Trout Passing Mossdale (1988-2004).</u>

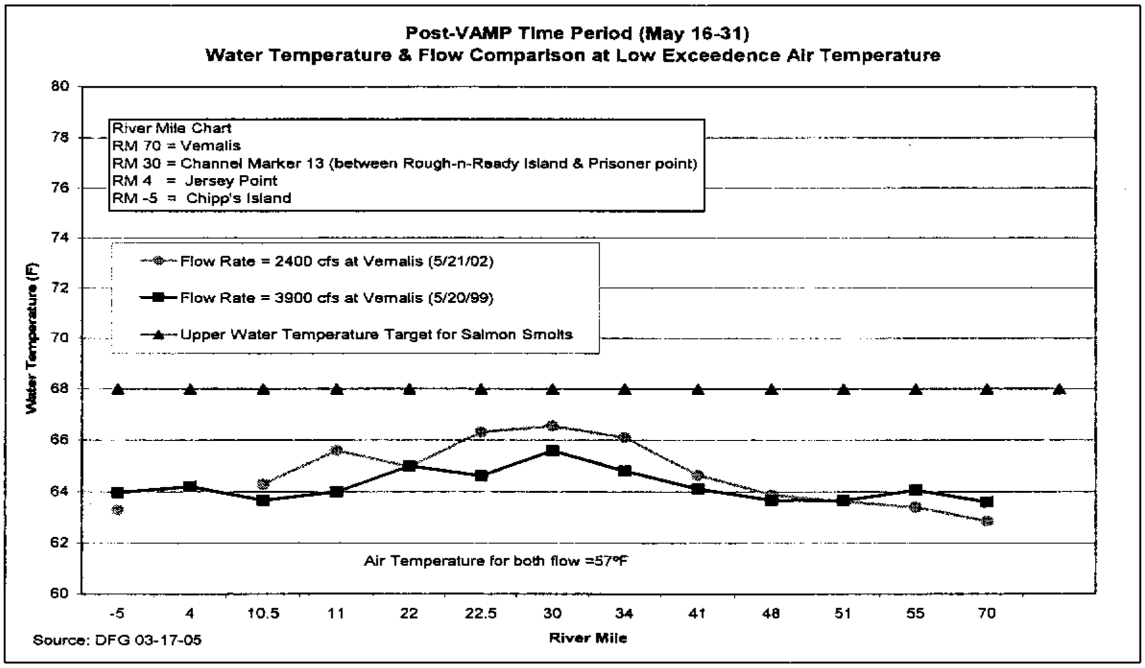


5. Post VAMP Water Temperature Concern:

The Department is concerned about excessively warm water temperatures for salmon and steelhead smolts after the VAMP window time period (e.g., after May 15). Post-VAMP flows at Vernalis drop substantially. This tends to occur simultaneously with increasing air temperatures right at a time when many salmon smolts are still trying to out-migrate through the SJR. Water temperature, air temperature and flow data collected in the south Delta suggests that the degree to which water temperatures warm in the south Delta is dependent upon flow level into the south Delta (e.g., flow level at Vernalis), water temperature at Vernalis, and ambient air temperature in the south Delta.

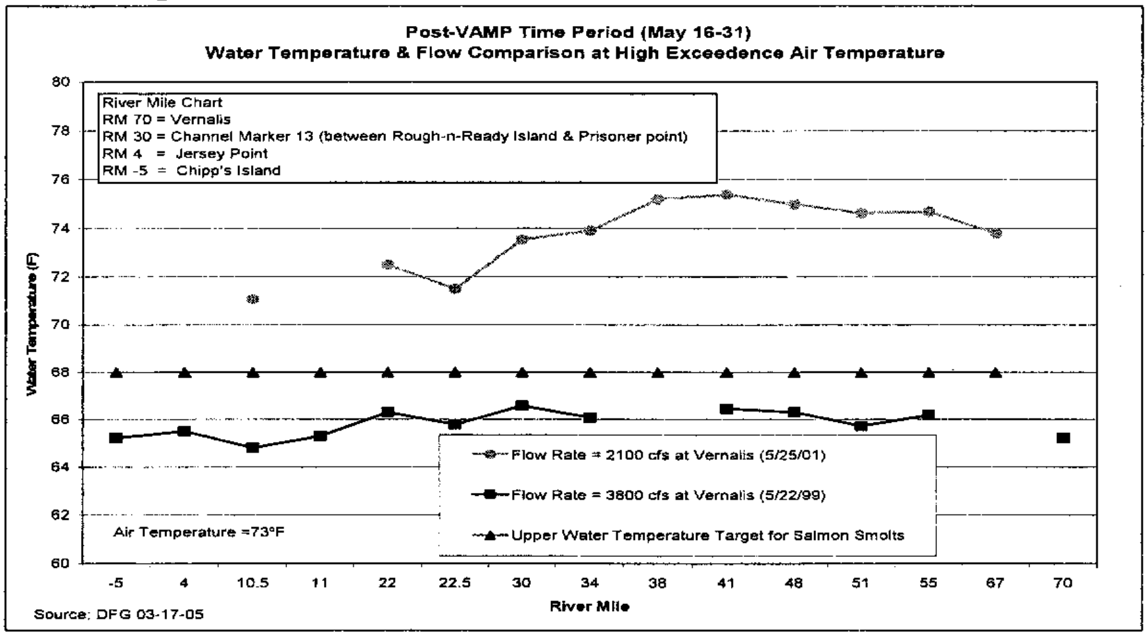
Data collected in the last 10 years suggests that if flows at Vernalis remain elevated (e.g., to approximately 4,000 cfs) during the May 16th through May 31st time frame, fed by cool east-side tributary outflows, then water temperatures from Vernalis to Jersey Point (e.g., interior Delta) should remain under the lethal limit (68 °F daily average) for salmon smolts outmigrating past Mossdale during the warmer air temperature time periods (Figure 10 & 11). Providing suitable water temperature, through increased flows, for a longer period in May would improve smolt survival and would likely lead to increased adult salmon production, given the relationship between SJR basin salmon smolt abundance at Chipp's island and adult salmon returns three to four years later. Water temperature affect upon survival of out-migrating salmon thru the east-side tributaries and South Delta, and upon adult escapement, during and after the VAMP time frame should also be a key component of the charge given to the Independent Science Peer Review Panel should the Board choose to convene this panel.

Figure 10. SJR-South Delta Water Temperature Response to Flow (Cool Air Temp).



Note: Temperatures are daily average values

Figure 11. SJR-South Delta Water Temperature Response to Flow (Warm Air Temperature).



Note: Temperatures are daily average values

6. Protection of Salmon Fry in Combination with Increased Smolt Protection:

The Department's management practice, with respect to population management of salmon smolts and salmon fry, is to place management priority and protection emphasis upon the smolt life history stage. The Department bases this management practice upon the existing body of scientific evidence that suggests there is a strong correlation between the number of out-migrating smolts passing Mossdale and subsequent returns of adult salmon (see Figure 2 and 3). The Department would support an expanded window with higher Vernalis flow objectives for increased protection of fry, if it came about in addition to rather than at the expense of the salmon smolt window of protection.

7. Water Quality Objectives and Recovery of Steelhead and Salmon:

The Department realizes that salmon and steelhead restoration in the SJR is challenging due the complex and varied life history stages associated with Chinook salmon and steelhead rainbow trout, the remaining uncertainty in predicting the influence of environmental factors (e.g., flow level, water quality, and habitat quality/quantity etc.) and societal decisions (e.g., harvest management, priorities for reservoir operation, etc.). Varied and sometimes opposing views as to what factor has the most influence, and what degree of improvement would occur to salmon and steelhead populations if a change in a particular factor were to occur, **provides the Board with justification to convene an independent peer review process and/or panel** at this 10-year milepost (e.g., since 1995) to: (i) assess all available knowledge regarding fall-run Chinook salmon and steelhead rainbow trout in the SJR; (ii) develop population models that are used to evaluate which groupings of factors may have the most influence on progress in protection and restoration of salmon and steelhead in the SJR; and (iii) identify key missing information that would help the Board with continued development of standards and objectives to protect fish and wildlife beneficial uses and foster improvement in the status of salmon and steelhead rainbow trout populations. The Department believes there is sufficient body of evidence to justify the Board considering options to provide greater protection for salmon and steelhead in the SJR Delta, and east-side tributaries.

8. Scientific Study Integrity vs Adaptive Salmon Management:

The Department is cognizant of the need to maintain scientific study integrity in order to obtain results that cover the full range of variability intended within the VAMP experiment. However, the VAMP experiment and underlying San Joaquin River Agreement, in terms of flow magnitude and duration, which touches upon the time period and biological issues of concern and time frames identified in Issue #8, was instituted to accomplish two objectives: (i) determine relationship between magnitude of Vernalis flow level and Delta export on survival of out-migrating salmon smolts; and (ii) provide protection for salmon at a level above that which currently existed at the time VAMP was implemented. These two objectives, which at times appear to conflict, need to be routinely evaluated to provide a balance between the two objectives: (i) resolve uncertainty; and (ii) improve salmon population abundance. For the first five years of VAMP, scientific study design and integrity has taken preeminence over improving salmon population abundance. Because of the cyclical nature of salmon abundance in connection with hydrology, the Department suggests that the Board consider whether it is in the long term best interest of salmon beneficial use to continue the VAMP study as presently designed, in terms of magnitude, duration, frequency or modify it either in terms of magnitude, or duration, or frequency or all three. As a key partner in VAMP, the Department believes this is very important for all participants to consider at this juncture.

9. SJR Basin Model Integration:

The Department is aware that several SJR basin wide system assessment tools are currently in varying stages of development: (i) Water Operations Model (CALSIM); (ii) Water Quality Model (CALSIM); (iii) Water Temperature Model (HEC-5Q); and (iv) Fall-run Chinook Salmon Population Model (CALFED Science Program PSP Proposals). The Department wholly supports development and application of these system-wide evaluation tools, as they will provide scientists and managers with better understanding of the variables that influence water supply reliability, water quality, and salmon abundance over time. The Department is concerned that there does not appear to be an oversight body in place that will help ensure that these system wide models will be integrated with one another, not in terms of model code but in terms of scenarios evaluated, for purposes of understanding how several variables influence the operation of the SJR as a whole to maximize water use efficiency and accomplish the full array of beneficial uses. The Department recommends that the Board make model integration a component of the charge given to the independent science review panel discussed above should the Board decide act upon the Department's recommendation.

Conclusion Issue #8 Question #1:

Recent salmon escapement trends suggest that a change in south Delta Inflow levels is needed to reverse this trend. Increasing the Vernalis flow level by increasing the minimum flow level, extending the VAMP target flow level to April 1 to May 31, and changing the frequency of flows appears to be capable of substantially increasing salmon escapement. Extending the Vernalis flow level from April 1 to May 31 would provide a greater out-migration window of protection for both salmon and steelhead. Increasing the magnitude of the Vernalis flow objective would resolve most of the water quality issues. Convening an independent peer review process would help resolve contentious issues among the VAMP parties.

Issue #8 Question #1 Summary Recommendations:

1. The Board should not reduce Vernalis flow standards, but instead strongly consider expanding the current window, and increasing required flow magnitudel, to provide additional protection for migrating steelhead and salmon smolts.
2. The Department encourages the Board to continue VAMP in concept, and emphasize now the importance of the adaptive management spirit of VAMP to increase the level of protection intended for the SJR salmon beneficial uses intended at the on-set of the 1995 Water Quality Control Plan and the implementation of VAMP.
3. The Department encourages the Board Staff to participate with VAMP signatory agencies/entities to develop, and evaluate, refinements in VAMP study protocols, and consider alternative target flow scenarios to increase the duration, frequency and magnitudes of SJR inflow at Vernalis, to provide better protection for fall chinook salmon and steelhead originating in the SJR tributaries and migrating through the South Delta.
4. Should the Board convene an independent peer review process, the Department encourages the Board to consider charging the peer panel with evaluating how VAMP is protecting beneficial uses for SJR steelhead as well.
5. The Board challenge the VAMP parties to accelerate design, construction, and operation of a permanent Head of Old River Barrier that allows for >10,000 flows at Vernalis to occur as part of VAMP.

Issue 8, Question #2. Should the SWRCB change the methodology for determining the applicable San Joaquin River flow objectives that currently are determined by reference to the required Delta Inflow objective? How should the methodology for determining required flows be modified and what are the scientific and legal arguments in support of and against modification?

We have neither completed a detailed analysis of our own nor seen one done by anyone else that provides a clear indication as to how the methodology for determining the San Joaquin River flow objective should be modified.

It is apparent that habitat needs for San Joaquin River tributary salmon are not being satisfied because these stocks have declined in recent years, even as salmon populations in the Sacramento basin generally have increased due to a combination of factors, at least some of which should also positively affect adult returns of San Joaquin basin salmon stocks (e.g. substantially more restrictive ocean harvest management for Central Valley salmon). The importance of spring flow for San Joaquin basin Chinook salmon populations has been established. Vernalis flows in the spring appear to be inadequate to protect beneficial uses for salmon in the San Joaquin River portion of the Delta and poor survival during out-migration is contributing to the observed declining abundance trend for San Joaquin Basin salmon. Spring flow also influences the suitability of habitat conditions in the San Joaquin River portion of the Delta for other resident freshwater and estuarine fish, including both native and introduced species and influences fish community structure (Feyrer and Healey 2003).

Even without a detailed analysis, two things about the Spring Vernalis flow objective are apparent. First, the spring flow requirement is a very small fraction of the historical spring flow. Second, unless the water year-type changes during the spring months or X2 moves past Chipps Island (moving upstream or downstream), the flow objective is constant throughout the spring. In contrast, in a natural condition San Joaquin River flow into the Delta increases not only in February and March but typically is even higher in April and May.

The Department has no specific recommendation for modifying the present methodology. However, if there is a concern that the flow objective should be dependent solely on the San Joaquin basin hydrology and not be driven by the location of X2 because X2 is more strongly influenced by Sacramento River inflow to the Delta, then, consistent with our view stated above, the Department recommends that the year-type specific objectives be no less than those higher flows in the right hand column in Table 3.