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MEMORANDUM

TO: Ron Boyce, ODFW

FROM: David A. Benner

DATE: October 28, 2004

RE: Water Travel Time in the Snake and Columbia Rivers

In response to your request, I have evaluated the amount of drawdown needed at the Lower Snake River and John Day projects to increase water travel times in lower water years to speeds that are comparable to water travel times under ordinary pool elevations and minimum BIOP flows. For this analysis, I utilized flows that were presented by the NPCC in 2002 during the mainstem amendment process. During this process the NPCC used the GENESYS hydrosystem model to predict flows over monthly and bi-monthly time steps at Lower Granite and McNary Dams under various operational scenarios over the 50-year available record (1929-1978), one of the operational scenarios was the 2000 Biological Opinion. From this dataset, I utilized April 16-30, May, June, July, Aug 1-15, Aug 16-31 flows over the 50-year record at Lower Granite and McNary Dams under the 2000 Biological Opinion operational scenario.

I used the Reservoir Replacement Method for calculating water travel times through a reservoir. This method basically is a calculation of the times needed to completely drain a reservoir of a known volume at some discharge. This method is routinely used to calculate water travel times. Because storage tables were only available at mainstem projects (JDA, LGS, LMN, IHR) for normal operating elevations, reservoir storage had to estimated below minimum operating pool (MOP). For this estimation, I had to assume the storage per foot of reservoir space was uniform throughout the water column. With this assumption, I simply averaged the storage per foot of all points that were available in storage tables, then subtracted this average storage (per foot) for each foot below MOP.

Using the 50-year record of average April 16-30, May, June, July, Aug 1-15, and Aug 16-31 BIOP flows at Lower Granite and McNary, I averaged flows over periods that were similar to BIOP flow periods: April 16-30 though June and July through August. For each years flow, I

calculated the water travel time between locations. In the lower Snake River, water travel times were calculated from Lower Granite to Ice Harbor Dam with all three pools in this stretch at MOP (LGS, LMN, IHR). In the Lower Columbia, water travel times were calculated from Ice Harbor to Bonneville Dam with John Day at Minimum Irrigation Pool (MIP) and both Bonneville and McNary at average pool elevations. Therefore, water travel times were calculated for both the spring and summer periods in the Lower Snake (LGR to IHR) and Lower Columbia (IHR to BON) for each year of the 50 year record with projects at "normal[1]" levels. For each year that water travel times were larger than the water travel time at the minimum BIOP flow (McNary 220/Spring, 200/Summer: Lower Granite 85/Spring, 50/Summer) pools were drawn down until the water travel time was similar to that at normal elevations and at the minimum of the BIOP flow level. All Snake River pools used in this analysis were drawn down (LGS, LMN, IHR) and in the Lower Columbia only the John Day pool was drawn down. The following tables display the results of this analysis.

Overall, in the springtime, Lower Snake pools had to be drawn down in 17 of 50 years (average of 13 feet) to decrease the water travel time to that at the minimum BIOP flow (85 Kcfs) with the reservoirs at MOP. During the summer flow period, pools in the Lower Snake had to be drawn down in 41 of 50 years (an average of nine feet) to decrease the water travel time to that at the summer BIOP flow (50 Kcfs) with the reservoir at MOP.

In the Lower Columbia, during the spring period, the JDA pool had to be drawn down in 14 of 50 years (average of nine feet) to decrease the water travel time to that at the minimum BIOP flow (220 Kcfs) with the John Day reservoir at MIP. During the summer flow period, the JDA pool had to be drawn down in 33 of 50 years (an average of seventeen feet) to decrease the water travel time to that at the summer BIOP flow (200 Kcfs) with the John Day reservoir at MIP.

It should be pointed out that pool drawdowns of more than several feet below MOP or MIP are unrealistic in the current configuration at most projects. Much below MOP or MIP problems would likely be encountered fish ladders, lockages, navigation channel depth, and turbine problems. The severity of each of these problems and the repairs that would be necessary to allow significant drawdown are unknown to the FPC at this time.

[1] Normal levels were: LGS, LMN, IHR at Minimum Operating Pool, John Day at Minimum Irrigation Pool and Bonneville and McNary Pool were at average spring/summer elevations.

Table 1. Lower Snake Water Travel Time results.

	Flows at Lower Granite		April 16-June	July- Aug	April 16-June		July-August	
Prob	April 16-June Ave (Kcfs)	July- Aug Ave (Kcfs)	WTT LGR to IHR at Flow and MOP days	WTT LGR to IHR at Flow and MOP days	WTT at # of feet below MOP at flow (days)	# of Feet Each reservoir Must draft below MOP to equal WTT at Min BIOP Flow at MOP	WTT at # of feet below MOP at flow (days)	# of Feet Each reservoir Must draft below MOP to equal WTT at Min BIOP Flow at MOP
2	187097	68384	3.4	9.3	na		na	
4	172199	65091	3.7	9.7	na		na	
6	164632	61153	3.9	10.4	na		na	
8	159351	59594	4.0	10.6	na		na	
10	155360	56142	4.1	11.3	na		na	
12	154252	55331	4.1	11.5	na		na	
14	146721	55015	4.3	11.5	na		na	
16	141255	52694	4.5	12.0	na		na	
18	137963	50444	4.6	12.6	na		12.6	
20	136485	49723	4.6	12.8	na		12.5	1
22	129888	48711	4.9	13.0	na		12.5	2
24	128921	48462	4.9	13.1	na		12.6	2
26	125403	48141	5.1	13.2	na		12.4	3
28	123093	47925	5.2	13.2	na		12.5	3
30	119047	47131	5.3	13.5	na		12.7	3
32	113265	46689	5.6	13.6	na		12.6	4
34	111985	46424	5.7	13.7	na		12.6	4
36	110995	46345	5.7	13.7	na		12.6	4
38	109515	45805	5.8	13.9	na		12.5	5
40	107440	45396	5.9	14.0	na		12.6	5
42	106111	45267	6.0	14.0	na		12.7	5
44	104316	45126	6.1	14.1	na		12.5	6
46	101140	44926	6.3	14.1	na		12.5	6
48	99290	44707	6.4	14.2	na		12.6	6
50	98039	44497	6.5	14.3	na		12.6	6
52	97016	44242	6.5	14.3	na		12.4	7
54	94842	44003	6.7	14.4	na		12.5	7
56	93086	43817	6.8	14.5	na		12.6	7
58	91379	42831	6.9	14.8	na		12.6	8
60	90216	42475	7.0	14.9	na		12.7	8
62	88907	42175	7.1	15.0	na		12.5	9
64	85897	41680	7.4	15.2	na		12.6	9

66	84826	41573	7.5	15.3	7.5		12.7	9
68	82741	41274	7.7	15.4	7.5	1	12.5	10
70	80442	40486	7.9	15.7	7.6	2	12.7	10
72	77685	40286	8.2	15.7	7.5	4	12.5	11
74	76324	39540	8.3	16.0	7.5	5	12.7	11
76	71997	39201	8.8	16.2	7.5	8	12.5	12
78	69382	37372	9.1	17.0	7.4	10	12.7	13
80	67637	36902	9.4	17.2	7.4	11	12.6	14
82	66769	36514	9.5	17.4	7.5	11	12.4	15
84	61937	36238	10.2	17.5	7.5	14	12.5	15
86	60823	35728	10.4	17.8	7.5	15	12.7	15
88	59637	35556	10.6	17.8	7.4	16	12.4	16
90	58233	34868	10.9	18.2	7.6	16	12.7	16
92	57287	34283	11.1	18.5	7.5	17	12.5	17
94	53285	33901	11.9	18.7	7.6	19	12.7	17
96	50851	31698	12.5	20.0	7.5	21	12.8	19
98	45475	30233	14.0	21.0	7.6	24	12.6	21
100	37382	29207	17.0	21.7	7.6	29	12.6	22

Table 2. Lower Columbia Water Travel Time results.

	Flows at McNary		April 16-June WTT IHR to BON at Flow and MCN and TDA at Ave Pool and JDA at MIP,days	July- Aug WTT IHR to BON at Flow and MCN and TDA at Ave Pool and JDA at MIP, days	April 16-June		July-August	
Prob	April 16-June Ave (Kcfs)	July- Aug Ave (Kcfs)			WTT at # of feet below MIP (JDA) at flow, days	# of Feet Each reservoir Must draft below MIP to equal WTT at Min BIOP Flow at MIP	WTT at # of feet below MIP (JDA) at flow, days	# of Feet Each reservoir Must draft below MOP to equal WTT at Min BIOP Flow at MIP, days
2	469490	277209	4.1	7.0	na		na	
4	434697	261023	4.4	7.4	na		na	
6	415372	252765	4.6	7.6	na		na	
8	394037	242667	4.9	8.0	na		na	
10	388021	238382	5.0	8.1	na		na	
12	382045	237390	5.1	8.1	na		na	
14	379439	234259	5.1	8.2	na		na	
16	369127	228633	5.2	8.4	na		na	
18	358984	227527	5.4	8.5	na		na	
20	354660	225074	5.4	8.6	na		na	
22	348581	222880	5.5	8.7	na		na	
24	331251	211305	5.8	9.1	na		na	
26	328253	209815	5.9	9.2	na		na	
28	321605	209547	6.0	9.2	na		na	
30	316323	205936	6.1	9.4	na		na	
32	313095	205624	6.2	9.4	na		na	
34	310718	199025	6.2	9.7	na		9.7	
36	296730	195437	6.5	9.9	na		9.8	1
38	295094	192822	6.5	10.0	na		9.8	2
40	286824	190686	6.7	10.1	na		9.8	3
42	285077	186370	6.8	10.4	na		9.7	5
44	279319	183056	6.9	10.5	na		9.8	6
46	273643	181830	7.1	10.6	na		9.7	7
48	270291	180296	7.1	10.7	na		9.8	7
50	265605	179109	7.3	10.8	na		9.7	8
52	263912	177369	7.3	10.9	na		9.8	8
54	260237	176523	7.4	10.9	na		9.7	9
56	249782	174207	7.7	11.1	na		9.7	10
58	243723	170264	7.9	11.3	na		9.8	11
60	239738	169181	8.1	11.4	na		9.7	12
62	239211	168119	8.1	11.5	na		9.8	12
64	235249	161693	8.2	11.9	na		9.7	15

66	232995	160252	8.3	12.0	na		9.8	15
68	231432	157920	8.3	12.2	na		9.8	16
70	229781	152633	8.4	12.7	na		9.8	18
72	222644	150916	8.7	12.8	8.7		9.8	19
74	217002	145973	8.9	13.2	8.8	1	9.8	21
76	215240	143556	9.0	13.5	8.7	2	9.8	22
78	213443	142444	9.0	13.6	8.7	3	9.7	23
80	211061	137825	9.1	14.0	8.7	4	9.8	24
82	206329	134225	9.4	14.4	8.7	6	9.7	26
84	204727	131223	9.4	14.7	8.7	6	9.8	27
86	202403	129837	9.5	14.9	8.7	7	9.7	28
88	197868	128953	9.8	15.0	8.8	8	9.8	28
90	194914	126763	9.9	15.2	8.8	9	9.7	29
92	187394	125371	10.3	15.4	8.8	12	9.7	30
94	180580	123161	10.7	15.7	8.8	14	9.8	30
96	172883	120773	11.2	16.0	8.8	17	9.8	31
98	168682	113253	11.4	17.0	8.8	19	9.8	34
100	153244	110052	12.6	17.5	8.8	24	9.7	36