HYDSIM Use in Analysis of Removing 115% TDG Forebay Gauge Requirements
BPA Report to the Adaptive Management Team – May 2008

Objective

The Adaptive Management Team (AMT) was tasked with assessing the biological effects of a proposal to remove the requirement to maintain total dissolved gas (TDG) levels below 115% saturation levels at forebay monitors. The Corps of Engineers' (COE) SYSTDG model is not capable of identifying the extent spill must occur due to lack of markets since it does not incorporate a load-resource balancing function. SYSTDG is also very difficult to use for a large number of flow conditions since it is an hourly model. HYDSIM is a monthly model, capable of analyzing 70 flow conditions and does identify all the types of spill that can occur, including the amounts of spill expected due to lack of market. The NOAAF COMPASS model is useful in estimating changes in biological effects of alternative scenarios but also does not have the capability to identify spill due to lack of market. COMPASS has been used recently to assess the most recent Biological Opinion effects using project outflows and total spills provided from BPA's HYDSIM model. It was decided by the federal agencies that the best approach for aiding the AMT in their consideration was to link the uses of the SYSTDG, HYDSIM and COMPASS models, using the strengths of each model. SYSTDG analysis provided spill caps for each project for two scenarios (with and without the 115% TDG forebay requirement in effect) which were then used as input to HYDSIM which in turn produced project outflows and total spills for use in the COMPASS analysis of biological effects. This paper will describe more of the details of HYDSIM'S part in the process.

HYDSIM Overview

The HYDSIM model is used to evaluate how the region's system of hydro electric projects operates (within parameters established by the user) for each month of 70 years of historical inflow data. It analyzes the operation of approximately 70 hydroelectric projects one month at a time starting with the projects farthest from the ocean (the headwaters of the river system) and working the project outflows through all projects downstream, meeting all requirements (power and non-power) at each according to priorities established by the user. Non-power operating requirements include obligations for such things as International Treaties, flood control, navigation, irrigation, recreation, water quality, fish and wildlife, etc. Physical operating characteristics of all the projects are also observed in the model. After all projects' non-power requirements have been met each month, the energy produced by the projects is summed and compared to the system energy requirement (load) the user has specified for the month. When system energy production is less than or equal to the system load, the model moves on to the analysis of the next month. When it is greater than system load, the total system energy production is compared to the sum of the system load and the maximum expected secondary market established by the user. If energy production is less than or equal to that sum, the model moves on to the analysis of the next month. If it exceeds the sum, energy production at some of the projects is reduced by converting some of the flow at the project/s to additional spill until system energy production just matches that sum.

Again, the projects that implement this additional spill due to lack of markets (over-generation spill) are designated by the user.

Process

Total project outflows and juvenile passage spill criteria input to HYDSIM were the same in both scenarios. The only input modeling difference between scenarios were the TDG spill caps so that resulting HYDSIM changes in project operations could only be attributed to those changes.

In real-time operations, the combination of spill due to lack of turbine capacity and juvenile passage spill are not allowed to exceed TDG caps established by the COE using their SYSTDG model. In order to simulate real-time operations as closely as possible, HYDSIM was provided month average TDG spill caps for each scenario that varied by modeling period and low, medium or high flow condition as established by SYSTDG modeling of representative recent historical years.

The low, medium or high flow TDG caps were assigned to each of the 70 water conditions on the basis of the April-August average regulated flow at The Dalles in HYDSIM. Years with average flow less than 209 kcfs were low (23 years), above 263 kcfs high (23 years) and those in between medium (24 years).

HYDSIM identified month average outflow and total spill quantities from each scenario for each project. Total spill is the sum of forced spill (due to lack of turbine capacity), spill in accordance with juvenile passage spill criteria and over-generation spill (due to lack of markets for power). The month average project outflows and total spills were shaped into daily time increments for use as input to the NOAA Fisheries COMPASS model by a modulation routine provided by a BPA contractor, Charlie Paulsen. The modulation process was based on historical daily shape data from a recent year.

Conclusions

As expected, relieving the 115% TDG requirement in the forebays resulted in additional spill in some conditions. This was most noticeable at Bonneville and Lower Monumental because they operate with spill at the gas cap as their juvenile passage objective. Spill increases were not as frequent or as large as some anticipated due to the influence of the over-generation spill in the analysis. Removing the 115% TDG forebay limit during times when the hydro system was already spilling due to lack of market did not result in an increase in total spill on the system of projects because the system was already spilling above those caps for another purpose. That is, when juvenile passage spill increased at some projects because the TDG cap was higher, other projects were then able to reduce their over-generation spill and overall system spill did not increase. (This phenomenon is demonstrated in the example on Slide 8 of the attached PowerPoint file.) This is also the explanation for some projects showing a negative change (reduced spill) caused by removing the 115% forebay TDG requirement in some periods in the following Results tables.

Results

70-Year Average Spill with 115% TDG Caps in Forebays - KAF

(HYDSIM Forced + Bypass + Overgeneration spills)

	AP1	AP2	MAY	JUNE	JUL	AU1	AU2	Total
LWG	495	667	1,294	2,341	1,437	179	0	6,412
LGS	482	675	1,346	2,420	1,107	89	0	6,118
LMN	383	680	1,221	2,295	1,145	169	0	5,894
IHR	557	1,106	2,803	3,584	1,517	124	0	9,691
MCN	1,674	3,102	8,248	9,694	6,133	1,965	1,622	32,438
JDA	992	2,430	5,817	8,828	4,853	1,460	1,221	25,600
TDA	1,214	2,874	6,908	9,076	5,580	1,982	1,658	29,290
BON	1,601	3,198	7,734	8,643	6,492	2,757	2,669	33,094
Total	7,398	14,732	35,371	46,881	28,263	8,723	7,170	148,538

70-Year Average Spill without 115% TDG Caps in Forebays - KAF

(HYDSIM Forced + Bypass + Overgeneration spills)

	AP1	AP2	MAY	JUNE	JUL	AU1	AU2	Total
LWG	495	659	1,294	2,341	1,437	179	0	6,403
LGS	477	698	1,346	2,457	1,120	89	0	6,187
LMN	551	997	1,505	2,332	1,145	169	0	6,700
IHR	557	1,096	2,791	3,583	1,517	124	0	9,668
MCN	1,665	3,085	8,248	9,679	6,132	1,960	1,622	32,392
JDA	982	2,410	5,838	8,805	4,852	1,457	1,218	25,561
TDA	1,210	2,900	7,050	9,089	5,563	1,982	1,658	29,450
BON	1,601	3,253	7,863	8,732	7,007	2,948	2,738	34,142
Total	7,536	15,098	35,935	47,018	28,773	8,907	7,236	150,504

70-Year Average Spill Changes due to Removal of 115% TDG Caps in Forebays - KAF

(HYDSIM Forced + Bypass + Overgeneration spills)

	AP1	AP2	MAY	JUNE	JUL	AU1	AU2	Total
LWG	-1	-8	0	0	0	0	0	-9
LGS	-5	23	0	37	14	0	0	69
LMN	167	317	284	37	0	0	0	806
IHR	0	-10	-12	-1	0	0	0	-23
MCN	-9	-17	0	-15	-1	-4	0	-46
JDA	-11	-20	21	-23	-1	-3	-3	-39
TDA	-4	26	142	13	-17	0	0	160
BON	0	55	130	89	515	191	69	1,049
Total	138	365	565	138	511	184	66	1,966

70-Year Average Spill Changes due to Removal of 115% TDG Caps in Forebays - CFS

(HYDSIM Forced + Bypass + Overgeneration spills)

	AP1	AP2	MAY	JUNE	JUL	AU1	AU2
LWG	0	0	0	0	0	0	0
LGS	-175	955	0	1,518	416	0	0
LMN	5,850	10,651	5,275	1,205	0	0	0
IHR	0	0	0	0	0	0	0
MCN	0	0	0	0	0	0	0
JDA	0	-440	2,970	3,188	726	0	0
TDA	0	2,173	2,302	1,236	0	0	0
BON	0	1,836	2,109	1,692	9,421	6,420	2,161

23 LOW Year Average Spill Changes due to Removal of 115% TDG Caps in Forebays - KAF

(HYDSIM Forced + Bypass + Overgeneration spills)

	AP1	AP2	MAY	JUNE	JUL	AU1	AU2	Total
LWG	0	0	0	0	0	0	0	0
LGS	0	0	0	0	0	0	0	0
LMN	126	206	290	66	0	0	0	688
IHR	0	0	0	-2	0	0	0	-2
MCN	-13	0	0	0	-3	0	0	-16
JDA	0	0	0	-9	0	0	0	-9
TDA	0	0	0	0	-25	0	0	-25
BON	0	0	123	158	833	89	4	1,207
Total	112	206	413	213	805	89	4	1,843

24 MED Year Average Spill Changes due to Removal of 115% TDG Caps in Forebays - KAF

(HYDSIM Forced + Bypass + Overgeneration spills)

	AP1	AP2	MAY	JUNE	JUL	AU1	AU2	Total
LWG	0	-1	0	0	0	0	0	-2
LGS	0	14	0	19	0	0	0	33
LMN	185	380	329	0	0	0	0	894
IHR	0	-26	-35	0	0	0	0	-61
MCN	0	-10	0	-25	0	0	0	-35
JDA	-17	-28	0	-12	0	0	0	-57
TDA	0	-4	65	8	0	0	0	68
BON	0	42	184	44	499	119	7	895
Total	168	366	544	35	499	119	7	1,737

23 HIGH Year Average Spill Changes due to Removal of 115% TDG Caps in Forebays - KAF

(HYDSIM Forced + Bypass + Overgeneration spills)

	AP1	AP2	MAY	JUNE	JUL	AU1	AU2	Total
LWG	-2	-23	0	0	0	0	0	-25
LGS	-16	56	0	93	42	0	0	176
LMN	191	362	232	46	0	0	0	831
IHR	0	-4	0	0	0	0	0	-4
MCN	-13	-40	0	-21	0	-12	0	-87
JDA	-14	-32	64	-49	-2	-9	-9	-50
TDA	-12	83	363	33	-26	0	0	441
BON	0	122	80	68	215	368	197	1,050
Total	134	524	738	170	229	347	188	2,330

Example of HYDSIM data:

HYDSIM Output with 115% FB & 120% TW Caps in Place

TOTAL SPILL (FORCED + BYPASS + OVERGEN) **CFS**

MCNARY

	AP1	AP2	MAY	JUNE	JUL	AU1	AU2
1929	17211	44806	57585	79168	60778	52861	43797
1930	18877	60862	56504	75283	62541	55981	45065
1931	20955	47319	55484	78935	61279	54629	44740
1932	58808	145000	160162	153128	69269	53763	52150
1933	26919	79335	101000	230000	230000	80000	64219
1934	145000	156837	118634	86334	68049	52575	46130
1935	23087	80457	99584	81661	81640	70223	49073
1936	21037	97280	115546	145001	64000	56220	46941
1937	18196	49735	60168	81437	57640	57877	50280
1938	49238	145000	173826	104905	74966	52305	45540
1939	25134	87170	111379	67650	62027	54290	44169
1940	29154	94815	88587	80542	54026	51745	43169
1941	19058	49510	57102	86019	62794	55031	49336
1942	20010	86347	81970	145000	83175	70393	47167
1943	146104	230000	145000	230000	83318	69371	44109
1944	16728	41208	59878	77578	56189	53427	45395
1945	17292	43550	87477	145000	60169	53847	49115
1946	72282	145000	208443	100168	82545	67050	47529
1947	47936	90350	144220	145000	82465	65183	46190
1948	26735	103419	212380	406612	145000	78713	62476
1949	56395	145000	191710	145000	59517	53470	38898
1950	65666	101246	135403	316964	145000	72595	54783
1951	145000	149245	193642	145000	145000	77832	49096
1952	116276	151912	218809	145000	79378	62079	46209
1953	19174	75689	123702	229957	145000	68416	47407
1954	28392	90124	146754	230000	230000	137714	80000
1955	19080	56636	87125	230000	230000	80000	58684
1956	95079	248407	273852	238355	145000	68915	52725
1957	59416	96106	211948	230000	72068	54183	43679
1958	33928	111548	181109	145000	66832	54625	47128
1959	62257	89685	152619	249277	76860	70640	51430
1960	145000	145000	109332	145000	80000	62223	44850
1961	63803	79117	126853	240727	73934	57339	48627
1962	43711	145000	113518	145000	65416	55440	47055
1963	22543	73964	98779	145000	80000	65028	48463
1964	26854	77007	104905	310000	145000	80000	52844
1965	42116	179023	199987	167998	80000	71903	59598
1966	131827	82191	91269	86964	82574	69387	45135
1967	24989	61341	115785	257314	145000	74406	50271
1968	19428	61483	91264	145000	145000	74319	57734
1969	145000	230000	212718	145000	84700	60087	44069
1970	22286	64399	105382	162591	72734	52785	41966
1971	101767	145000	243492	236982	145000	80377	62315
1972	145000	99681	222323	345673	230000	88322	73520
1973	15672	45380	71641	83822	61333	51549	39791
1974	145000	178375	227320	385882	230000	80000	62464
1975	20698	77915	149776	236671	145000	65360	51202
1976	131542	145000	215289	145000	145000	145000	145000
1977	15325	38550	56876	68811	51034	54338	47578
1978	97782	92895	149418	97552	84589	63423	48432
1979	22875	70266	125968	66665	60866	46848	42398
1980	22627	93561	172179	145000	69150	50338	43022
1981	17817	64002	99493	230000	145000	80000	68071
1982	78580	101476	190256	310000	91414	80000	60990
1983	75702	100059	145254	130459	145000	80000	58222
1984	87621	129612	125282	230000	145000	73063	43912
1985	63445	111128	124638	77548	56222	44192	37766
1986	145000	112733	92774	142443	74131	58714	44594
1987	24490	66473	84342	81208	63169	50995	40297
1988	17185	79290	58571	75563	68799	57905	51370
1989	57292	115655	115757	85392	55523	50467	44833
1990	48885	145000	101781	145508	75071	65680	51461
1991	27778	80813	130383	145000	145000	80000	57680
1992	19229	49282	58481	79728	60096	46252	39941
1993	22898	66583	114527	95325	65914	58068	47456
1994	18855	89803	75764	64434	64941	58215	42155
1995	43460	70844	112687	105070	82365	60360	45167
1996	91890	230000	184004	173643	145000	80000	54280
1997	145000	230000	319020	336134	145000	80000	59574
1998	26200	76979	141673	230000	81465	63819	37639
Ave.	56251	104264	134148	162915	99742	66031	51120