



**THE PAUL F. ROMBERG
TIBURON CENTER FOR ENVIRONMENTAL STUDIES**
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For your consideration:

Enclosed please find a review by Dr. Luna Leopold, a Member of the National Academy of Sciences and former Chief and Senior Research Hydrologist at the U.S. Geological Survey, of the report "Analysis of the influence of water withdrawals on runoff to the Delta-San Francisco Bay ecosystem (1921-83)" by M. Rozengurt, M. Herz and S. Feld.

This report was presented by Dr. Rozengurt on July 13, 1987 at the D-1415 Hearings of the State Water Resources Control Board in Sacramento. It was funded by the San Francisco Foundation and Buck Trust, presently the Marin Community Foundation.

Sincerely,

Patricia S. Briggs

Patricia S. Briggs
Administrative Secretary

Enc.

SACRAMENTO DELTA WATER SUPPLY AND REVIEW OF THE TIBURON REPORT

Luna B. Leopold
Consulting Engineer

California must take heed of well documented experience in the Soviet Union where diversion of fresh water from the natural supply to an estuary has resulted in immense economic loss and the near destruction of an important estuary. Regulation of the Don River has resulted in an increase of salinity of the Azov Sea by a mere 7 percent and the result was to reduce total fish production from about 15 to 3 thousand tonnes annually. This has been documented in detail by Volovik (1986) and reviewed in the Tiburon report here being discussed. x)

The Tiburon report as it will here be called is a detailed study of the water situation in the Sacramento Delta. The reference is:

Rozengurt, M., Herz, M.J., and Feld, S., 1987, Analysis of the influence of water withdrawals on runoff to the Delta-San Francisco Bay ecosystem (1921-1983): Paul F. Romberg Tiburon Center for Environmental Studies, Tech. Rept. No 87-7.

This voluminous study cannot be either read or taken lightly for it is statistical, detailed, and in many places less than clear. Nevertheless the more one studies it the more impressive is the informational content. The present review deals only with the discussion and data dealing with annual flow data whereas the Tiburon report analyses both annual and monthly data.

The present discussion is an attempt to bring out those points that seem most significant and to present some reanalysis to clarify and emphasize some of the important conclusions.

The data base is reviewed in some detail. It appears that during the planning and construction stages of water development and diversion in the Sacramento system, two somewhat shortcut data compilations were used. The "Four River Index" is a data base that includes runoff from only 75 % of the total drainage area. A "modified method" had previously been employed also selecting less than the full runoff. Finally a compilation was made that estimated the runoff not only from the major rivers but included runoff from the foothill areas and is thought to represent a good approximation of the full runoff volume of 100% of the basin area. The Tiburon report shows that the planning done in the early years based on these less than full runoff volumes have given an over-optimistic picture of the water available for diversion from the Delta system.

x) emphasis added

Then using the most up-to-date data base that most realistically describes what water is really available, the report introduces a statistical analysis of this water supply. Generally this analysis is couched in the form of deviations above and below the mean or average value of the runoff series, and expressed among other ways as probability of occurrence. When values of deviation from the mean are plotted as the probability of being equalled or exceeded, the differences in actual runoff quantities among different data sets can be eliminated so that the particular length of the record becomes unimportant.

The method of analysis will be demonstrated below to help explain and support the major conclusions in the report. First, however, it would be desirable to summarize the major findings of the study.

First, the role of fresh water runoff is of highest importance in controlling salinity and the functioning of the "nutrient trap", that zone of an estuary where fresh water with its load of sediment and nutrients interacts with the saline water from the ocean. This is the area richest in plankton production where many fish species thrive as juveniles (see pp. 1.3, 1.6, and Fig. 1.2). In the Delta area, this is between Chipps Island and Benicia. Reduction of fresh water reaching the Bay has made the saline zone move upstream and is the cause of the historic increase in salinity. The loss of fish populations, a well documented fact, is related to these complex changes. Salinity in the Delta has increased in the present century from an original value of .01-2.0 grams per liter to a present value of 1.0-14. The increase in salinity experienced in the Sea of Azov of the Soviet Union was less than two-fold whereas the increase in the Delta has been ten-fold. Even with the modest increase in the Sea of Azov the result has demonstrably been disastrous in that country.

Second, the Tiburon report shows that use of an unsatisfactory data set to describe the available water has in the planning and construction stages of water development seriously underestimated the probability of critically dry conditions in the estuary. Further, the use of frequency curve analysis is necessary to evaluate properly the effect of the already operative water diversions that deplete the fresh water supply so essential to the continued functioning of the ecosystem.

Third, the report shows what should be an obvious fact, that continued diversion of the same magnitude of fresh water in dry years as well as wet years makes a much larger percentage change in available water in a dry period than in a wet one. Yet there is no attempt to adjust the amount of diversion in response to the available supply.

Fourth, the amount of water diverted has continued to increase with time despite the data on biologic populations and salinity that have given ample warning that even the present amount of diversion is impacting the ecosystem .

Both to check quantitatively the results presented on annual flows in the Tiburon report, and to explain in new words its findings, I have reanalysed some of the data. My results are in qualitative agreement with those in the report though my numbers are not as exact. One reason for this is that I have generally rounded the data to three significant figures, for my work was done by hand whereas the Tiburon computations were made on a computer.

Four sets of data were used in my analysis. They are a) the list of annual flows representing natural, unimpaired inflows to the delta; b) the regulated annual inflow to the Delta; c) the natural or unimpaired outflows from the Delta, and d) the regulated or altered outflow annual values. These tabulations of basic data are included as printed tables in this study. The annual natural inflow data are those representing the flow from all or 100% of the drainage area as previously stated as being necessary for a correct analysis.

The method of analysis is similar to that used in the Tiburon report. The data array was retabulated in order of magnitude of the values. For each the recurrence interval was calculated as $n+1/m$ where n is the number of years of record, and m is the rank order of the value or runoff quantity. The reciprocal of recurrence interval is the probability of occurrence, that is $m/n+1$ is the probability. For example, the value of probability of 0.10, that is 10 chances out of 100, means that in 100 years, it is probable that 10 years will experience a flow less than the quantity specified.

To make this more specific consider Figure 1 of the present study. Four graphs are plotted. They show the probability that any value of annual flow will be equalled or exceeded. The four graphs describe the annual natural inflow to the Delta, the regulated inflow, the natural outflow, and the regulated outflow.

Consider first, the graph of natural inflow, plotted as the symbol x . There is a 50 percent probability that the annual natural inflow will be equal to or less than 25,000,000 acre feet. This is the median value of the array, that is half the annual values are larger and half smaller. The arithmetic mean is somewhat larger, about 28.1 million. Now look at the value 25% on the bottom scale. At a probability of 25% the annual runoff value is about 37 million acre feet. This says that there is a 25% chance, one in four, that the annual value of natural inflow will be equal to or larger than 37 million. By the same token, the

The above comparisons deal with the probability of experiencing any given quantity and do not mean to apply to any particular year. However, when one looks at the probability of one in ten, it means that next year or any given year in the future has a one in ten chance of experiencing an outflow to the Bay of less than 7.5 million acre feet. Like tossing a coin, each toss has the same chance of coming up heads.

Note also that the regulated outflow to the Bay is considerably less than the regulated inflow to the Delta. This means that after regulation the losses or depletions within the Delta have increased. Before regulation the losses within the Delta were negligible as previously stated.

The Tiburon report wisely makes an important issue of the number of dry and critical years under natural as compared with regulated conditions. To check and extend those findings I have prepared Figure 2. I have used the same definitions of wet, abnormal, subnormal, dry, critically dry, and drought as used by the Dept. of Resources Bulletins 23-62 and 130-70s (see Tiburon report Table I-9 p I.45). I have added a category of very dry so that all years may be described. The definitions are given in Figure 2.

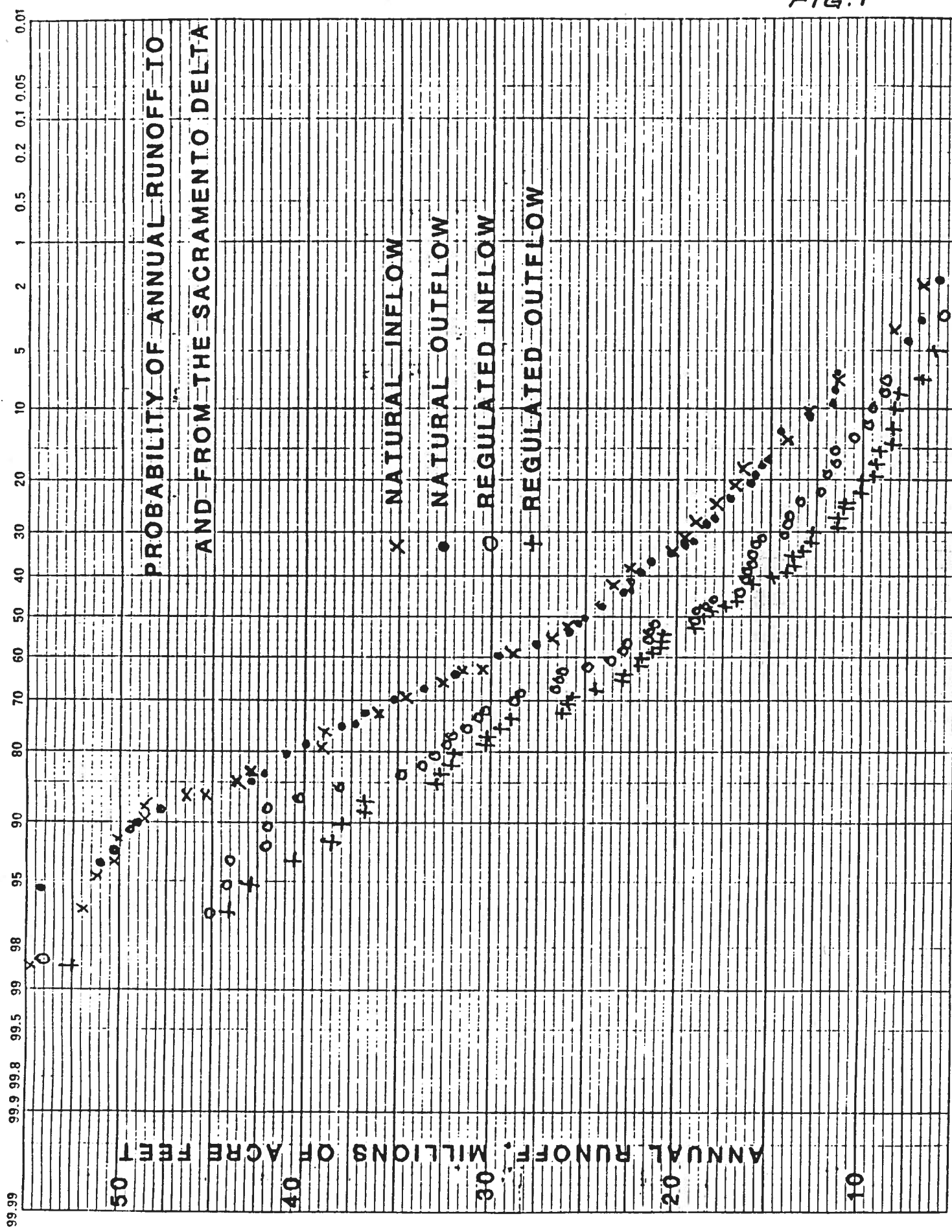
In my tables with the annual flows arranged in order of magnitude it is easy to count the number of years in each category. As Figure 2 shows, regulation and diversion of water have increased the number of years in the dry categories and reduced the number of years in the wet categories. The Figure refers to annual values of inflow to the Delta.

Years in which the inflow is considered wet have decreased from natural conditions from 17 to 9, or from 30 percent of all years to 15 percent of years.

Subnormal years have changed from 11 to 7 or from 19 percent of all years to 12 percent.

The important change is in the number of critically dry years, an increase from 8 to 23 in the period of record or from 14 percent of all years to 39 percent. Thus the amount of diversion and depletion under present conditions has doubled the number of years considered critically dry.

Further, the increase in depletion has been continuous over time. A measure of depletion is the difference between natural and regulated values of outflow from the Delta. The depletion by periods of time is shown below.



Number of years of different supplies of water
comparing regulated flow with natural unimpacted
flow, inflow to delta

Inflow to Delta					
Definitions:					
1	Normal flow is average inflow to delta in				
2	natural, unimpacted condition,				
3	28.1 x 10 ⁶ ac-ft per year.				
4	Abnormal is 100 to 125 % of normal or				
5	28.1 to 35.1 x 10 ⁶ a-ft.				
6	Wet year, runoff > 35.1 x 10 ⁶				
7					
8	Subnormal 1.00 to 0.80 of normal				
9	or 28.1 to 22.5 MAF				
10					
11	Dry .70 to .80 normal or 19.7 to 22.5				
12	Very dry: .57 to .70 or 16.0 to 19.7 MAF				
13	Critically dry: less than .57 or 16.0 MAF				
14					
15	Drought: 0.30 or < 8.5 MAF				
16	 				
17	No of years in category in period of record				
18		Natural %	Regulated %		
19	Wet	17	30	7	15
20	Abnormal	7	12	10	17
21	Subnormal	11	19	7	12
22	Dry	4	7	3	5
23	Very dry	10	18	7	12
24	Critically dry	8	14	23	39
25		57	100	59	100
26					
27	Drought	2		3	
28					
29					
30					

SAN FRANCISCO BAY

DATA FILE - RGINACF - REGULATED INFLOW TO THE DELTA

ACREFEET X 1000

YEAR	O	N	D	J	F	M	A	M	J	J	A	S	ANN
2324	624	499	551	617	1254	579	622	350	113	77	105	183	557
2425	375	790	1083	1088	5632	2587	3995	3475	1422	441	227	334	2144
2526	522	597	824	738	4598	1796	4052	1335	367	144	141	309	1547
2627	462	1253	2834	2502	7180	4822	4951	3392	2219	591	299	388	3089
2728	564	1397	1306	1543	2605	5394	5165	2040	605	293	218	360	2149
2829	488	659	765	802	1384	1147	1048	1254	677	200	187	316	892
2930	418	428	2422	2009	1857	3521	2127	1478	736	240	207	398	1584
3031	534	596	618	963	888	1058	493	291	133	0	38	188	580
3132	293	418	1564	2157	2330	2222	2043	2981	2153	627	202	256	1724
3233	353	402	589	882	934	1612	1463	1334	1278	235	130	259	947
3334	386	516	1030	2071	1625	1728	1063	483	240	86	92	214	953
3435	325	842	796	2677	1675	2888	6960	4179	2264	459	243	345	2365
3536	548	568	722	3926	7362	4059	3698	2962	1869	478	243	366	2680
3637	461	487	628	807	3304	4835	4236	3811	1968	445	182	315	2147
3738	578	2461	6010	2462	10398	11602	7306	7341	4963	1589	534	515	5575
3839	719	838	1129	1052	1098	1636	1221	619	221	99	110	314	910
3940	432	428	726	4016	5772	8658	7371	2945	1410	333	234	432	3275
4041	524	767	3672	7193	7616	7731	6709	5083	2927	1115	407	415	4420
4142	586	747	3758	5524	8662	3026	5117	4447	3490	1068	348	466	3723
4243	656	986	1928	5471	4422	6948	4413	2925	1727	433	265	387	3056
4344	617	675	782	947	1776	2214	1233	1702	761	246	229	381	1156
4445	428	1022	1439	1292	4405	2454	2267	2628	1639	634	494	588	1929
4546	759	1235	4539	4946	1771	2040	2408	2572	1086	484	464	582	2288
4647	653	939	1326	938	1555	2125	1576	778	546	318	355	474	1148
4748	661	820	1684	1586	827	1295	3577	3779	2719	676	545	678	1884
4849	744	806	998	899	941	3667	2132	1832	758	441	475	552	1424
4950	529	629	610	1807	2974	2145	2682	2316	1480	529	460	582	1674
5051	707	4162	7973	4749	5086	3294	1894	2270	886	556	588	642	3280
5152	720	986	2860	6498	5978	5304	6275	6650	4085	1318	645	728	4205
5253	690	768	2518	7076	2165	1637	1731	2321	2071	568	380	759	2273
5354	759	936	1038	1987	3843	3497	3389	1376	509	282	393	563	1907
5455	643	939	1686	1729	1013	858	731	1218	604	323	334	491	1057
5556	442	649	7362	11498	5696	3950	2272	3720	2243	743	599	855	4002
5657	910	1040	970	890	1330	3970	1340	2210	1330	640	660	810	1607
5758	1280	1280	1630	2590	9900	6670	8960	4990	3270	1190	990	1120	4456
5859	990	1010	980	1890	3090	1890	930	760	510	670	760	700	1435
5960	540	500	520	780	2740	2220	1220	1050	680	660	620	600	1222
6061	520	770	1250	900	2330	1820	1040	840	670	660	720	600	1221
6162	460	530	1030	700	3830	2980	1890	1430	1060	700	770	790	1641
6263	2730	1110	2170	1360	5380	1830	6060	3530	1560	870	780	1070	2879
6364	1050	1580	1530	1810	1340	960	820	930	720	740	780	850	1313
6465	690	990	6540	8240	3230	1840	3470	2330	1410	900	970	1050	3163
6566	1150	1540	1850	2680	1960	1700	1400	940	610	740	790	700	1611
6667	640	1210	3630	3670	4700	3480	4570	4840	3980	1680	960	1290	3486
6768	1240	1100	1300	1530	2960	2690	1000	900	720	810	860	850	1603
6869	810	920	1670	7720	8850	5950	4360	4300	3130	1280	1310	1490	4224
6970	1370	1310	2840	11620	6260	3580	1020	1060	880	910	1000	1210	3322
7071	1060	1510	5170	4080	2100	2220	2520	2000	1830	1380	1440	1560	2683

REGULATED INFLOW CON'T.

YEAR	O	N	D	J	F	M	A	M	J	J	A	S	A
7172	1190	1060	1550	1470	1490	1600	890	860	870	960	1000	1100	14
7273	1120	1570	1900	6180	5600	4670	1610	1270	1090	1020	1080	1150	28
7374	1210	3770	4860	8570	3590	2650	6750	2160	1760	1470	1600	1710	40
7475	1500	1600	1890	1450	3340	4390	2470	2260	1830	1260	1340	1420	24
7576	1520	1610	1820	1140	870	1020	840	740	700	790	890	830	12
7677	580	360	540	670	490	440	370	490	420	520	480	420	5
7778	290	430	770	4360	3540	5450	3790	2840	1220	1010	1130	1290	26
7879	1020	980	1000	1890	2540	2560	1290	1360	920	940	1080	1010	16
7980	990	1080	1500	7440	7230	6350	2060	1700	1460	1340	1060	1200	33
8081	960	850	1220	1270	1560	1970	1200	990	740	1030	1000	840	13
8182	700	2340	5430	6020	5360	5310	8770	4080	2140	1540	1560	1890	45

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1921	436	3000	4084	6679	4496	5462	3875	4522	3332	982	417	335	37620
1922	330	464	1636	1487	4484	3457	4565	7665	5494	1376	483	374	31765
1923	390	783	3740	2461	1604	1784	4161	4128	2206	1065	393	357	22602
1924	404	375	468	566	1318	656	1092	1006	352	249	179	179	6924
1925	320	869	1148	1132	6058	2650	4691	4307	2204	823	397	304	25783
1926	350	454	708	910	4246	1979	4603	2326	871	382	234	220	17323
1927	289	2455	2414	2928	8827	4508	6053	4810	3395	1074	416	320	37439
1928	351	1643	1295	1704	2591	7511	4519	3706	1181	507	287	257	25152
1929	273	514	700	625	1743	1440	1780	2642	1462	456	195	210	11870
1930	211	247	2870	1842	2315	3547	2589	2470	1621	497	250	247	19106
1931	277	430	353	826	837	1307	1277	1180	455	192	152	156	7502
1932	263	359	2401	1025	2004	1943	2065	4582	3179	985	339	228	22974
1933	220	264	401	800	645	2196	2154	2590	2605	564	234	204	12893
1934	247	307	1286	1760	1974	2129	1709	1084	598	242	169	165	11665
1935	245	524	879	2610	2013	2934	1708	5338	3145	811	343	342	27292
1936	334	357	521	4247	7897	3486	4576	4748	2566	843	327	248	28510
1937	260	273	454	619	3619	4675	4633	5022	2635	793	288	225	24276
1938	344	2009	6158	2454	8447	11189	7528	8681	5820	2016	712	461	55810
1939	573	645	821	849	941	2226	2470	1523	659	314	216	251	11508
1940	370	207	658	5182	8147	8179	5572	4285	2016	624	328	309	36025
1941	390	624	4603	6122	7616	6710	6702	6770	3819	1618	624	449	45667
1942	464	691	4698	6062	7351	2948	5006	5822	4742	1699	609	429	41121
1943	461	1232	2315	6752	3856	7506	4058	4087	2482	1063	498	389	35667
1944	417	474	558	890	1910	2591	2135	3680	1884	807	331	261	15938
1945	350	1386	1704	1243	5789	2856	3330	4264	2846	1017	418	293	25566
1946	667	1566	6381	3387	1831	2804	3977	4036	1793	693	379	305	27589
1947	400	1021	1236	641	1925	3035	2495	2155	1170	389	260	244	14971
1948	692	506	489	2145	769	2029	5372	5141	3645	926	393	333	22520
1949	358	474	719	587	1116	4892	3752	3724	1571	441	286	245	17946
1950	277	381	414	2402	3597	2980	4366	4120	2240	665	314	288	22044
1951	1016	6079	8097	5028	4544	3421	3190	3574	1654	637	370	303	37913
1952	463	1068	4636	6123	5619	5538	7470	8613	5117	2205	754	501	40107
1953	438	509	2614	7216	1839	2617	3785	3826	3703	1430	526	437	28940
1954	439	887	847	2873	3703	4503	5882	3606	1505	638	402	367	25332
1955	378	836	1658	1646	1130	1442	2250	3562	1948	566	312	290	16018
1956	303	615	12618	10926	5397	3797	4004	5957	3844	1585	624	471	50392
1957	628	594	600	879	3338	4167	2688	4424	2625	743	398	429	21514
1958	946	901	1925	3271	11029	6961	8900	7777	4096	1729	769	536	49520
1959	484	520	576	2666	2518	2256	2482	1910	1044	441	297	508	16705
1960	345	334	437	1003	4236	3633	2781	2508	1324	429	284	277	17875
1961	316	781	1559	1017	2568	2275	2251	2339	1233	401	223	286	15249
1962	322	574	1360	981	5859	3134	4387	3414	2653	666	371	287	24008
1963	3214	774	2319	2217	6101	2754	7309	5775	2882	1192	534	433	35584
1964	575	1931	935	2046	1154	1290	2117	2659	1621	509	222	250	15424
1965	345	1039	11783	8025	2795	2332	6015	4285	2996	1359	811	417	42272
1966	418	1722	1323	2604	2072	2947	3762	2731	888	427	306	225	19496
1967	293	1582	3800	5153	3220	5277	5579	7594	6202	2757	775	453	42785
1968	488	541	960	2115	4796	3125	2425	2323	1081	475	449	331	19110
1969	473	974	2375	11373	7697	5697	6927	6555	4932	1902	858	487	51461
1970	629	675	4291	14492	4022	4115	2087	3043	2849	771	441	362	36926
1971	497	2426	4666	3906	2240	4674	5500	4645	3627	1247	549	461	32918
1972	505	693	1487	1521	2096	3838	2772	2575	1532	423	313	419	18243
1973	602	1119	2266	6775	5739	4821	1723	5310	3370	716	434	391	33096
1974	654	1582	4925	5148	2716	8417	6486	5299	3482	1415	646	455	49285
1975	461	615	966	1103	4312	6538	3708	6139	4426	1250	889	497	30684
1976	945	915	812	611	1054	1447	1420	1460	429	802	620	394	180276
1977	316	356	317	778	447	524	1756	905	162	250	225	368	5501
1978	281	466	2262	1397	2999	7174	5880	5434	4083	1714	586	726	41961
1979	366	529	925	2059	3124	3228	3181	2016	1948	461	378	218	21827
1980	680	591	1657	5459	4663	4895	3752	4185	3130	1788	542	489	40171
1981	407	386	1024	2043	2078	3085	2546	2238	960	360	254	268	15651
1982	687	5302	7543	5201	7411	6880	11107	8880	3665	1805	714	822	57313
1983	1437	2677	5522	6735	9749	15890	6708	8739	8199	3978	1485	866	72045
SUM	31274	70723	154357	220626	250253	255057	263696	267072	164467	61132	27322	22514	1788493
AVE	496	1123	2450	3502	3972	4049	4186	4239	2611	970	434	357	28389

DIR DOP STATEWIDE PLANNING BRANCH

8117 18264 3946 56755 69053 65857 69772 68941 43520 15710 2231 5950 31208

228 517 1128 1613 1955 1865 1946 1952 1232 447 205 168 1110

SAN FRANCISCO BAY

DATA FILE - RGFLACF - REGULATED OUTFLOW FROM THE DELTA

ACREFEET X 1000

YEAR	O	N	D	J	F	M	A	M	J	J	A	S	AN
2122	384	512	1566	1649	4226	3386	3909	5242	3761	791	110	240	258
2223	468	897	3358	2646	1660	1501	3576	2562	1332	413	70	290	187
2324	500	439	538	716	1431	581	584	247	000	0000	0000	29	47
2425	301	769	1167	1115	6872	2350	4245	3331	1353	213	11	185	219
2526	388	570	836	1083	4358	1665	3795	1289	210	000	000	166	144
2627	371	2236	2272	2801	4911	8540	5465	3311	2082	359	85	238	326
2728	508	1452	1359	1716	2539	4524	3989	1955	444	60	8	210	214
2829	349	711	856	873	1482	1297	1153	1154	565	000	000	174	85
2930	289	322	2297	2151	1931	3570	2088	1394	583	22	7	260	149
3031	438	535	533	1055	918	1058	424	231	000	0000	0000	40	48
3132	170	386	1744	2158	2548	2183	1982	2893	1992	399	00	110	165
3233	217	309	577	1007	927	1647	1387	1259	1118	8	000	112	84
3334	290	411	1100	2014	1769	1683	1005	391	92	0000	0000	78	85
3435	207	850	808	2897	1699	3106	7015	4052	2110	234	35	197	232
3536	459	489	709	3971	7888	3992	3687	2909	1730	256	31	230	258
3637	356	383	666	900	3710	5211	4263	3708	1805	220	000	163	212
3738	469	2041	5508	2635	9296	11918	7328	6918	4800	1360	322	375	529
3839	629	804	1076	1070	1134	1687	1151	518	54	0000	0000	171	80
3940	326	326	663	4317	6068	8685	7352	2859	1248	107	18	280	322
4041	416	685	4014	7412	7832	7901	5830	5011	2762	882	189	263	441
4142	488	688	3854	5754	3823	3086	3247	4398	3329	833	130	314	369
4243	539	1010	1950	5692	4486	7196	4405	2831	1568	199	49	235	301
4344	490	595	747	979	1972	2229	1256	1635	603	11	15	231	107
4445	341	1072	1474	1268	4629	2584	2197	2535	1479	404	279	438	187
4546	713	1176	4753	4948	1783	2072	2353	2494	920	253	250	430	221
4647	526	942	1318	970	1588	2182	1499	669	384	75	131	315	105
4748	604	736	607	1547	820	1387	3591	3752	2545	427	319	518	168
4849	608	674	956	911	959	3856	2038	1700	582	158	223	383	130
4950	379	561	591	1945	3102	2219	2742	2206	1278	265	230	435	159
5051	635	4324	8293	4973	5112	3367	1817	2166	670	274	316	442	323
5152	591	953	3101	6882	6048	5628	6186	6520	3941	1081	423	587	418
5253	575	759	2571	7184	2158	1701	1853	2280	1980	344	188	576	221
5354	610	880	966	1986	4014	3672	3459	1820	376	59	179	437	184
5455	531	953	1773	1925	1053	860	780	1191	437	109	139	351	101
5556	334	601	8049	11896	5940	3987	2407	3674	2139	533	410	703	406
5657	763	931	880	913	1383	3890	1157	2049	944	141	205	527	137
5758	1127	1155	1628	2766	10301	6894	9231	4964	3033	732	547	832	431
5859	769	874	907	1967	3230	1729	645	454	102	149	297	525	116
5960	318	355	451	826	2824	2087	988	758	252	132	143	305	94
6061	279	768	1172	944	2284	1717	785	536	231	96	221	305	93
6162	230	488	966	658	4152	2956	1627	1105	639	166	284	486	137
6263	2697	971	2135	1442	5448	1820	6110	3262	1159	343	288	722	264
6364	829	1572	1437	1857	1212	810	531	589	328	186	271	526	101
6465	475	934	6707	8370	3147	1699	3415	2009	990	352	492	746	293
6566	898	1543	1893	2714	1948	1509	1127	604	170	195	273	390	132
6667	396	1308	3636	3750	4866	3342	4512	4434	3672	1440	582	990	329
6768	1002	990	1212	1548	3018	2382	582	402	216	222	312	360	126
6869	330	630	1542	7620	9340	5520	4150	3860	2780	786	744	1308	386

REGULATED OUTFLOW CON'T.

Table 3 cont'd

YEAR	O	N	D	J	F	M	A	M	J	J	A	S	A
6970	1170	1200	2740	11280	6534	3300	660	648	372	318	474	876	29
7071	810	1662	5022	3828	2046	1890	2208	1596	1272	708	786	1188	23
7172	840	834	1440	1278	1314	1092	456	324	186	384	396	648	9
7273	708	1554	1626	6108	6126	4510	1302	714	438	288	366	678	24
7374	846	3600	4590	8244	3510	4512	6450	1536	1026	570	774	1266	36
7475	1146	1404	1686	1105	2545	3056	1760	1611	1298	616	478	737	17
7576	816	972	1206	600	414	438	456	252	252	264	234	174	6
7677	232	216	259	268	272	188	182	248	149	195	149	172	2
7778	128	238	522	4069	3119	5260	3646	2573	541	244	353	725	21
7879	592	650	540	1877	2574	2342	862	826	317	331	214	301	11
7980	481	725	1170	7270	7005	6099	1708	1286	885	688	262	589	30
8081	453	374	767	1118	1247	1817	694	561	274	326	194	280	6
8182	321	2139	5113	6015	4937	4937	8361	3555	1690	1030	820	1540	38

Natural and regulated inflow
to the delta, annual, acre feet

1	2	3				
Water year	Natural inflow (1) AF · 10 ³	Regulated inflow (2)	Diff col 2 - col 3			
1 1921	38682					
2 22	32693					
3 23	23594					
4 24	8202	5574				
5 25	26718	21449				
6 26	18495	15473				
7 27	38442	30898				
8 28	26241	21490				
9 29	12895	8927				
10 30	20304	15841				
11 31	8756	5800				
12 32	24021	17246				
13 33	14142	9471				
14 34	12852	9534				
15 35	28341	23653				
16 36	30325	26801				
17 37	25118	21479				
18 38	56529	55759				
19 39	12754	9106				
20 40	36990	32757				
21 41	46590	44209				
22 42	42009	37239				
23 43	36437	30561				
24 44	17105	11563				
25 45	26533	19290				
26 46	28662	22886				
27 47	16209	11483				
28 48	23708	18847				
29 49	19087	14245				
30 50	23161	16743				

(1) Table I 10 p. 246 Tiburon report
 (2) Table I this report

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Natural & regulated inflow to the delta

1	2	3				
Water year	Natural inflow AF 10 ⁻³	Regulated inflow	Diff Col 2 - Col 3			
1 1951	38611	32807				
2 52	48775	42053				
3 53	30104	22734				
4 54	26530	19072				
5 55	17165	10574				
6 56	51046	40029				
7 57	22686	16074				
8 58	50064	44566				
9 59	17945	14358				
10 60	19131	12220				
11 61	16626	12215				
12 62	25125	16419				
13 63	36550	28796				
14 64	16652	13136				
15 65	43125	31634				
16 66	20704	16119				
17 67	43537	34861				
18 68	20311	16032				
19 69	52137	42245				
20 1970	37956	33229				
21 71	34088	26830				
22 72	19591	14032				
23 73	34662	28496				
24 74	50238	40183				
25 75	31737	24873				
26 76	11606	12754				
27 77	6756	5953				
28 78	48846	26700				
29 79		16672				
30 80		33556				
81		13667				
82		45349				
ave	28115	22823	1346567/59			

Delta Unimpaired Total Outflow
from Table 2, annual and regulated
outflow from Table 3

Year	Natural outflow AF x 10 ⁶	Regulated outflow	D. ft Col 2 - Col 3	Ave depletion in decade			
1 1921	37.62						
2 22	31.76	25.88	5.88				
3 23	22.60	18.77	3.83				
4 24	6.92	4.73	2.19				
5 25	25.70	21.91	3.79	3.77			
6 26	17.32	14.41	2.91				
7 27	37.44	32.67	4.77				
8 28	25.15	21.49	3.66				
9 29	11.67	8.58	3.09				
10 30	19.12	14.91	4.21				
11 31	7.50	4.83	2.67				
12 32	22.98	16.56	6.42				
13 33	12.89	8.49	4.40				
14 34	11.67	8.58	3.09	3.79			
15 35	27.29	23.21	4.08				
16 36	29.51	25.85	3.66				
17 37	24.28	21.25	3.03				
18 38	55.81	52.97	2.84				
19 39	11.51	8.06	3.45				
20 40	36.02	32.25	3.77				
21 1941	45.65	44.20	1.45				
22 42	41.12	36.94	4.18				
23 43	35.67	30.16	5.51				
24 44	15.94	10.76	5.18	4.73			
25 45	25.55	18.70	6.85				
26 46	27.60	22.14	5.46				
27 47	14.97	10.60	4.37				
28 48	22.52	16.85	5.67				
29 49	17.95	13.05	4.90				
30 1950	22.04	15.95	6.09				

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Uncompensated Natural & regulated outflow from
the delta

from Table 2

Year	Natural outflow AF x 10 ⁶	Regulated outflow (Table 3)	Diff Col 2 - Col 3	ave depletion			
1 1951	37.91	32.39	5.52				
2 52	48.11	41.82	6.29				
3 53	28.94	22.17	6.77				
4 54	25.33	18.46	6.87				
5 55	16.02	10.10	5.92	6.64			
6 56	50.39	40.67	9.72				
7 57	21.51	13.78	7.73				
8 58	49.52	43.11	6.41				
9 59	16.71	11.65	5.06				
10 60	17.87	9.44	8.43				
11 61	15.35	9.34	6.01				
12 62	24.01	13.76	10.25				
13 63	35.58	26.45	9.13				
14 64	15.42	10.15	5.27	8.74			
15 65	42.27	29.34	12.93				
16 66	19.50	13.26	6.24				
17 67	42.71	32.93	9.78				
18 68	19.11	12.65	6.46				
19 69	51.46	38.61	12.85				
20 70	31.92	24.57	7.35				
21 71	32.92	23.02	9.90				
22 72	18.34	9.19	9.15				
23 73	33.70	24.44	9.26				
24 74	49.28	36.92	12.36				
25 75	30.68	17.44	13.24	10.94			
26 76	20.28	6.08	14.20				
27 77	5.50	2.53	2.97				
28 78	41.98	21.42	20.56				
29 79	21.94	11.55	10.39				
30 80	40.17	30.05	10.12				

Unimpared natural outflow from delta

from
Table 2

year	Natural outflow	Regulated outflow	Diff Col 2 - Col 3	ave depletion			
1 1981	15.65	6.86	8.79	12.70			
2 82	57.31	38.11	19.20				
3 83	72.04						
4							
5 Ave.	28.39						
6							
7							
8							
9							
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Natural unimpaired inflow to delta
(57 years)

	AF $\times 10^{-6}$ ranked	$\frac{n+1}{m}$	prob.	AF $\times 10^{-6}$ ranked	$\frac{n+1}{m}$	prob.		
1	56.5	58.0	.017	25.1				
2	52.1	29.0	.034	24.0	1.81	.552		
3	51.0	19.3	.052	23.7				
4	50.2	14.5	.069	23.5	1.71	.586		
5	50.0	11.6	.086	23.1				
6	48.8	9.7	.103	22.7	1.61	.621		
7	48.8	8.3	.121	20.7				
8	46.6	7.2	.138	20.3	1.53	.655		
9	43.5	6.44	.155	20.3				
10	43.1	5.8	.172	19.5	1.45	.690		
11	42.0			19.1				
12	38.6	4.8	.207	19.0	1.38	.724		
13	38.6			18.5				
14	38.4	4.14	.24	17.9	1.31	.759		
15	37.9			17.2				
16	36.5	3.62	.276	17.1	1.26	.793		
17	36.4			16.6				
18	34.6	3.22	.310	16.6	1.21	.828		
19	34.1			16.2				
20	32.7	2.90	.345	14.1	1.16	.862		
21	31.7			12.9				
22	30.3	2.63	.379	12.8	1.11	.897		
23	30.1			12.7				
24	28.6	2.41	.414	11.6	1.07	.931		
25	28.3			8.8				
26	26.7	2.23	.448	8.2	1.04	.966		
27	26.5			6.7	1.01	.983		
28	26.5	2.07	.483					
29	26.2							
30	25.1	1.93	.517					

Regulated Inflow to delta

59 yrs.

	AF $\times 10^{-6}$ ranked	$\frac{n+1}{m} =$ RI (yrs)	probabil	AF $\times 10^{-6}$ ranked	$\frac{n+1}{m} =$ RI (yrs)	prob.		
1	55.8	60	.017	19.1	1.93	.52		
2	45.3	30	.033	18.8	1.87	.53		
3	44.6	20	.050	17.2	1.82	.55		
4	44.2	15	.067	16.7	1.77	.57		
5	42.2	12	.083	16.7	1.71	.58		
6	42.0	10	.100	16.4	1.67	.60		
7	40.2	8.6	.117	16.1	1.62	.62		
8	40.0	7.5	.133	16.1	1.58	.63		
9	37.2	6.7	.150	16.0	1.54	.65		
10	34.9	6.0	.167	15.8	1.50	.67		
11	33.6	5.45	.183	15.5	1.46	.68		
12	33.2	5.0	.20	14.4	1.43	.70		
13	32.8	4.6	.22	14.2	1.40	.72		
14	32.8	4.3	.23	14.0	1.36	.73		
15	31.6	4.0	.25	13.7	1.33	.75		
16	30.9	3.7	.27	13.1	1.30	.77		
17	30.6	3.53	.28	12.8	1.28	.78		
18	28.8	3.33	.30	12.2	1.25	.80		
19	28.4	3.16	.32	12.2	1.22	.82		
20	26.8	3.00	.33	11.6	1.20	.83		
21	26.8	2.86	.35	11.5	1.18	.85		
22	26.7	2.73	.37	10.5	1.15	.87		
23	24.9	2.61	.38	9.5	1.13	.88		
24	23.7	2.50	.40	9.5	1.11	.90		
25	22.9	2.40	.42	9.1	1.09	.92		
26	22.7	2.31	.43	8.9	1.07	.93		
27	21.5	2.22	.45	5.9	1.05	.95		
28	21.5	2.14	.47	5.8	1.03	.97		
29	21.4	2.07	.48	5.6	1.02	.98		
30	19.2	2.00	.50					

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Natural unimpaired outflow from
delta 63 yrs.

	AF x 10 ⁻⁶ ranked	$\frac{n+1}{m}$	probab		AF x 10 ⁻⁶	$\frac{n+1}{m}$	probab	AF x 10 ⁻⁶
1	72.0	64	.016		25.5	2.86	.484	7.5
2	57.3	32	.031		25.3	2.00	.500	6.9
3	55.8	21.3	.047		25.1	1.93	.516	5.5
4	51.5	16	.063		24.3	1.88	.531	
5	50.4	12.8	.078		24.0	1.83	.547	
6	49.5	10.7	.094		22.9	1.78	.562	
7	49.3	9.1	.109		22.6	1.73	.578	
8	48.1	8.0	.125		22.5	1.68	.594	
9	45.6	7.1	.141		22.0	1.64	.609	
10	42.7	6.4	.156		21.9	1.60	.625	
11	42.3	5.8	.172		21.5	1.56	.641	
12	41.9	5.3	.188		20.3	1.52	.656	
13	41.1	4.9	.203		19.5	1.49	.672	
14	40.2	4.6	.219		19.1	1.45	.687	
15	37.9	4.3	.234		19.1	1.42	.703	
16	37.6	4.0	.250		18.3	1.39	.719	
17	37.4	3.8	.266		17.9	1.36	.734	
18	36.9	3.6	.281		17.9	1.33	.750	
19	36.0	3.4	.297		17.3	1.31	.766	
20	35.7	3.2	.313		16.7	1.28	.781	
21	35.6	3.0	.328		16.0	1.25	.797	
22	33.7	2.91	.344		15.9	1.23	.812	
23	32.9	2.78	.359		15.6	1.21	.828	
24	31.8	2.67	.375		15.4	1.18	.844	
25	30.7	2.56	.391		15.3	1.16	.859	
26	29.5	2.46	.406		14.9	1.14	.875	
27	28.9	2.37	.422		12.9	1.12	.891	
28	27.6	2.29	.437		11.7	1.10	.906	
29	27.3	2.21	.453		11.7	1.08	.922	
30	25.7	2.13	.469		11.5	1.07	.937	

Regulated outflow from delta (Table 3)
(59 years)

	AF $\times 10^{-6}$ ranked	$\frac{n+1}{m}$	prob.	AF $\times 10^{-6}$ ranked	$\frac{n+1}{m}$	prob.		
1	53.0	60	.017	18.5	1.94	.517		
2	44.2	30	.033	17.4	1.87	.533		
3	43.1	20	.050	16.8	1.82	.550		
4	40.7	15.0	.067	16.6	1.76	.567		
5	38.6	12.0	.083	15.9	1.71	.583		
6	38.1	10.0	.100	14.9	1.67	.600		
7	36.9	8.57	.117	14.4	1.62	.617		
8	36.9	7.5	.133	13.8	1.58	.633		
9	32.9	6.7	.150	13.8	1.54	.650		
10	32.7	6.0	.167	13.2	1.50	.667		
11	32.4	5.45	.183	13.0	1.46	.683		
12	32.2	5.0	.200	12.6	1.43	.700		
13	30.2	4.61	.217	11.6	1.39	.717		
14	30.0	4.28	.233	11.5	1.36	.733		
15	29.5	4.00	.250	10.8	1.33	.750		
16	29.3	3.75	.267	10.6	1.30	.767		
17	26.4	3.52	.283	10.1	1.28	.783		
18	25.9	3.33	.300	10.1	1.25	.800		
19	25.8	3.16	.317	9.4	1.22	.817		
20	24.4	3.00	.333	9.3	1.20	.833		
21	23.2	2.86	.350	9.2	1.18	.850		
22	23.0	2.73	.367	8.6	1.15	.867		
23	22.2	2.60	.383	8.6	1.13	.883		
24	22.1	2.50	.400	8.5	1.11	.900		
25	21.9	2.40	.417	8.1	1.09	.917		
26	21.5	2.31	.433	6.9	1.07	.933		
27	21.4	2.22	.450	6.1	1.05	.950		
28	21.2	2.14	.467	4.8	1.03	.967		
29	18.8	2.06	.483	4.7	1.02	.983		
30	18.7	2.00	.500					