EFFECTS OF THE CVP UPON THE SOUTHERN DELTA WATER SUPPLY SACRAMENTO-SAN JOAQUIN RIVER DELTA, CALIFORNIA

JUNE 1980

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F. SUMMARY OF QUALITY IMPACTS

Generally, the water quality at Vernalis has deteriorated since the 1930's. How much degradation has occurred and what have been the principal causes, have been the topics of this chapter. In the analysis of data and interpretation of results, several methods have been employed, sometimes with differing results. The discussion that follows attempts to summarize results and reconcile differences wherever possible. In cases where the methods yield disparate results, ranges are given to include all estimates.

Changes that have occurred in the quality of water at Vernalis between the pre-1944 and post-1952 periods are summarized in tables VI-28 and VI-29. The tables present data derived from the records of mean monthly TDS at Vernalis (mg/L) given in tables VI-13, VI-14, and VI-18. Maximum and mean values are given for three periods--the maximum month, the April-September period and the entire water year--and for each type of year--dry, below normal, above normal and wet.

Data presented in the tables indicate that the TDS at Vernalis has increased in almost all categories listed. The greatest effect is shown in the drier years and the least in the wettest years. Table VI-30 is a composite of tables VI-28 and VI-29, showing the range of estimated impacts at Vernalis. Using the April-September period in a dry year as an example, the mean TDS increased somewhere between 327 and 363 mg/L from pre-1944 to post-1952 years. This increase corresponded to 93 to 116 percent of the pre-1944 period TDS.

As noted in previous discussion, the general deterioration in quality at Vernalis is identified both with reductions in flows along the main stem of the San Joaquin and increases in salt burden transferred to the river. When

Table VI-28. SUMMARY OF IMPACTS ON QUALITY AT VERNALIS PRE-1944 AND POST-1952

YEAR TYPE & PERIOD	Total Dissolved Solids, mg/L PRE-1944 Max	PRE-1944 Mean	POST-1952 Max	POST-1952 Mean	Percent Increase PRE-1944 to POST-1952 Max	Percent Increase PRE-1944 to POST-1952 Mean
DRY						
Max.month	444	387	941	765	112	98
April-Sept	383	314	840	677	119	116
Full Year	342	288	681	549	99	91
BELOW NORMAL						
Max.month	370	370	729	544	97	47
April-Sept	282	287	683	419	142	46
Full Year	282	261	502	364	78	40
ABOVE NORMAL						
Max.month	517	382	805	641	56	68
April-Sept	244	260	387	325	59	52
Full Year	269	233	489	394	82	69
WET						
Max.month	384	374	462	439	20	17
April-Sept	180	173	226	209	26	21
Full Year	224	197	252	237	13	20
ALL YEARS						
Max.month	517	381	941	584	82	53
April-Sept	383	239	840	433	119	81
Full Year	342	234	661	392	99	68

*BASED ON MOSSDALE DATA

TABLE VI-29. SUMMARY OF IMPACTS ON QUALITY AT VERNALIS
PRE-1944 AND POST-1952

Year type and period	Total dissolved solids, mg/L				Percent increase	
	PRE-1944		POST-1952		PRE-1944 to POST-1952	
	Max	Mean	Max	Mean	Max	Mean
DRY						
Max month	616	490	941	765	53	56
Apr-Sept	453	350	840	677	85	93
Full year	374	310	681	549	82	77
BELOW NORMAL						
Max month	407	407	729	544	79	34
Apr-Sept	278	278	683	419	146	51
Full year	262	262	502	364	92	39
ABOVE NORMAL						
Max month	415	398	805	641	94	61
Apr-Sept	236	228	387	325	64	43
Full year	251	229	489	394	95	72
WET						
Max month	366	358	462	439	26	23
Apr-Sept	202	194	226	209	12	8
Full year	207	200	252	237	22	19
ALL YEARS						
Max month	616	424	941	588	53	39
Apr-Sept	453	267	840	434	85	63
Full year	372	254	681	383	82	51

* Based on load-flow regression data.

TABLE VI-30. RANGE OF ESTIMATED IMPACTS* ON QUALITY AT VERNALIS (1930-1944) to (1952-1966)

Year type & period	Total dissolved solids, mg/L		Percent increase	
	Max	Mean	Max	Mean
DRY				
Max month	325 - 497	275 - 378	53 - 112	56 - 98
Apr-Sept	387 - 457	327 - 363	85 - 119	93 - 116
Full year	307 - 339	239 - 261	82 - 99	77 - 91
BELOW NORMAL				
Max month	322 - 359	137 - 174	79 - 97	34 - 47
Apr-Sept	401 - 405	132 - 141	142 - 146	46 - 51
Full year	220 - 240	102 - 103	78 - 92	39 - 40
ABOVE NORMAL				
Max month	288 - 390	243 - 259	56 - 94	61 - 68
Apr-Sept	143 - 151	65 - 97	59 - 64	25 - 43
Full year	220 - 238	161 - 165	82 - 95	69 - 72
WET				
Max month	78 - 96	65 - 81	20 - 26	17 - 23
Apr-Sept	24 - 46	15 - 36	12 - 26	8 - 21
Full year	45 - 59	37 - 40	22 - 31	19 - 20
ALL YEARS				
Max month	325 - 497	164 - 203	53 - 112	39 - 53
Apr-Sept	387 - 457	167 - 194	85 - 119	63 - 81
Full year	307 - 339	129 - 158	82 - 99	51 - 68

* Based on results from Mossdale data and load-flow regression data. See tables VI-28, VI-29.

the total change in quality at Vernalis that has occurred between the two periods is distributed between reduced flow and increased salt load, it is noted that the effect of increased salt load is becoming relatively more important in recent years. Tables VI-31 and VI-32 summarize the changes in total salt load that have occurred in the two decades 1950-59 and 1960-69 in relation to the period of 1930-49.

In the 1950's, the estimated increased in annual TDS load at Vernalis. In the 1960's the load increased 530 to 569 kilotons TDS per year. This increase between the 1950's and 1960's, a 50-56 percent jump, indicates the more recent impact on water quality at Vernalis. During the 1960's the average annual runoff at Vernalis was about 710,000 acre-feet lower than for the 1930-1949 period while the total TDS load actually increased.

In the 1950's the estimated increase in the April-September TDS load at Vernalis ranged from -18 to +21 kilotons TDS. In the 1960's the load increased +251 to 290 kilotons TDS per year. This increase, 44 to 54 percent of 1930-1949 is indicative also of more recent impacts on Vernalis water quality. During the 1960's the average April-September runoff at Vernalis was about 610 thousand acre-feet lower than in the 1930-1949 period.

A similar analysis based on chloride data summarized in table VI-10, indicates an overall increase in salt load (as chlorides) of about 0-35 percent in the post-1949 years depending on year classification, the dry and below normal years showing the greatest change.

Analysis of the sources of salt load contributing to the San Joaquin River, and which account for, in part, the increases noted at Vernalis, indicates that about 45 to 85 percent of the total load, depending somewhat on the

Table VI-31. SUMMARY OF CHANGES IN TDS LOAD AT VERNALIS, 1930-1969

Month of Year	TDS Load, Tons x 10^3		
	1930-49 *	1950-59	1960-69
Oct	41	49	61
Nov	42	66	63
Dec	57	81	90
Jan	71	97	152
Feb	122	98	186
Mar	148	131	208
Apr	140	168	199
May	136	137	207
Jun	155	119	215
Jul	75	58	104
Aug	35	35	47
Sep	35	41	55
Apr-Sep	576	558	827
Percent change from 1930-49	0	-3	44
Year	1057	1080	1587
Percent Change from 1930-49	0	2	50

* Based on Mossdale chloride data

TABLE VI-32. SUMMARY OF CHANGES IN TDS LOAD AT VERNALIS, 1930-1969

Month of year	TDS load, tons x 10^3		
	1930-49*	1950-59	1960-69
Oct	48	49	61
Nov	44	66	63
Dec	62	81	90
Jan	66	97	152
Feb	108	98	186
Mar	153	131	208
Apr	102	168	199
May	111	137	207
Jun	149	119	215
Jul	94	58	104
Aug	40	35	47
Sept	41	41	55
Apr-Sept	537	558	827
% Change from 1930-49	0	4	54
Year	1018	1080	1587
% Change from 1930-49	0	6	56

* Based on load-flow regression data.

quality constituent considered and the year type, enters within upper San Joaquin River basin. The remaining fraction includes the contributions of the Tuolumne gas wells that have been the subject of efforts by the State of California to reduce point source salt accretions to the river, local drainage returns between Newman and Vernalis and runoff from the east side streams.

Table VI-33 is a summary of the results obtained from salt balances using chloride data for the four representative months of October, January, April, and July. The tabulated results show that virtually no change has occurred in the proportion of salt load contributed by the upper San Joaquin River basin. The table shows that the most apparent changes have taken place on the Tuolumne River and in "other" flows, the unidentified sources and sinks of salt load within the San Joaquin River basin.

Table VI-33 summarizes estimated impacts on the water quality of the San Joaquin River at Vernalis as determined by the two methods, one utilizing the Mossdale chloride data and the second based on chloride load-flow regressions. Data presented in the summary table were derived from various tables presented earlier in this chapter; specifically tables VI-9, 30, 31, 32, and 33 were utilized. Footnotes on table VI-34 describe the procedures used in calculation of the values given.

The effects of upstream development, both in the entire San Joaquin River basin and in the upper San Joaquin River basin as given in table VI-34, are outlined briefly for each year classification as follows:

Dry Years

In dry years the average TDS increase at Vernalis, resulting from development upstream after 1947, was estimated at about 350 mg/L for the April-September

Table VI-33 PERCENT OF VERNALIS CHLORIDE LOAD AND THEIR ORIGINS*

	Upper San Joaquin River Basin %		"Others" %		Stanislaus River %		Tuolumne River %		Upper San Joaquin plus "others" %	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
DRY										
Apr-Sep	107	86	-67	-55	4	2	57	69	40	30
Full Year	72	71	-22	-28	3	2	47	56	50	43
BELOW NORMAL										
Apr-Sep	83	81	-28	-49	3	2	43	66	55	32
Full Year	61	67	-1	-21	3	2	38	52	59	46
ABOVE NORMAL										
Apr-Sep	59	63	17	1	2	3	23	35	75	63
Full Year	51	55	22	9	2	2	26	34	72	64
WET										
Apr-Sep	68	56	37	25	2	3	16	21	82	77
Full Year	47	49	31	25	2	2	21	26	78	73
ALL YEARS										
Apr-Sep	78	73	-11	-24	3	2	35	51	63	48
Full Year	58	62	7	-7	2	2	33	44	65	55

*Based on load-flow regression salt balances.
Pre refers to 1930-1944 period with 5-Dry, 1-B.Norm., 7-A.Norm., 2-Wet
Post refers to 1952-1966 period with 4-Dry, 5-B.Norm., 2-A.Norm., 4-Wet

TABLE VI-34. SUMMARY OF ESTIMATED IMPACTS ON THE QUALITY OF THE SAN JOAQUIN RIVER AT VERNALIS

1	2	3	4	5	6	7	8
		Increase in TDS mg/L due to decreased flow		Increase in total salt load			
				Vernalis total		Increased caused by CVP	
Year Type & Period	Total increase in TDS mg/L at Vernalis	Percent of Pre-CVP	Percent due to CVP	Increase Tons x 10^3	% of Pre-CVP	Increase Tons x 10^3	% of Pre-CVP
DRY							
Apr-Sep	327 - 363	84 - 100	1.8 - 2.1	68	49	58	42
Full Year	239 - 261	22 - 26	6.3 - 7.4	143	55	102	39
BELOW NORMAL							
Apr-Sep	132 - 141	100	36	95	57	77	46
Full year	102 - 103	100	45	193	62	129	41
ABOVE NORMAL							
Apr-Sep	65 - 97	100	37	33	39	21	25
Full year	161 - 165	100	59	72	46	40	26
WET							
Apr-Sep	15 - 36	81 - 100	45 - 55	76	46	43	26
Full year	37 - 40	65 - 73	44 - 50	143	46	70	23
ALL YEARS							
Apr-Sep	167 - 194	90 - 100	30 - 33	73	49	54	36
Full year	129 - 158	70 - 73	37 - 39	147	53	91	33

Col. 2 - See Table VI-30.
3 - Obtained by assuming no change in salt load and flow reduction TDS=50 mg/L.
4 - Col 3 x ratio of upper San Joaquin flow reductions to total San Joaquin flow reduction.
5 - Obtained by pro-rating average TDS load increase between 1960's and 1930-49 period (Tables VI-31 and 32) in proportion to salt load increase in each year type (Table VI-9) and number of years of each year type in 1950-69 period.
6 - Col 5 salt load for 1930-49 period x proportion of years in each class.
7 - Col 5 x proportion of total chloride load contributed by upper San Joaquin basin (Table VI-33)
8 - Col 7 x proportion of years in each year class.

period and 250 mg/L for the full year. Of this increase the proportion due to reduced flow from all sources was 90 percent in the April-September period, but only 25 percent for the entire year. The impact of the CVP on water quality (as expressed by changes in TDS) in dry years, caused by flow reductions in the upper San Joaquin basin, was relatively small, only 2 percent in the April-September period and 7 percent for the entire year.

Salt loads at Vernalis in dry years were estimated to have increased in the period subsequent to 1947, by 68,000 tons in the April-September period and by 143,000 tons for the whole year. These increases corresponded to roughly 49 percent and 55 percent, respectively, of the pre-1944 TDS loads at Vernalis. The CVP salt load impact in dry years was estimated at 58,000 tons in the April-September period and 102,000 tons for the full year, corresponding to 42 percent and 39 percent increases, respectively, of pre-1944 salt loads at Vernalis.

Below Normal Years

In below normal years, the increase in average TDS concentration at Vernalis between the pre- and post-CVP periods was estimated at about 135 mg/L for the April-September period and slightly more than 100 mg/L for the full year. Virtually all of this increase is attributed to reductions in flow from all sources. The impact due to reduced flow attributed to the CVP was about 36 percent in the April-September period and 45 percent for the full year.

TDS load increases in below normal years subsequent to 1947 are estimated at 95,000 tons for the April-September period and 193,000 tons for the year. Of this increase, 77,000 tons and 129,000 tons, respectively, were estimated to have been derived from the upper San Joaquin basin. The proportionate impact

of the CVP on salt loads at Vernalis was largest for below normal years, 46 percent of the total increase at Vernalis in the April-September period and 41 percent for the whole year.

Above Normal Years

In above normal years the average TDS increase at Vernalis, resulting from development upstream after 1947, was estimated at about 80 mg/L for the April-September period and 165 mg/L for the full year. Of this increase, the proportion due to reduced flow from all sources was 100 percent in both the April-September and full year periods. The impact of the CVP on water quality (as expressed by changes in TDS) in above normal years, caused by flow reductions in the upper San Joaqin basin, was 37 percent in the April-September period and 59 percent for the entire year.

Salt loads at Vernalis in above normal years were estimated to have increased in the period subsequent to 1947 by 33,000 tons in the April-September period and by 72,000 tons for the entire year. These increases correspond to roughly 39 percent and 46 percent, respectively, of pre-1944 TDS loads at Vernalis. The CVP salt load impact in above normal years was estimated at 21,000 tons in the April-September period and 40,000 tons for the full year, corresponding to 25 and 26 percent increases respectively, in pre-1944 salt loads at Vernalis.

Wet Years

In wet years, the increase in average TDS concentration at Vernalis between the pre- and post-CVP periods was estimated at about 25 mg/L for the April-September period and about 40 mg/L for the full year. Of this increase the proportion due to reduced flow from all sources was 90 percent in the April-September period, and 70 percent for the entire year. The impact due to

reduced flow attributed to the CVP was about 50 percent for both the April-September and full year periods.

TDS load increases in wet years subsequent to 1947 are estimated at 76,000 tons for the April-September period and 143,000 tons for the year. Of this increase, 43,000 tons and 70,000 tons, respectively, were estimated to have been derived from the Upper San Joaquin Basin. The proportionate impact of the CVP on salt loads at Vernalis was 26 percent of the total increase at Vernalis in the April-September period and 23 percent for the full year.