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March 14, 2017

Tuolumne River Diverters:

Mr Hashimoto
Mr Hoy

Mr Carlin

Ms Levin

Ms Hannaford

State Water Board

Honorable Felicia Marcus

Mr Grober

Technical Details—2016 Bay Delta Plan Amendments & SED

Tuolumne River Diverters and SWB members:

I'm greeting you all in the belief that if 69 TAF from each future WY are held from UF in cumulative storage for releases in likely 35% of WY to meet SWB 40% goal, as an example, for the Tuolumne River without undo cost to ratepayers or farmers by wise irrigation and SFPUC water supply managements. 69 TAF which is about 3% of average UF during the past 44 WY, 1971 through 2015, are likely if present weather patterns continue. Calculation results are in spreadsheet 14. A peculiar flow for Dry Creek arose for 2013 through 2015 that is discussed in column U of spreadsheet 14.

The increased releases in the Tuolumne River to meet 40% of unimpaired flow suggested by the SWB for February through June will be important for environmental and fishery purposes. While Diverters are concerned about the increase it, is my belief that the impact will be less than assumed. My goal is to try to understand how release amount might be more clearly understood than was quickly explained for me by Mr Grober at the Modesto SWB hearing. As a result of my confusion, I have ***consulted the*** *Districts 2012* data base for UF and USGS data for the past 44 WY for La Grange and Modesto gauges for February 1 through June 30.

Summary of ideas: The present "Next Year" release method, as I view it, identifies additional SWB releases in 35% of 44 WY, 15 of 44. These years would need extra release, and I believe additional 69 TAF added to storage each WY would prepare the water agencies for large groups of yearly releases that occasionally occur roughly in groups of possibly three every 20 years (Column Y in spread sheet 14). I see a possible pattern of these deficient years that give some hope that reserves held in storage over time and added to each WY can supply the more challenging years that occur. The key reserve amounts are 2.9% of average UF from 1971 through 2015. A method of gaining that storage without large impact on irrigators and SFPUC water supply would be to improve irrigation water use and encourage more

conservation in the MID and TID service areas and SFPUC service area. The present releases plan appears to be what I call the "Next Year" method by holding La Grange release until the next WY, for example 1971 flow held in storage (Col S) until added to 1972 Dry Creek unimpaired flow (Col U), all flowing into the San Joaquin River and on to the Delta.

Observations and Calculations: from years of canoeing on the Tuolumne below La Grange and living on Dry Creek, I observed the "Next Year" method of operating that holds last years release in storage (Col S) and release it in the following WY for FERC fishery and recreation requirements at La Grange in several months including May, and also for generation purposes. Two USGS set of data for February through June were used as a group of five in my work. As I dug into the need for extra water, I was surprised to find that 28 of the 43 WY required no extra release, (column X and Y). Releases are needed in 15 of 43 WY in groups mainly during low precipitation years. Of course precipitation patterns will not to be like those in the past 44 WY, but I know of no better mix of forecast patterns to suggest for the future. A visual explanation of my logic is shown on page 4 using WY 2012 and 2013 as the example from spreadsheet 14 at row 59 columns S and 2013 in row 60 in column U with the two row sums in column Y where the needed release is shown. Spreadsheet 14 repeats this calculation 43 times which leads to the releases needed in column Y that displays the needed extra releases shown in 35% of 43 years. Holding some water in storage in every WY could have provide for the preliminary SWB goal of 40% that can probably be managed by the Diverters through continued diligent carryover storage of about 69 TAF in each WY into their three large reservoirs. All my results are shown in spreadsheet 14 column X and Y. The overall suggestion is to add to reserve for each of those 15 WY that make up 35% in all years. For those 29 abundant precipitations WY I noted that present releases are up to 22 times more than the SWB goal shown in column X. This is serious work, but I laugh that the SWB never sends a letter of thanks for those abundant years of release to the Delta. The total extra SWB release in very low UF, for example 2015 in column O for that drought year will probably be zero release beyond the prior storage that years 540 TAF shown in column Y. There is a likely SWB rule shown as a no-release category due to severe drought, which I can't yet quantify. For all years a conservative storage plan should begin before the SWV release rules go into effect to have storage immediately available when needed. I guess that holdover storage would amount to less than a 12 WY reserve held for deficient years that will come fairly often (see bottom spreadsheet 14 Col O and Y). My point is that holdover storage will not be a huge amount of reservoir capacity. This abundant WY would be a good time to start that 69 TAF reserve. My calculations lumped February through June releases together for each WY which might make a small difference by separating the five release amounts into monthly results. Also holdover storage goals could be a small problem for Don Pedro with Army Corps flood rule in some years. Tuolumne Diverters now calculate UF daily to apportion flow that would assure WY calculations are accurate. There is another method of handling release flow from above La Grange that I call "This Year" method that might save some of the SWB required amount, but that workable method is too difficult to discuss here.

Notes that may be helpful to the SWB to calm fears of large economic impacts should the 40% rule or larger be implemented. A review of water history from my point of view that may have escaped SWB analysis may be useful. About six years ago a now retired MID General Manager floated a trial balloon at a public meeting about improving canal operations by preventing 37,000 acre feet (37 TAF) of tail-water per year from spilling into the Tuolumne at the end of an irrigation canal near the river confluence. His idea was to sell 37,000 acre feet of water per year to fund automation of the canal system to reduce that spill and improve system operation. Water users did not approve

selling MID water. Another tail water release sometimes spills into the Stanislaus River. Improving canal operation and on-farm water use methods will likely continue very slowly, because the easy steps have partly been taken and irrigation water is very cheap, so there is not a strong incentive to invest money in efficiency improvements. Changes might be funded by using electricity profits (depending on a court finding) to help farmers change to more controllable water application methods that MID uses power revenue presently to subsidize water delivered to farmers and that revenue could also be used to improve on-farm water application . Another method is to raise the cost of water delivered to farmers that replace flood irrigation. My hope is the Diverters will join with the SWB and Regional Boards to encourage improved on-farm operation for their communities' economy while meeting the SWB goals. MID already have low cost loans for piping water to individual farms. MID took over the core of domestic water supply for Modesto in about 1990 which slightly increase demand on the Tuolumne at La Grange Dam by replacing ground water pumping. TID will likely be doing the same in a few years for Turlock, that plan to increase river release eventually up to 100 CFS for recapture of that amount downstream of salmon spawning redds into under-drains already in place. Both core cities are growing, but both districts say increased domestic demand outside their cores cities will be matched by the shift of land use from farm irrigation to urban demand. SFPUC plans for an 8-year drought at the beginning of every year. All three Tuolumne Diverters generate and sell electricity to their water customers partly to support their farm and some school irrigation customers. Possible solutions for meeting SWB goals in future years could include improving on-farm irrigation, business evaporative cooling using recycled waste water. Urban wastewater recycling is already in use for some farm irrigation will help, as will using recycled water for business for evaporative cooling and improving landscape irrigation efficiency. A temperature profile is being prepared for below La Grange Dam for FERC licensing. Salmon fry or smolt (not sure which) were taken ca 25 years ago in Dry Creek are from ca 0.9 mile above the confluence by a licensed scientific collector. Sources of Dry Creek flow are accretion, spills, pirating, frequent on-farm irrigation errors and smaller streams.

I hope each Diverter and the SWB will confirm my work on a monthly basis and will publish their results to calm water user fears by the Diverters having a plan of Water use implementation to meet SWB goal that doesn't heavily impact local economies that ameliorate fears of local water use. My contact information is at the bottom of spread sheet 14 if there are questions and comments. I look forward to hearing from each of you.

Sincerely,

Bob Hackamack

Bob Hackamack P.E., BOD Tuolumne River Trust

Page 4 and spread sheet 14 are enclosed

Example of how "Next Year" method is calculated.

As an example, data from Sheet Page 14 is the method of calculation of any extra release with data from WY 2012 and 2013 that is shown on Rows 59 and 60 of spread sheet show 14 with details for these two years of extra release in Feb thru June.

Col	Col	Col	Col	Col
S	U	V	X	Y
L a Grange	Dry Creek	Sum	% of SWB goal of 40%	Amount needed to
Release	adder	S59 + U60	is shown on	reach SWB Goal
			Line 60	for 40% in 2013 is shown on line 60
Year 2012	Year 2013	Sum		
				Total
Row 59 *555.4* TAF				
	Row 60 93.6 TAF	649.0 TAF	97%	**= 22.3 TAF**

Result for release in 2013: **22.3 TAF equals 75 CFS extra for 150 days**

Abbreviations:

UF is Unimpaired Flow, i.e. as if there were no impoundments or diversion above La Grange Dam

TAF is thousand acre feet of water

CFS is cubic feet per second of flow

WY is water year that begins Oct 1 of the current calendar year and ending September 30 of the next calendar year

SWB with full name is of SWRCB abbreviated to State Water Board, appointed by the Governor

44 Water Years of Tuolumne River releases that fit SWB goals.

Present method of operating appears to hold 1971 flow in storage (Col S) until added to 1972 Dry Cr flow (Col U) going into SJ River.
This spread sheet follows the "Next Year" method of releases.

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Water Year 1-Oct Thru Sept 30 WY	UF Unimpaired flow UF, at La Grange Dam, using 2012 data. TAF	<<<<<< >>>>>> Modesto Gauge USGS 11280000 Monthly Feb 1 thru each WY CFS	sum for 30-Jun conversion 0.29752066 TAF	<<<<<<>>>>> La Grange Gauge USGS Gauge 1128965(flow Feb 1 through June 30 CFS	conversion 0.29752066 TAF	Col P - R <<<<<<<<<>>>>>>>> Modesto Gauge flow mi La Grange Gauge flow is Feb thru end of Jur CFS	conversion factor is 0.29752066 TAF	Col S18 + U19 release 1 WY later than S18 release due to > 44 WY of custom for the 3 Diverters TAF	Col O * 0.40 40% SWB Goal or whatever % the SWB sets as a goal from UF release in this column each WY TAF	Col V / W Mod Ga & La Grange Ga together as % Of SWB goal of 40% TR release	Col W - X Extra release to meet SWB Goal of 40% total release 44 WY Feb 1 thru June 319,520.4 TAF See full equation at bottom of page. YAF
Row 15---											
1969		30037	8936.63								
1970	6773.00	6773	2015.11						671.36		Extra release needed
1971	1,678.39	3653	1086.84	2316.55	689.22	1336.5	397.62		483.422		in 15 of 43 WY
1972	1208.55	2100.2	624.85	1118.79	332.86	981.4	291.99	981.21	483.422	203%	0
1973	2030.67	2856	849.72	1015.7	302.19	1840.3	547.53	880.39	812.270	108%	0
1974	2238.80	3338.6	993.30	1616.3	480.88	1722.3	512.42	814.61	895.522	91%	80.9
1975	2030.84	5337	1587.87	3012.7	896.34	2324.3	691.53	1172.41	812.336	144%	0
1976	671.80	2243.1	667.37	1119.5	333.07	1123.6	334.29	1230.63	268.719	458%	0
1977	381.83	1031.4	306.86	410.3	122.07	621.1	184.79	517.86	152.733	339%	0
1978	2899.60	6322.4	1881.04	4285.1	1,274.91	2037.3	606.14	728.21	1159.838	63%	431.6
1979	1912.37	8885.5	2643.62	6327.2	1,882.47	2558.3	761.15	2036.05	764.949	266%	0
1980	3031.54	18817	5598.45	17039	5,069.45	1778.0	528.99	2411.46	1212.615	199%	0
1981	1056.73	3601.1	1071.40	2231.8	664.01	1369.3	407.40	5476.85	422.694	1296%	0
1982	3804.93	24458	7276.76	21803	6,486.84	2655.0	789.92	1453.92	1521.971	96%	68.0
1983	4632.19	39174	11655.07	35706	10,623.3	3468.0	1031.80	7518.64	1852.876	406%	0
1984	2556.26	12399.6	3689.14	8566.9	2,548.83	3832.7	1140.31	11763.58	1022.506	1150%	0
1985	1233.21	3189.3	948.88	1699.4	505.61	1489.9	443.28	2992.11	493.285	607%	0
1986	2990.44	18323	5451.47	16505	4,910.58	1818.0	540.89	1046.50	1196.175	87%	149.7
1987	655.86	2607.8	775.87	1416.5	421.44	1191.3	354.44	5265.01	262.342	2007%	0
1988	820.35	1094.8	325.73	517.3	153.91	577.5	171.82	593.26	328.139	181%	0
1989	1311.90	1115.2	331.80	512.5	152.48	602.7	179.32	333.22	524.760	64%	191.5
1990	844.97	1149.9	342.12	604.1	179.73	545.8	162.39	314.87	337.990	93%	23.1
1991	1104.00	1455.7	433.10	853.8	254.02	601.9	179.08	358.81	441.602	81%	82.8
1992	832.20	1503.6	447.35	817.1	243.10	686.5	204.25	458.27	332.881	138%	0
1993	2555.69	2781.9	827.67	1883.5	560.38	898.4	267.29	510.397	1022.275	50%	511.9
1994	832.26	1843	548.33	1333.2	396.65	509.8	151.68	712.06	332.906	214%	0
1995	3877.95	31418	9347.50	28397	8,448.69	3021.0	898.81	1295.46	1551.180	84%	255.7
1996	2305.29	18739.3	5575.33	16620	4,944.79	2119.3	630.54	9079.23	922.115	985%	0
1997	3170.34	18987	5649.02	13237	3,938.28	5750.0	1710.74	6655.54	1268.136	525%	0
1998	3307.93	14939.7	4444.87	2502.1	744.43	12437.6	3700.44	7638.72	1323.170	577%	0
1999	2093.91	13394.4	3985.11	12203	3,630.64	1191.4	354.47	1098.89	837.564	131%	0
2000	1948.84	11208.5	3334.76	9937.6	2,956.64	1270.9	378.12	4008.76	779.535	514%	0
2001	1096.07	4250.7	1264.67	3206.1	953.88	1044.6	310.79	3267.43	438.427	745%	0
2002	1429.60	2152.4	640.38	1518	451.64	634.4	188.75	1142.63	571.839	200%	0
2003	1632.28	2342	696.79	1763.5	524.68	578.5	172.12	623.75	652.913	96%	29.2
2004	1304.35	3870	1151.40	2866.7	852.90	1003.3	298.50	823.2	521.742	158%	0
2005	2972.79	20486	6095.01	18899	5,622.84	1587.0	472.17	1325.07	1189.117	111%	0
2006	3303.81	28574	8501.36	26547	7,898.28	2027.0	603.07	6225.92	1321.523	471%	0
2007	850.20	2510	746.78	1712.6	509.53	797.4	237.24	8135.52	340.080	2392%	0
2008	1145.99	2361	702.45	1653.4	491.92	707.6	210.53	720.06	458.396	157%	0
2009	1676.74	2027.5	603.22	1544.1	459.40	483.4	143.82	635.74	670.695	95%	35.0
2010	1881.17	7258.4	2159.52	7112.2	2,116.03	146.2	43.50	502.90	752.467	67%	249.6
2011	**3536**	25180	7491.57	24141	7,182.45	1039.0	309.12	2425.15	1414.400	171%	0
2012	1932.82	2416.1	718.84	1866.7	555.38	549.4	163.46	7345.90	773.127	950%	0
2013	1678.39	1457.6	433.67	1142.9	340.04	314.7	93.63	649.01	671.358	97%	22.3
2014	1676.74	1135.6	337.86	922.8	274.55	212.8	63.31	403.35	670.695	60%	267.3
2015	2086.60	1039.9	309.39	972.8	289.43	67.1	19.96	294.52	834.640	35%	540.1
2016			0.00		0.0			289.43			* Col U note
	103,331.95 TAF Sum 1971--2015 **Average T. 2,348.50** is close to 1993 & 1996	Normal or Median is	**92,670.6** TAF Sum		**21,667.00** TAF Sum	114156.5 TAF Sum		**41,332.78** TAF Sum			**2,938.7 TAF Sun**

* Col U Dry Creek had extremely low flow 2013-2015 due to low rainfall or farm improved water use practices or pumping from creek to fields, which seem to require more release from Don Pedro in equal amount in that Feb through June.
Col U data for 2015 are from 2 USGS gauge data printed in 2016.
Col Y sum/43 =about 69 TAF to UF storage per WY, or about 2.9% of each UF WY to be ready for a large group of WY releases like WY 2013 thru 2015.

196 TAF av group release in these 3 WY clusters.

Excel equation for Column Y Row 19: =IF((V19-W19)>0,"0",W19-V19)

Prepared by Bob Hackamack P.E., BOD Tuolumne River Trust bhackamack@frontier.com

ExcelFile: Copy of TR 14a NxYr to Diverters & SWB 3-2017