State of California – The Resources Agency
DEPARTMENT OF FISH AND GAME
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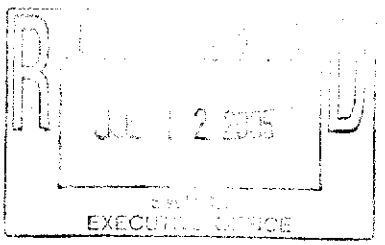
ARNOLD SCHWARZENEGGER, Governor



June 30, 2005

Mr. Art Baggett, Chairman
State Water Resources Control Board
Division of Water Rights
Post Office Box 2000
Sacramento, CA 95812-2000

Dear Mr. Baggett:

Department of Fish and Game Supplemental Comments and Recommendations on the Vernalis Flow and Salmon Doubling Objectives in the 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin River Delta Estuary

The 1995 Water Quality Control Plan (Plan) has been operable for ten (10) years. We applaud the State Water Resources Control Board (Board) for proceeding with its "Periodic Review." The Department of Fish and Game has actively participated in several of your Workshop topics to provide oral and written testimony to assist in your review of the Plan.

In the March, 2005 Workshop we expressed our serious concerns about the level of protection afforded salmon and steelhead on the San Joaquin River under the Vernalis flow objectives in the Plan. Monitoring and other study results over the years since adoption of the Plan have substantially convinced us that the current Vernalis flow objectives, and the method chosen to meet those particular objectives, is not providing the level of protection anticipated and needed for anadromous fish migrating from the San Joaquin basin tributary rivers through the South Delta. The scientific results from the Vernalis Adaptive Management Plan (VAMP) to date indicate that further refinements in that study design at this half-way point are critical if an adaptive implementation strategy is to be successful in meeting flow objectives that adequately protect the beneficial uses there. Moreover, the narrative salmon "doubling objective" has not been met in the San Joaquin basin nor has the Board adopted an implementation strategy to do so.

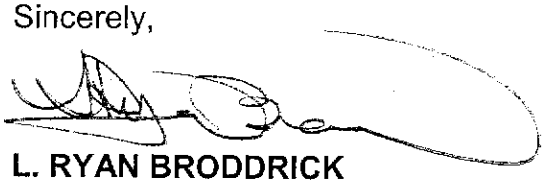
The net result in our view is that the level of protection afforded salmon and steelhead, and other beneficial uses in the South Delta under the Plan remain at unacceptably low levels. Thus, the flow objectives and the manner in which they are met is precluding healthy fish stocks in this basin and placing this important public trust resource at risk. Further, the actions of your Regional Water Quality Control Board (Regional Board) to regulate individual water quality objectives independent of the establishment of adequate flow objectives is exacerbating the situation by further reducing accretion flows to the lower San Joaquin River. Thus, the sequence of actions by the Board and Regional Board together needs your careful consideration because in combination they are not protecting key ecosystem values.

Therefore we recommend that the State Water Resources Control Board proceed with the appropriate administrative processes to revise the Vernalis flow objective aspects of the Plan to a) improve the level of protection afforded the beneficial uses of the San Joaquin River, b) add an implementation strategy to meet the narrative "doubling objective" and , c) assist in refinement of a VAMP or other implementation strategy which meets revised flow objectives, the narrative doubling strategy, and provides improved scientific study results. We urge you to recognize that adequate freshwater base flow objectives at Vernalis should be considered among the first elements in the strategies selected to meet the other water quality objectives in the San Joaquin River.

Attached is our document entitled "San Joaquin River at Airport Way Bridge Vernalis Annual Spring Instream Flow Recommendations," dated June 2005. After hearing our concerns with the current flow objectives at your March Workshop, you asked that we provide our revised Vernalis flow objective recommendations for the Board's consideration. After analyzing a series of alternative Vernalis flow objective scenarios, we offer our "preliminary recommendations" in the form of Scenario #9 in Table 3 and the Appendix of the attachment. This Scenario represents a substantive potential increase in the volume, duration and frequency of improved conditions for beneficial uses at Vernalis, that we believe will result in healthy salmon populations which meet the doubling objectives. Scenario #9 flows would also provide the Regional Board with additional freshwater flows as a basis for regulating to meet other water quality objectives on the San Joaquin River. Our request that you proceed with formal processes to revise the Vernalis flow objectives and VAMP as soon as possible includes our commitment to actively participate in such a process and evaluate a full range of flow scenarios with parties participating in your administrative process.

Thank you for this opportunity to provide our preliminary recommendations during your "Periodic Review" and for your efforts to make further improvements in the protection of key resources in the San Joaquin River. If you or your staff have questions on our recommendations or the attachment, please contact Mr. Bill Loudermilk, Regional Manager, in our Fresno office at (559) 243-4005, extension 156.

Sincerely,



L. RYAN BRODDRICK
Director

Attachment

cc: Mr. Allen Short
San Joaquin River Group Authority
400 Capitol Mall
Sacramento, CA 95814-4407

Mr. Steve Thompson
U. S. Fish and Wildlife service
2800 Cottage Way
Sacramento, CA 95825

Mr. Rodney McInnis
National Oceanic and Atmospheric Administration
501 West Ocean Boulevard
Long Beach, CA 90802

Mr. Kirk Rodgers
U.S. Bureau of Reclamation
2800 Cottage Way
Sacramento, CA 95825

Mr. Lester Snow
Department of Water Resources
1416 – 9th Street, Room 111-9
Sacramento, CA 95814

San Joaquin River at Airport Way Bridge Vernalis
Annual Spring Instream Flow Recommendations

California Department of Fish and Game
June 2005

Background

The Department of Fish and Game (Department) presented comments, both written and oral, at the State Water Resources Control Board's (SWRCB) March 2005 Workshop regarding the adequacy of the present Vernalis flow objectives, as identified in the 1995 Water Quality Control Plan and implemented under the current Vernalis Adaptive Management Program. This workshops were convened by the Board as an element of it's Periodic Review of the 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. The Department provided information that the present Plan's Vernalis flow objectives, as implemented through the current VAMP, do not adequately protect salmon (or steelhead) migrating to and from the San Joaquin River basin.

The Department and others familiar with the scientific evidence developed since 1995 now recognize that the 31-day pulse flow period in the Plan, and integrated into the VAMP implementation strategy, provides a period of improved protection for only 50% of the salmon smolts migrating downstream in the spring months instead of the 75% we envisioned in our recommendations and testimony leading to the adoption of the 1995 Plan. Further, the Plan provides no specific protection for the salmon fry which migrate past Vernalis and through the South Delta from approximately mid-December through mid-March in many years.

The evidence available today strongly indicates that the instream flow magnitudes and frequencies required in the Plan's spring flow objectives at Vernalis on the San Joaquin River are not sufficient to protect salmon, or to accomplish the Plan's Narrative Doubling Goals for San Joaquin fall-run Chinook salmon, or meet the other water quality objectives during that time period.

The Department also provided information that the current VAMP study design was not yielding the intended scientific study results at this half-way point in that study program, making it important that we adapt the design soon. The VAMP should continue as the implementation strategy under the Plan with refinements in target flows and other aspects to assure that more useful scientific results are obtained by the end of the original VAMP period. Further, we recommended that the Board convene or help convene a peer review process to help the parties assure the adaptive refinements of VAMP are effective relative to the Board's needs to protect beneficial uses.

At the conclusion of the Department's testimony the Board asked the Department what its specific instream flow recommendations for Vernalis were. The Department representative offered no specific recommendation. At that time, we did not have a robust analytical planning tool to evaluate various Vernalis instream flow levels in terms of magnitude, frequency and duration of flow protection window. At the conclusion of the March Workshop, the Board gave all parties more time to provide additional information. To assist the Board in its Periodic Review assessment, we offer preliminary recommendations for revising the Vernalis flow objectives for the March 15th thru June 15th time period, in order to adequately protect out-migrating juvenile fall-run Chinook

salmon smolts and make substantive improvement towards attainment of the Narrative Salmon Doubling Goal. The Department's Vernalis flow recommendations remain preliminary due to Workshop timelines set by the Board, the ongoing internal review within the Department, the need for further review by many other affected and interested parties. We offer them as preliminary recommendations in this Workshop process to point out the seriousness and urgency of remediating the current flow objective inadequacies, as well as defining what we believe are the approximate magnitudes of the additional water needed.

Methods

The Department, in its March 2005 comments to the Board, provided information that Vernalis flows were directly linked to: 1) Salmon smolt production at Mossdale as a function of prior year adult salmon escapement and current year instream flow level at Vernalis; 2) Salmon smolt survival thru the South Delta; and, 3) Adult salmon cohort abundance[1] and future year adult salmon escapement[2]. The Department provided examples of how increased juvenile and hence adult salmon abundance in the San Joaquin River could be achieved if: a) Vernalis flows were increased above those afforded in VAMP; b) the window of protection were expanded from 31 to 60 days; and, c) if the minimum flow level provided in VAMP were to occur at a much lower frequency than has occurred since VAMP implementation.

Since the Board's March 2005 Plan Workshop, the Department has built a Vernalis flow-based juvenile and adult salmon production model (Model) to evaluate the potential effect of various San Joaquin River at Vernalis Flow levels on San Joaquin River juvenile salmon smolt and adult abundance. This model is an extension of the methods used by the Department for our presentation to the Board in March 2005. The Model is a planning tool that allows the Department to evaluate variations of Vernalis flow magnitude, duration, and frequencies and predict the outcome in the salmon population and the relative health of San Joaquin basin fall-run Chinook salmon over time under a range of incremental improvements in the Vernalis flow objectives with reasonable accuracy.

The Model predicts salmon abundance at the following locations: 1) smolts at Mossdale using a multi-regression relationship between prior year combined San Joaquin River East-side tributary adult salmon escapement and current year Vernalis Flow (e.g., daily average for April 1 thru May 31) versus predicted smolt abundance at Mossdale as determined by the Department's Mossdale Trawl; 2) smolts at Chipp's Island via application of the South Delta salmon smolt survival vs. river flow regression relationship; 3) adult salmon cohort abundance by regressing the number of salmon

[1] Adult salmon cohort abundance (adult recruits) is the total number of adult salmon returning to spawn over several successive years (e.g., up to five) that originate from a specific salmon stock production brood year.

[2] Adult salmon escapement is the annual number of adult salmon predicted to have escaped into the San Joaquin River each fall to spawn in the Stanislaus, Tuolumne, and Merced Rivers, and is comprised of adults of from up to five different salmon production cohorts.

smolts predicted to have survived to Chipp's Island (e.g., juvenile cohort) against the number of adult salmon predicted to have returned at ages one thru five from the juvenile cohort leaving the San Joaquin River in particular year; and 4) annual San Joaquin River adult salmon escapement (e.g., combined annual escapement for the Stanislaus, Tuolumne, and Merced Rivers). Table 1 shows the regression characteristics for each of the aforementioned regression relationships.

Using the regressions relationships provided in Table 1[3], a spreadsheet-based computer simulation model was developed using Vernalis spring time flows to predict juvenile and adult salmon abundance was developed. Figure 1 shows the process used to combine spring-time Vernalis flow and salmon abundance to calculate juvenile and adult salmon abundance over time. The simulation time period used was 1967 thru 1991, the same time period used to develop the Plan's Narrative Salmon Doubling Goal. Model calibration results are depicted in Figure 2. Based upon calibration results, the Department conducted model simulations of various scenarios to evaluate how Vernalis flow level, combined with flow protection window duration could influence adult salmon abundance using the 1967 thru 1991 time period. The following types of scenarios to assess potential benefits to San Joaquin basin fall-run Chinook salmon abundance and population health were evaluated using the Model: 1) Vernalis flow levels as referenced in VAMP (e.g., 2,000 to 7,000 cfs) and 30 to 90-day windows of protection[4] at Vernalis ; 2) Constant Vernalis flow levels (e.g., 5,000, 10,000 and 15,000 cfs) and variable smolt out-migrant protection windows (e.g., ranging from 30 to 90 days); 3) Vernalis flow levels varied by water year type and variable smolt out-migrant protection windows; and 4) Vernalis flow levels and smolt out-migrant protection windows both varied by water year type. Model results for nine different scenarios were evaluated based on the ability to: 1) attempt to accomplish Narrative Salmon Doubling Goal; 2) achieve a 1:1 adult salmon replacement ratio[5]; and 3) minimize the amount of additional water needed. The baseline for Model comparison is the adult escapement predicted by the Model from historical conditions for the years 1967 thru 1991.

[3] As adjusted for zero y-intercept to prevent prediction of negative numbers

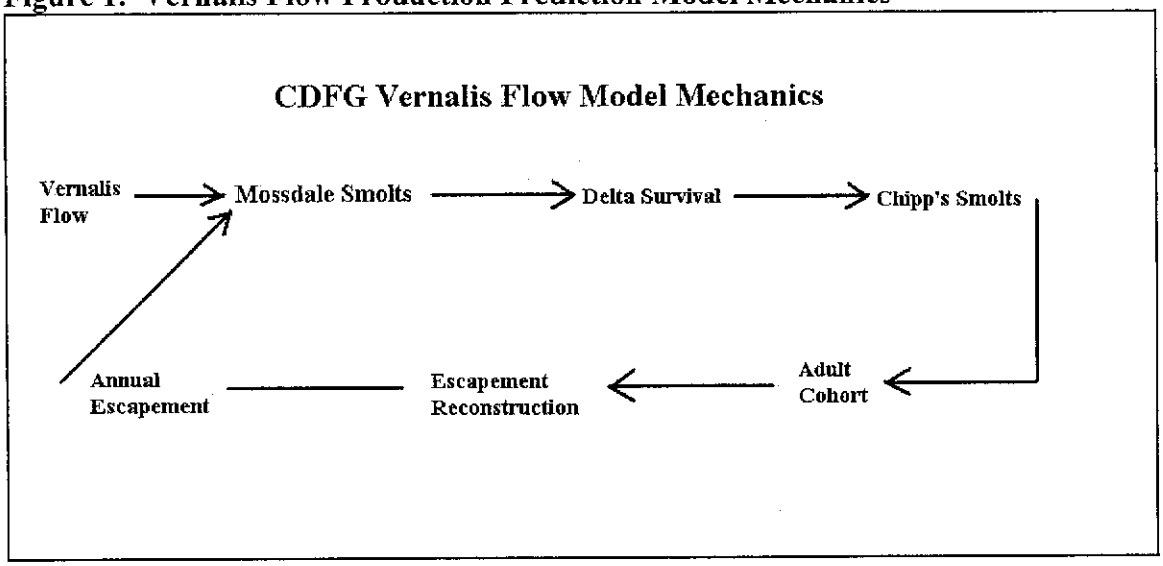
[4] Maximum flow window time period is March 15 thru June 15. All flow windows have May 1 as its central point.

[5] Adult Salmon Replacement Ratio is the escapement of one year divided by the escapement three years later and assumes based upon recovery of coded-wire-tagged adult salmon from Central Valley rivers that age three adult salmon comprise the majority of escaping adult salmon into Central Valley rivers. A replacement ratio of 1:1 is considered one barometer of reasonable population health. A geometric mean was used to adequately reflect the replacement ratio trend over time.

Table 1. Regression Relationships for DFG's Vernalis Flow Salmon Abundance Prediction Model

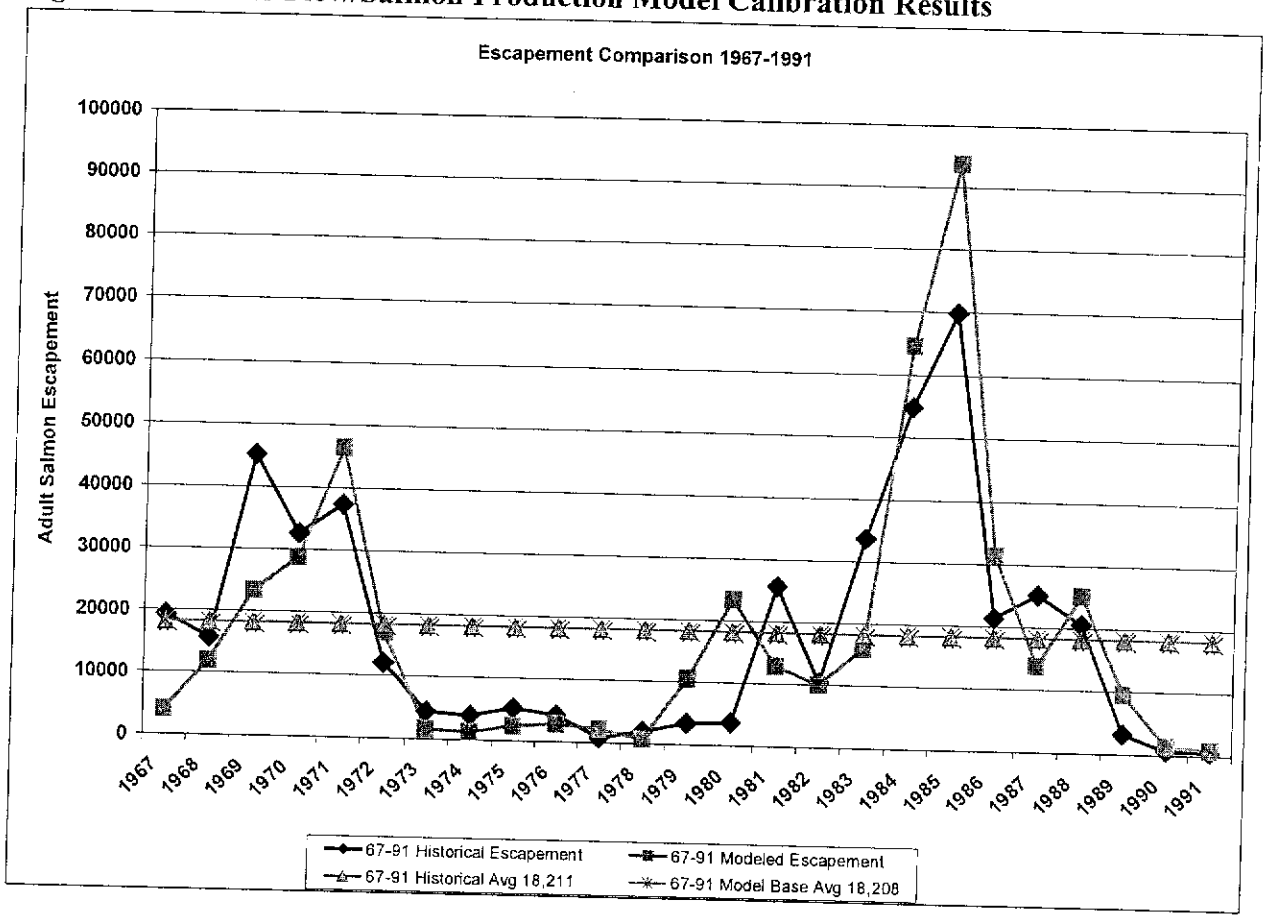
Vernalis Salmon Production Model Regression Relationships				
Mossdale Abundance				
Independent Variable(s)	**Dependent Variable**	**Observations**	**R-squared Value**	**Significance (P)**
Fall Adult Escapement Vernalis Spring Flow	Smolt Abundance	15	0.84	1.49E-05
South Delta In-Flow vs. Survival				
Vernalis Spring Flow	Smolt Survival	10	0.42	0.041
Chipp's Island Smolt Abundance				
Smolt Abundance	Adult Cohort	11	0.63	0.004

Figure 1. Vernalis Flow Production Prediction Model Mechanics[6]



[6] Model "Mechanics" refers to numerical calculation methods used to project, thence predict, both juvenile, and adult, salmon abundance as a function of: 1) fall adult escapement; 2) Vernalis spring-time flow; 3) salmon smolt survival as a function of flow thru the South Delta; 4) adult salmon cohort abundance as a function of salmon smolt abundance at Chipp's; and 5) reconstructed adult escapement as a function of individual adult cohort years to escapement.

Figure 2. Vernalis Flow/Salmon Production Model Calibration Results



Results

A summary of Model results is provided in Table 2. Complete Model results for the nine scenarios are provided in Appendix A. The results indicate that a Vernalis flow objective that varies, both in magnitude and window of duration, based on water year type may be a water-efficient way of accomplishing the Plan's Narrative Salmon Doubling Goal objective for the San Joaquin River basin (e.g., a 25 year average adult salmon escapement of 36,000). These results also indicate that Vernalis flow level in the drier year types strongly influence the adult salmon recruitment ratio (e.g., salmon population health indicator), and that Vernalis flow level in the wettest year types influence the overall salmon abundance trend (e.g., the peak abundance occurs in association with wet year conditions). Model scenario #9 which varied Vernalis flow level and duration by water year type at: 1) Wet at 20,000 cfs and 90[7] day window of protection); 2) Above Normal at 15,000 cfs and 75 day window of protection; 3) Below Normal at 10,000 cfs and 60 day window of protection; 4) Dry at 7,000 cfs and 45 day window of protection; and Critical at 5,000 cfs and 30 day window of protection, best accomplished the Department's modeling objectives of meeting the Narrative Salmon Doubling Goal in a 1:1 replacement ratio and minimizing the amount of additional water needed.

[7] The "90 day" window is actually 93 days based upon the number of days between March 15 and June 15.

Table 2. Vernalis Model Results Summary

Model Results Comparison Summary									
Model Scenario Number[8]	Vernalis Flow Target (k=cfs)	Window of Flow Duration Protection	Predicted 25 Year Average Escapement[9]	Additional Predicted 25 Year Average Escapement[10]	Replacement Ratio	Additional Water			Salmon per 1000 acre-feet
						Average Annual Acre-Feet[11]	Percent Additional[12]	% Total Available[13]	
1	2-7K	60 Day	19,479	1,271	0.89	139,788	28%	4%	9
2	5k	60 Day	19,956	1,748	0.98	243,960	72%	9%	7
3	10k	60 Day	25,961	7,753	1.10	674,223	183%	23%	11
4	15k	60 Day	37,035	18,827	1.19	1,146,137	295%	38%	16
5	5-10k	60 Day	22,261	4,053	0.99	388,671	92%	12%	10
6	5-15k	60 Day	26,841	8,633	1.00	575,033	113%	15%	15
7	5-20k	60 Day	33,416	15,208	1.02	774,039	132%	18%	20
8	5-15k	Variable	29,035	10,827	0.97	626,510	92%	13%	17
9	5-20k	Variable	38,164	19,956	1.00	893,517	110%	17%	22

Conclusions/Preliminary Recommendations

Subject to further internal review, independent scientific peer review, and ample review and refinement opportunity for all affected parties, the Department's model scenario 9 (Table 3) is our preliminary recommendation for revision of the Vernalis flow objectives in the Plan for the period March 15 through June 15. The Department recognizes that this preliminary recommendation represents a major incremental change to the Vernalis flow objectives and would require a dramatic change in VAMP. In March we recommended that the VAMP structure and function continue as the Boards selected implementation strategy for meeting the Vernalis flow objectives. We continue to support this approach if it can be adapted to: a) provide improved levels of protection for natural salmon; and b) the scientific study protocols and design (the target flows, exports, etc) can be adapted and implemented to obtain reliable results. Inherent in these refinements is the need to assure an ample supply of high quality study fish (hatchery salmon smolts) to help reduce the scientific uncertainty such as has occurred in the first five years of the VAMP study. In recognition that the Head of Old River Barrier remains a temporary structure for now, this barrier would be constructed/operated during the years when the Vernalis flow objectives are 7,000 cfs or less until such time as the permanent barrier can be constructed, tested and operated. In addition, the Department

[8] Corresponds to Model Scenario results provided in Appendix A

[9] Predicted Escapement is the 25 year (e.g., 1967 to 1991) model predicted escapement average.

[10] Additional Predicted Escapement is the amount of additional 25 year model predicted escapement average (e.g., average amount of salmon above the model predicted average of 18,208).

[11] Average Annual Acre-Feet is the calculated average (weighted by number of years within a water year type) annual additional volume of water (in acre-feet) over and above that which historically occurred.

[12] Percent Additional is the calculated amount of additional water (in percent) on average (weighted by number of years within a water year type) compared to that which occurred historically.

[13] The "% Total Available" is the amount of additional water needed to accomplish the scenario results as compared to the amount of combined San Joaquin River Basin run-off provided by the San Joaquin River Water Year Type Index (e.g., combined October thru July river flow into New Melones, New Don Pedro, New Exchequer, and Friant). This calculation does not account for reservoir carry-over supply which would represent an additional available amount of water.

brings to the Board's attention that flow levels at Vernalis for the March 15th thru June 15th time period at the magnitude described in Table 3 would provide additional water quality benefits to salmon and other aquatic species (e.g., reduced water temperatures, increased dissolved oxygen, decreased salinity etc.).

Table 3. CDFG's Recommended Vernalis Flows to Protect Fall-run Chinook Salmon[14]

CDFG Recommended Vernalis Flow Targets		
Water Year Type	**Flow Level (daily average cfs)**	**Window Duration (days)[15]**
Wet	20,000	90
Above Normal	15,000	75
Below Normal	10,000	60
Dry	7,000	45
Critical	5,000	30

[14] The Department submits these Vernalis flow recommendations to the Board within the following caveats:

1. DFG is proceeding with further internal review of it's preliminary recommendations;
2. DFG will be proceeding with external stakeholder (including VAMP partners) and scientific peer review activities to refine the utility of the Model as another tool in defining a revised set of Vernalis flow objectives which provide adequate protection; and,
3. DFG encourages the Board to give serious consideration to the process necessary to revise the Vernalis flow objectives, and the refinement of VAMP as an implementation strategy, over the next 3 years.

[15] Window Duration assumes a May 1 central time period date for all window lengths regardless of window duration.

Appendix A

CDFG Vernalis Flow Based Salmon Abundance Prediction Model Results

Scenario #1: 1967 to 1991 CDFG Vernalis Flow Adult Salmon Production Model Results--VAMP Flow Levels											
Water Year Type	Minimum Flow	Fish Summary					Water Summary*				
		Smolt Protection Window (# of days)**					Smolt Protection Window*				
		30	45	60	75	90	30	45	60	75	90
		Adult Salmon Escapement					Additional Water (AF)				
W	7000	18,884	19,217	19,479	19,678	19,875	41,771	54,480	69,848	78,696	95,019
AN	5700						190,115	263,694	319,947	369,284	411,715
BN	4450						149,141	223,663	304,628	372,705	442,923
D	3200						89,747	140,220	186,564	227,815	271,510
C	2000						37,723	57,614	76,485	94,407	114,384
Weighted Average (*According to Number of Each Water Year Type*)							**76,344**	**109,317**	**139,788**	**165,209**	**193,267**
Yr Type	**Flow**	**Percent Increase Adult Escapement*** **					**Percent Additional Water**** **				
W	7000	3.7%	5.5%	7.0%	8.1%	9.2%	1.4%	1.8%	2.3%	2.6%	3.1%
AN	5700						27.8%	38.6%	46.8%	54.0%	60.2%
BN	4450						39.5%	59.2%	80.6%	98.7%	117.3%
D	3200						27.6%	43.2%	57.5%	70.2%	83.6%
C	2000						13.6%	20.7%	27.5%	33.9%	41.1%
Weighted Average (*According to Number of Each Water Year Type*)							**14.7%**	**21.9%**	**28.4%**	**34.3%**	**40.3%**
Yr Type	**Flow**	**1:1 Replacement Ratio Geometric Mean--All Yr Types**					**Additional Percent of Total Available Water***** **				
W	7000	0.89	0.89	0.89	0.89	0.89	0.7%	0.9%	1.1%	1.2%	1.4%
AN	5700						3.2%	4.4%	5.3%	6.1%	6.8%
BN	4450						3.1%	4.7%	6.4%	7.8%	9.2%
D	3200						2.8%	4.4%	5.8%	7.1%	8.4%
C	2000						2.4%	3.6%	4.8%	6.0%	7.2%
Weighted Average (*According to Number of Each Water Year Type*)							**2.0%**	**2.9%**	**3.8%**	**4.5%**	**5.4%**

Notes:

* Does not account for VAMP Water (e.g., up to 110 TAF single step years)

** May 1 is the central point for all Smolt Protection Window time periods

*** Defined as modeled adult escapement increase as compared to modeled historical baseline (100% is the Narrative Doubling Goal)

**** Defined as percent water increase as compared to historical flows (AF)

***** Defined as amount of water (% WY Type Total Oct-July) used for fishery beneficial use (1967-1991 Average = 18.0%)

Scenario #2: 1967 to 1991 CDFG Vernalis Flow Adult Salmon Production Model Results--Min. Vernalis Flow Level of 5,000 cfs											
		Fish Summary					Water Summary*				
		Smolt Protection Window (# of days)**					Smolt Protection Window*				
Water Year Type	Minimum Flow	30	45	60	75	90	30	45	60	75	90
		Adult Salmon Escapement					Additional Water (AF)				
W	5000	19,083	19,560	19,956	20,271	20,598	15,921	18,235	23,417	23,759	27,068
AN	5000						148,472	201,418	240,999	275,820	306,269
BN	5000						181,861	272,742	370,067	454,504	544,353
D	5000						196,710	300,724	400,609	493,929	597,371
C	5000						209,989	316,662	421,680	523,381	643,874
Weighted Average (*According to Number of Each Water Year Type*)							**127,032**	**186,482**	**243,960**	**296,440**	**356,386**
Yr Type	**Flow**	**Percent Increase Adult Escapement*** **					**Percent Additional Water**** **				
W	5000	4.8%	7.4%	9.6%	11.3%	13.1%	0.5%	0.6%	0.8%	0.8%	0.9%
AN	5000						21.7%	29.5%	35.2%	40.3%	44.8%
BN	5000						48.1%	72.2%	98.0%	120.3%	144.1%
D	5000						60.6%	92.6%	123.4%	152.1%	184.0%
C	5000						75.5%	113.8%	151.6%	188.1%	231.4%
Weighted Average (*According to Number of Each Water Year Type*)							**36.4%**	**54.5%**	**72.0%**	**88.6%**	**107.5%**
Yr Type	**Flow**	**1:1 Replacement Ratio Geometric Mean--All Yr Types**					**Additional Percent of Total Available Water***** **				
W	5000	0.94	0.96	0.98	0.99	1.00	0.3%	0.3%	0.4%	0.4%	0.4%
AN	5000						2.5%	3.4%	4.0%	4.6%	5.1%
BN	5000						3.8%	5.7%	7.7%	9.5%	11.4%
D	5000						6.1%	9.4%	12.5%	15.3%	18.5%
C	5000						10.9%	16.4%	21.9%	27.2%	33.4%
Weighted Average (*According to Number of Each Water Year Type*)							**4.7%**	**7.0%**	**9.2%**	**11.3%**	**13.7%**

Notes:

* Does not account for VAMP Water (e.g., up to 110 TAF single step years)

** May 1 is the central point for all Smolt Protection Window time periods

*** Defined as modeled adult escapement increase as compared to modeled historical baseline (100% is the Narrative Doubling Goal)

**** Defined as percent water increase as compared to historical flows (AF)

***** Defined as amount of water (% WY Type Total Oct-July) used for fishery beneficial use (1967-1991 Average = 18.0%)

Scenario #3: 1967 to 1991 CDFG Vernalis Flow Adult Salmon Production Model Results--Min. Vernalis Flow of 10,000 cfs											
		Fish Summary					Water Summary*				
		*Smolt Protection Window (# of days)***					*Smolt Protection Window**				
Water Year Type	**Minimum Flow**	*30*	*45*	*60*	*75*	*90*	*30*	*45*	*60*	*75*	*90*
		Adult Salmon Escapement					**Additional Water (AF)**				
W	10000	21,501	23,801	25,961	27,878	29,994	84,317	121,155	164,880	208,565	264,883
AN	10000						445,922	647,405	827,149	992,853	1,160,471
BN	10000						479,311	718,917	964,967	1,198,129	1,466,448
D	10000						494,160	746,899	995,509	1,237,554	1,519,466
C	10000						507,439	762,837	1,016,580	1,267,006	1,565,969
Weighted Average (*According to Number of Each Water Year Type*)							**342,023**	**509,055**	**674,223**	**834,635**	**1,021,277**
Yr Type	**Flow**	**Percent Increase Adult Escapement*** **					**Percent Additional Water**** **				
W	10000	18.1%	30.7%	42.6%	53.1%	64.7%	2.8%	4.0%	5.4%	6.9%	8.8%
AN	10000						65.2%	94.7%	121.0%	145.2%	169.7%
BN	10000						126.9%	190.3%	255.5%	317.2%	388.2%
D	10000						152.2%	230.0%	306.6%	381.1%	467.9%
C	10000						182.4%	274.2%	365.4%	455.4%	562.8%
Weighted Average (*According to Number of Each Water Year Type*)							**91.9%**	**137.8%**	**182.9%**	**226.9%**	**278.3%**
Yr Type	**Flow**	**1:1 Replacement Ratio Geometric Mean--All Yr Types**					**Additional Percent of Total Available Water***** **				
W	10000	1.02	1.06	1.10	1.12	1.14	1.3%	1.9%	2.5%	3.1%	3.8%
AN	10000						7.3%	10.7%	13.6%	16.3%	19.1%
BN	10000						10.0%	15.0%	20.1%	25.0%	30.6%
D	10000						15.3%	23.2%	30.9%	38.4%	47.1%
C	10000						25.6%	38.4%	51.2%	63.8%	78.8%
Weighted Average (*According to Number of Each Water Year Type*)							**11.7%**	**17.4%**	**23.1%**	**28.7%**	**35.3%**

Notes:

* Does not account for VAMP Water (e.g., up to 110 TAF single step years)

** May 1 is the central point for all Smolt Protection Window time periods

*** Defined as modeled adult escapement increase as compared to modeled historical baseline (100% is the Narrative Doubling Goal)

**** Defined as percent water increase as compared to historical flows (AF)

***** Defined as amount of water (% WY Type Total Oct-July) used for fishery beneficial use (1967-1991 Average = 18.0%)

Scenario #4: 1967 to 1991 CDFG Vernalis Flow Adult Salmon Production Model Results--Min. Vernalis Flow of 15,000 cfs											
Water Year Type	Minimum Flow	Fish Summary					Water Summary*				
		Smolt Protection Window (# of days)**					Smolt Protection Window*				
		30	45	60	75	90	30	45	60	75	90
		Adult Salmon Escapement					Additional Water (AF)				
W	15000	25,614	31,304	37,035	42,385	48,380	203,694	299,272	418,153	549,597	696,538
AN	15000						743,372	1,093,580	1,422,049	1,736,478	2,082,566
BN	15000						776,761	1,165,092	1,559,867	1,941,754	2,388,543
D	15000						791,610	1,193,074	1,590,409	1,981,179	2,441,561
C	15000						804,889	1,209,012	1,611,480	2,010,631	2,488,064
Weighted Average (*According to Number of Each Water Year Type*)							**575,366**	**858,730**	**1,146,137**	**1,433,327**	**1,766,813**
Yr Type	**Flow**	**Percent Increase Adult Escapement*** **					**Percent Additional Water**** **				
W	15000	40.7%	71.9%	103.4%	132.8%	165.7%	6.7%	9.9%	13.8%	18.2%	23.0%
AN	15000						108.7%	159.9%	208.0%	254.0%	304.6%
BN	15000						205.6%	308.4%	412.9%	514.0%	632.3%
D	15000						243.8%	367.4%	489.8%	610.1%	751.9%
C	15000						289.3%	434.6%	579.2%	722.7%	894.3%
Weighted Average (*According to Number of Each Water Year Type*)							**148.1%**	**221.9%**	**295.3%**	**367.7%**	**453.0%**
Yr Type	**Flow**	**1:1 Replacement Ratio Geometric Mean--All Yr Types**					**Additional Percent of Total Available Water***** **				
W	15000	1.08	1.15	1.19	1.22	1.25	2.9%	4.2%	5.8%	7.5%	9.4%
AN	15000						12.2%	17.9%	23.3%	28.5%	34.1%
BN	15000						16.2%	24.3%	32.6%	40.5%	49.9%
D	15000						24.6%	37.0%	49.3%	61.4%	75.7%
C	15000						40.2%	60.4%	80.5%	100.4%	124.3%
Weighted Average (*According to Number of Each Water Year Type*)							**18.8%**	**28.2%**	**37.6%**	**46.8%**	**57.7%**

Notes:

* Does not account for VAMP Water (e.g., up to 110 TAF single step years)

** May 1 is the central point for all Smolt Protection Window time periods

*** Defined as modeled adult escapement increase as compared to modeled historical baseline (100% is the Narrative Doubling Goal)

**** Defined as percent water increase as compared to historical flows (AF)

***** Defined as amount of water (% WY Type Total Oct-July) used for fishery beneficial use (1967-1991 Average = 18.0%)

Scenario #5: 1967 to 1991 CDFG Vernalis Flow Adult Salmon Production Model Results--Max. Vernalis Flow of 10,000 cfs											
		Fish Summary					Water Summary*				
		*Smolt Protection Window (# of days)***					*Smolt Protection Window**				
Water Year Type	**Minimum Flow**	*30*	*45*	*60*	*75*	*90*	*30*	*45*	*60*	*75*	*90*
		Adult Salmon Escapement					**Additional Water (AF)**				
W	10000	20,069	21,221	22,261	23,154	24,087	84,317	121,155	164,880	208,565	264,883
AN	8500						356,687	513,552	648,679	769,766	883,843
BN	7000						300,841	451,212	608,027	751,954	913,191
D	6000						256,200	389,959	519,589	642,654	781,790
C	5000						209,989	316,662	421,680	523,381	643,874
Weighted Average (*According to Number of Each Water Year Type*)							**199,247**	**294,891**	**388,671**	**477,695**	**578,671**
Yr Type	**Flow**	**Percent Increase Adult Escapement*** **					**Percent Additional Water**** **				
W	10000	10.2%	16.5%	22.3%	27.2%	32.3%	2.8%	4.0%	5.4%	6.9%	8.8%
AN	8500						52.2%	75.1%	94.9%	112.6%	129.3%
BN	7000						79.6%	119.4%	161.0%	199.1%	241.8%
D	6000						78.9%	120.1%	160.0%	197.9%	240.8%
C	5000						75.5%	113.8%	151.6%	188.1%	231.4%
Weighted Average (*According to Number of Each Water Year Type*)							**46.3%**	**69.3%**	**91.6%**	**112.8%**	**136.8%**
Yr Type	**Flow**	**1:1 Replacement Ratio Geometric Mean--All Yr Types**					**Additional Percent of Total Available Water***** **				
W	10000	0.94	0.97	0.99	1.00	1.01	1.3%	1.9%	2.5%	3.1%	3.8%
AN	8500						5.9%	8.5%	10.7%	12.7%	14.5%
BN	7000						6.3%	9.4%	12.7%	15.7%	19.1%
D	6000						8.0%	12.1%	16.1%	20.0%	24.2%
C	5000						10.9%	16.4%	21.9%	27.2%	33.4%
Weighted Average (*According to Number of Each Water Year Type*)							**6.0%**	**8.9%**	**11.8%**	**14.6%**	**17.7%**

Notes:

* Does not account for VAMP Water (e.g., up to 110 TAF single step years)

** May 1 is the central point for all Smolt Protection Window time periods

*** Defined as modeled adult escapement increase as compared to modeled historical baseline (100% is the Narrative Doubling Goal)

**** Defined as percent water increase as compared to historical flows (AF)

***** Defined as amount of water (% WY Type Total Oct-July) used for fishery beneficial use (1967-1991 Average = 18.0%)

Scenario #6: 1967 to 1991 CDFG Vernalis Flow Adult Salmon Production Model Results--Max. Vernalis Flow of 15,000 cfs											
		Fish Summary					Water Summary*				
		*Smolt Protection Window (# of days)***					*Smolt Protection Window**				
Water Year Type	**Minimum Flow**	*30*	*45*	*60*	*75*	*90*	*30*	*45*	*60*	*75*	*90*
		Adult Salmon Escapement					**Additional Water (AF)**				
W	15000	21,999	24,434	26,841	29,061	31,388	203,694	299,272	418,153	549,597	696,538
AN	12000						564,902	825,875	1,065,109	1,290,303	1,529,309
BN	9000						419,821	629,682	845,987	1,049,404	1,282,029
D	7000						315,690	479,194	638,569	791,379	966,209
C	5000						209,989	316,662	421,680	523,381	643,874
Weighted Average (*According to Number of Each Water Year Type*)							**289,814**	**430,402**	**575,033**	**719,447**	**881,602**
Yr Type	**Flow**	**Percent Increase Adult Escapement*** **					**Percent Additional Water**** **				
W	15000	20.6%	34.0%	47.2%	59.3%	72.1%	6.7%	9.9%	13.8%	18.2%	23.0%
AN	12000						82.6%	120.8%	155.8%	188.7%	223.7%
BN	9000						111.1%	166.7%	224.0%	277.8%	339.4%
D	7000						97.2%	147.6%	196.7%	243.7%	297.5%
C	5000						75.5%	113.8%	151.6%	188.1%	231.4%
Weighted Average (*According to Number of Each Water Year Type*)							**56.8%**	**85.0%**	**112.8%**	**139.5%**	**170.1%**
Yr Type	**Flow**	**1:1 Replacement Ratio Geometric Mean--All Yr Types**					**Additional Percent of Total Available Water***** **				
W	15000	0.95	0.98	1.00	1.02	1.03	2.9%	4.2%	5.8%	7.5%	9.4%
AN	12000						9.3%	13.6%	17.5%	21.2%	25.1%
BN	9000						8.8%	13.1%	17.7%	21.9%	26.8%
D	7000						9.8%	14.9%	19.8%	24.6%	30.0%
C	5000						10.9%	16.4%	21.9%	27.2%	33.4%
Weighted Average (*According to Number of Each Water Year Type*)							**7.5%**	**11.2%**	**14.9%**	**18.5%**	**22.6%**

Notes:

* Does not account for VAMP Water (e.g., up to 110 TAF single step years)

** May 1 is the central point for all Smolt Protection Window time periods

*** Defined as modeled adult escapement increase as compared to modeled historical baseline (100% is the Narrative Doubling Goal)

**** Defined as percent water increase as compared to historical flows (AF)

***** Defined as amount of water (% WY Type Total Oct-July) used for fishery beneficial use (1967-1991 Average = 18.0%)

Scenario #7: 1967 to 1991 CDFG Vernalis Flow Adult Salmon Production Model Results--Max. Vernalis Flow of 20,000 cfs											
		Fish Summary					**Water Summary***				
		*Smolt Protection Window (# of days)***					*Smolt Protection Window**				
Water Year Type	**Minimum Flow**	*30*	*45*	*60*	*75*	*90*	*30*	*45*	*60*	*75*	*90*
		Adult Salmon Escapement					**Additional Water (AF)**				
W	20000	24,626	29,002	33,416	37,453	41,768	351,846	529,917	746,207	974,025	1,226,704
AN	15000						743,372	1,093,580	1,422,049	1,736,478	2,082,566
BN	10000						479,311	718,917	964,967	1,198,129	1,466,448
D	8000						375,180	568,429	757,549	940,104	1,150,628
C	5000						209,989	316,662	421,680	523,381	643,874
Weighted Average (*According to Number of Each Water Year Type*)							**383,602**	**574,114**	**774,039**	**973,374**	**1,197,867**
Yr Type	**Flow**	**Percent Increase Adult Escapement*****					**Percent Additional Water********				
W	20000	35.2%	59.3%	83.5%	105.7%	129.4%	11.6%	17.5%	24.7%	32.2%	40.5%
AN	15000						108.7%	159.9%	208.0%	254.0%	304.6%
BN	10000						126.9%	190.3%	255.5%	317.2%	388.2%
D	8000						115.5%	175.1%	233.3%	289.5%	354.3%
C	5000						75.5%	113.8%	151.6%	188.1%	231.4%
Weighted Average (*According to Number of Each Water Year Type*)							**66.3%**	**99.4%**	**132.1%**	**163.9%**	**200.3%**
Yr Type	**Flow**	**1:1 Replacement Ratio Geometric Mean--All Yr Types**					**Additional Percent of Total Available Water*********				
W	20000	0.96	1.00	1.02	1.04	1.05	4.8%	7.2%	9.9%	12.8%	16.0%
AN	15000						12.2%	17.9%	23.3%	28.5%	34.1%
BN	10000						10.0%	15.0%	20.1%	25.0%	30.6%
D	8000						11.7%	17.7%	23.5%	29.2%	35.7%
C	5000						10.9%	16.4%	21.9%	27.2%	33.4%
Weighted Average (*According to Number of Each Water Year Type*)							**9.0%**	**13.5%**	**18.0%**	**22.4%**	**27.5%**

Notes:

* Does not account for VAMP Water (e.g., up to 110 TAF single step years)

** May 1 is the central point for all Smolt Protection Window time periods

*** Defined as modeled adult escapement increase as compared to modeled historical baseline (100% is the Narrative Doubling Goal)

**** Defined as percent water increase as compared to historical flows (AF)

***** Defined as amount of water (% WY Type Total Oct-July) used for fishery beneficial use (1967-1991 Average = 18.0%)

Scenario #8: 1967 to 1991 CDFG Vernalis Flow Adult Salmon Production Model Results--Variable Vernalis Flow and Window of Protection--5k to 15k											
		Fish Summary					**Water Summary***				
		*Smolt Protection Window (# of days)***					*Smolt Protection Window**				
Water Year Type	**Minimum Flow**	*30*	*45*	*60*	*75*	*90*	*30*	*45*	*60*	*75*	*90*
		Adult Salmon Escapement					**Additional Water (AF)**				
W	15000	29,035									696,538
AN	12000									1,290,303	
BN	9000								845,987		
D	7000							479,194			
C	5000						209,989				
Weighted Average (*According to Number of Each Water Year Type*)							**626,510**				
Yr Type	**Flow**	**Percent Increase Adult Escapement*****					**Percent Additional Water********				
W	15000	59.5%									23.0%
AN	12000									188.7%	
BN	9000								224.0%		
D	7000							147.6%			
C	5000						75.5%				
Weighted Average (*According to Number of Each Water Year Type*)							**92%**				
Yr Type	**Flow**	**1:1 Replacement Ratio Geometric Mean--All Yr Types**					**Additional Percent of Total Available Water*********				
W	15000	0.97									9.4%
AN	12000									21.2%	
BN	9000								17.7%		
D	7000							14.9%			
C	5000						10.9%				
Weighted Average (*According to Number of Each Water Year Type*)							**13%**				

Notes:

* Does not account for VAMP Water (e.g., up to 110 TAF single step years)

** May 1 is the central point for all Smolt Protection Window time periods

*** Defined as modeled adult escapement increase as compared to modeled historical baseline (100% is the Narrative Doubling Goal)

**** Defined as percent water increase as compared to historical flows (AF)

***** Defined as amount of water (% WY Type Total Oct-July) used for fishery beneficial use (1967-1991 Average = 18.0%)

Scenario #9: 1967 to 1991 CDFG Vernalis Flow Adult Salmon Production Model Results--Variable Vernalis Flow and Window of Protection--5k to 20k											
		Fish Summary					**Water Summary***				
		*Smolt Protection Window (# of days)***					*Smolt Protection Window**				
Water Year Type	**Minimum Flow**	*30*	*45*	*60*	*75*	*90*	*30*	*45*	*60*	*75*	*90*
		Adult Salmon Escapement					**Additional Water (AF)**				
W	20000	38,164									1,226,704
AN	15000									1,736,478	
BN	10000								964,967		
D	7000							479,194			
C	5000						209,989				
Weighted Average (*According to Number of Each Water Year Type*)							**893,517**				
Yr Type	**Flow**	**Percent Increase Adult Escapement*** **					**Percent Additional Water*****				
W	20000	109.6%									40.5%
AN	15000									254.0%	
BN	10000								255.5%		
D	7000							147.6%			
C	5000						75.5%				
Weighted Average (*According to Number of Each Water Year Type*)							**110%**				
Yr Type	**Flow**	**1:1 Replacement Ratio Geometric Mean--All Yr Types**					**Additional Percent of Total Available Water******				
W	20000	1.00									16.0%
AN	15000									28.5%	
BN	10000								20.1%		
D	7000							14.9%			
C	5000						10.9%				
Weighted Average (*According to Number of Each Water Year Type*)							**17%**				

Notes:

* Does not account for VAMP Water (e.g., up to 110 TAF single step years)

** May 1 is the central point for all Smolt Protection Window time periods

*** Defined as modeled adult escapement increase as compared to modeled historical baseline (100% is the Narrative Doubling Goal)

**** Defined as percent water increase as compared to historical flows (AF)

***** Defined as amount of water (% WY Type Total Oct-July) used for fishery beneficial use (1967-1991 Average = 18.0%)