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U.S. Army Corps of Engineers
Walla Walla District

Selection of Representative Hydrographs for Dissolved Gas Simulations of Lower Snake and Lower Columbia Rivers

Final Report

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1 Introduction

The U.S. Army Corps of Engineers (USACE) Dissolved Gas Abatement Program (DGAS) is evaluating methods to reduce dissolved gas supersaturation associated with spillway flows at the eight USACE operated dams on the Lower Columbia and Snake Rivers. Methods of reducing dissolved gas include both structural and operational alternatives. During FY98, one and two-dimensional models of dissolved gas transport were developed by Battelle's Pacific Northwest Division for the USACE under contract DACW68-96-D-0002 (delivery order 8). In FY99 (delivery order 9) these models are being used to perform a comparative evaluation of the different dissolved gas abatement design alternatives.

This letter report describes the work performed under task 2 of delivery order 9. The objective of task 2 was to recommend up to 3 periods of hydrologic record that would be suitable for use in the modeling study as inflow and project discharge boundary conditions. The results and recommendations in this report were also presented at a Fish Facility Design Review Work Group (FFDRWG) meeting (see Appendix A).

2 Background

The Corps of Engineers needs to assess the impact of elevated levels of dissolved gas on the fisheries of the Lower Snake and Lower Columbia River. Atmospheric gases are entrained in the water at supersaturated levels as a result of the turbulent mixing that occurs during spill operations. A physically-based multi-dimensional hydrodynamic model has been developed to support this assessment. The model estimates the generation, flow and transport of dissolved gas in the various pools behind the dams on the Lower Snake and Lower Columbia Rivers. The boundary conditions for this model require specifying the hourly flows (spill and turbine flow) occurring in both the dams in the study domain and the upstream and downstream dams. These flows are highly interdependent and reflect the policies of the reservoir system for both power and fish needs.

Two general approaches are available to provide representative flow boundary conditions. The first approach involves generating a synthetic flow record. The synthetic flow record should reproduce the relevant statistics including the mean, standard deviations, and auto correlations over a variety of time scales including year, month, day and hour. Historical records may be used to estimate these statistical characteristics, if the stationarity assumption is valid. Since short-term statistics often vary with long-term statistics, it is common practice to estimate the short-term statistics and subgroups of different long-term statistics. For example, the semivariogram of flow over short time scales would be characterized separately for low flow, medium flow, and high flow months. Once the statistics of the flow regime are estimated, a variety of established methods are available to generate one or more years of synthetic flow records with the prescribed statistical character.

The second approach involves selecting specific records from the historical observations. The selected records would be drawn from the set of historical records. Once each record is ranked in terms of long term flow statistics, individual records could be selected based on the rankings.

We have elected to use the second approach. However, due to the relatively short record from which the representative years were selected, it was necessary to compare the selected years' annual averages with a longer term observed and reconstructed records. The years selected have hourly values for all the projects in the study domain. The records are from the most recent available records and, therefore, are expected to represent the recent reservoir operation practices.

Historical records must be used with care. Since the construction of Grand Coulee Dam in the late 1930s, the flows in the Columbia River have been significantly altered. The construction of additional reservoirs, as well as changes in reservoir operating policies have continued to alter the annual hydrograph. Studies have been performed to estimate the "unregulated" monthly flows since 1928 by correcting the historical flows with monthly mean changes in upstream storage. However, these estimated "unregulated" flows are not available at time scales less than one-month. To reflect current reservoir operating practices these estimated "unregulated" flows would have to be simulated through one of the system reservoir models. Additional downscaling would be required to generate hourly flows. Both the system hydroregulation simulation and subsequent downscaling are nontrivial activities.

While the dams on the Lower Snake and Lower Columbia are large projects, they do not shape the monthly hydrograph. These projects are classified as run-of-river projects in as much as the projects active storage is a very small fraction of the mean annual flow. Therefore, the dams oper-

ation are defined by hourly and daily release patterns and have negligible influence on the weekly and monthly flows. Flows at these longer time scales are controlled by upstream storage projects such as Coulee and Dworshak. The hourly and daily release patterns are strongly influenced by operation of the hydropower system. These patterns also reflect longer time scale flow patterns and turbine maintenance activities.

3 Available Data

Three distinct datasets provided the basis for selecting representative flow records. Each of the datasets reflects different periods of different time scales. Each of the datasets is described below.

3.1 Adjusted Streamflow and Storage 1928-1989

This dataset was prepared by A.G. Crook Company for the Bonneville Power Administration in 1993. This study revised and updated the monthly data developed by the Depletions Task Force of the Columbia River Water Management Group. This dataset was developed in order to provide input to hydroregulation codes used in reservoir management studies. As well as adjusting for upstream regulation it includes estimates of upstream diversion and return flow schedules consistent with 1990 levels of irrigation. Monthly flow estimates are provided for each of the significant federal and non-federal projects in the Columbia River system.

3.2 USGS Daily Values

The USGS provides daily streamflow values. These records can extend back as far as 1900. The values are the actual historical stream flows and, therefore, are influenced by an upstream diversions and storage. Data is limited to specific locations and these locations do not relate to specific dams.

3.3 Corps Dam Operations

The Corps currently provides records of hourly data from each of the dams it manages on the Lower Snake and Lower Columbia. Data includes spill and total flow (i.e. spill plus turbine and bypass flows), as well as elevations of both the forebay and tailrace. Only data for 1995-1998 were considered.

The complete set of datasets used in this evaluation are included in an $EXCEL^{TM}$ spreadsheet that can be accessed at http://etd.pnl.gov:2080/DGAS/. Each of the worksheets include in the workbook are described in Table 3.1 .

Table 3.1: Table of Worksheets in Flows2.xls $EXCEL^{TM}$ Workbook.

Worksheet	**Contents**	**Source**
bon	Bonneville Dam - Hourly Spill, Total Flow Forebay Elevation, and Tailwater Elevation for 1995-1998	Corps Ops
ihr	Ice Harbor Dam - Hourly Spill, Total Flow Forebay Elevation, and Tailwater Elevation for 1995-1998	Corps Ops
jda	John Day Dam - Hourly Spill, Total Flow Forebay Elevation, and Tailwater Elevation for 1995-1998	Corps Ops
lgs	Little Goose Dam - Hourly Spill, Total Flow Forebay Elevation, and Tailwater Elevation for 1995-1998	Corps Ops
lmn	Lower Monumental Dam - Hourly Spill, Total Flow Forebay Elevation, and Tailwater Elevation for 1995-1998	Corps Ops
lwg	Lower Granite Dam - Hourly Spill, Total Flow Forebay Elevation, and Tailwater Elevation for 1995-1998	Corps Ops
tda	The Dalles Dam - Hourly Spill, Total Flow Forebay Elevation, and Tailwater Elevation for 1995-1998	Corps Ops
Table of Workbooks	this table	
sorted table	Adjusted monthly streamflows expressed as fraction of their respective min-max range	derived
USGS Hist Flow Snake at Anatone	Historical Daily Flows for the Snake River at Anatone for $(7/22/58 - 9/30/97)$	USGS
USGS Hist Flow The Dalles	Historical Daily Flows for the Lower Columbia at The Dalles $(1/1/1900 - 9/30/97)$	USGS

4 Streamflow Characterization

Streamflows were analyzed for two separate periods. The first characterization period was one year. The second characterization period was from April to August. Since the Columbia Basin runoff is dominated by snowmelt, the period from April to August represents the typical period of highest flow. It is during these high flow conditions that spill is most likely to occur and therefore is of increased interest.

Table 4.1 shows the estimated modified flow volumes, expressed in thousands of cubic feet per second - days (i.e. ksfd), and the relative percent of the flow to the min-max range of the period. Since these are estimated unregulated flows, the minimum and maximum values will be more extreme than the actual regulated flows. The monthly values have been summed for both the total year (water year) and the months of April-August.

The variance of each years' location with in the respective range of flows is also shown. Ideally, a "high year" would be high in all categories (annual and April-Aug) for all three locations resulting in a low variance. The mean value reported with the variance is the mean fraction of the range for both periods and all three locations.

Tables 4.3 and 4.4 are the summaries of historical flow data for locations on the Lower Snake and Lower Columbia respectively. These are based on daily measurements and do reflect the operation of the reservoir system in place at those dates. The data are ranked (1 being lowest) for both annual period (Water Year) and the period of April through August. Rankings were performed for the entire record and the period of the past 20 years.

Figures 4.1 and 4.2 show the average daily flows at selected locations on the lower Columbia and Snake Rivers, respectively for 1995, 1996, 1997, and 1998.

Table 4.1: Adjusted Monthly Streamflow Volumes (ksfd) at Priest Rapids, Lower Granite, and Bonneville.

	Priest Rapids				Lower Granite				Bonneville					
	April-Aug		Year		April-Aug		Year		April-Aug		Year			
Year	**Flow**	**Percent**	**Flow**	**Percent**	**Flow**	**Percent**	**Flow**	**Percent**	**Flow**	**Percent**	**Flow**	**Percent**	**Variance**	**Mean**
1928-29	22,847	16%	32,058	11%	8,615	29%	13,621	22%	32,954	20%	49,936	15%	0.004003052	18%
1929-30	25,048	24%	33,631	15%	7,447	20%	12,581	16%	33,120	20%	49,494	14%	0.001501212	18%
1930-31	22,937	16%	31,253	8%	5,941	9%	10,380	4%	30,661	14%	45,897	8%	0.001913844	10%
1931-32	33,597	58%	44,230	47%	12,402	57%	17,493	42%	49,979	62%	69,980	50%	0.005792665	53%
1932-33	37,392	73%	49,966	64%	11,514	50%	16,458	37%	52,944	70%	74,947	58%	0.018034871	59%
1933-34	35,087	64%	55,557	81%	6,890	16%	14,821	28%	44,370	48%	79,898	67%	0.061373702	51%
1934-35	31,254	49%	44,732	48%	8,186	25%	12,613	16%	42,066	43%	64,609	40%	0.017491729	37%
1935-36	29,090	40%	37,429	27%	11,495	50%	15,816	33%	43,634	47%	59,904	32%	0.008235844	38%
1936-37	24,029	20%	31,316	8%	7,419	20%	11,247	9%	34,887	25%	48,963	13%	0.004494874	16%
1937-38	32,846	55%	44,267	47%	13,201	63%	18,928	50%	50,151	63%	72,734	54%	0.004242286	55%
1938-39	27,083	32%	36,589	24%	8,195	26%	13,774	22%	37,802	32%	56,280	26%	0.001700939	27%
1939-40	25,327	25%	36,227	23%	8,729	30%	14,488	26%	36,587	29%	56,988	27%	0.000570843	27%
1940-41	21,952	12%	32,203	11%	7,673	22%	13,253	20%	32,277	18%	51,996	18%	0.001816623	17%
1941-42	28,274	37%	42,664	42%	10,630	44%	17,387	42%	41,995	42%	67,978	46%	0.000926988	42%
1942-43	34,586	62%	45,443	51%	17,118	92%	24,720	81%	54,678	74%	78,687	65%	0.021954569	71%
1943-44	19,839	4%	28,474	0%	7,731	22%	12,821	17%	28,753	9%	44,916	6%	0.007115951	10%
1944-45	26,270	29%	35,967	22%	10,294	41%	15,529	32%	38,552	34%	56,203	26%	0.004423468	31%
1945-46	36,231	68%	47,227	56%	11,988	54%	19,088	51%	51,437	66%	73,717	56%	0.004871949	58%
1946-47	33,574	58%	46,053	52%	11,949	54%	20,371	58%	47,462	56%	72,810	55%	0.000484148	55%
1947-48	41,484	89%	56,290	83%	16,052	84%	23,323	73%	61,772	92%	88,249	81%	0.00405892	84%
1948-49	30,427	45%	41,172	38%	12,387	57%	19,353	52%	45,928	52%	67,890	46%	0.004555295	48%
1949-50	38,906	79%	52,331	71%	14,449	72%	21,541	64%	56,911	80%	81,991	71%	0.003385274	73%
1950-51	37,856	75%	54,950	79%	12,877	61%	21,709	65%	53,551	71%	85,828	77%	0.005242515	71%
1951-52	32,931	55%	45,901	52%	15,907	83%	23,422	74%	51,442	66%	75,836	60%	0.014076396	65%
1952-53	32,355	53%	43,263	44%	12,566	58%	19,012	50%	47,545	56%	69,105	48%	0.002756867	52%
1953-54	41,297	88%	55,303	80%	11,713	52%	17,807	44%	55,555	76%	80,361	68%	0.029128238	68%
1954-55	34,028	60%	47,106	56%	10,729	44%	15,575	32%	46,700	54%	67,599	45%	0.010013785	49%
1955-56	42,637	93%	57,069	85%	16,045	84%	24,363	79%	63,584	96%	92,845	89%	0.004077942	88%
1956-57	33,065	56%	44,072	46%	14,392	72%	21,527	64%	50,997	65%	73,281	55%	0.008008154	60%
1957-58	31,453	49%	42,420	42%	12,689	59%	19,300	52%	47,525	56%	69,692	49%	0.003785057	51%
1958-59	40,264	84%	54,493	78%	11,197	48%	18,825	49%	53,188	70%	79,610	66%	0.021584903	66%
1959-60	33,361	57%	50,069	64%	10,107	40%	17,682	43%	45,755	52%	73,891	56%	0.008399028	52%

Table 4.2: Adjusted Monthly Streamflow Volumes (ksfd) at Priest Rapids, Lower Granite, and Bonneville (continued).

	Priest Rapids				Lower Granite				Bonneville					
	April-Aug		Year		April-Aug		Year		April-Aug		Year			
Year	**Flow**	**Percent**	**Flow**	**Percent**	**Flow**	**Percent**	**Flow**	**Percent**	**Flow**	**Percent**	**Flow**	**Percent**	**Variance**	**Mean**
1960-61	36,157	68%	49,357	62%	9,101	32%	15,147	30%	48,032	58%	72,473	54%	0.02526733	51%
1961-62	30,212	45%	41,034	37%	10,802	45%	16,477	37%	43,645	47%	64,334	40%	0.001769313	42%
1962-63	28,452	38%	42,278	41%	10,137	40%	17,594	43%	40,691	39%	66,222	43%	0.000450484	41%
1963-64	35,818	67%	46,358	53%	13,771	67%	18,984	50%	51,505	66%	70,533	51%	0.007120578	59%
1964-65	34,450	61%	49,395	62%	16,009	84%	26,730	92%	52,726	69%	84,607	75%	0.014699635	74%
1965-66	31,279	49%	43,223	44%	7,405	20%	13,737	22%	40,447	39%	61,962	36%	0.013608377	35%
1966-67	38,150	76%	50,791	66%	11,289	49%	17,031	40%	50,570	64%	72,526	54%	0.017105099	58%
1967-68	31,901	51%	46,177	53%	8,349	27%	15,709	33%	41,506	41%	66,899	44%	0.01045481	41%
1968-69	37,576	73%	50,829	67%	12,641	59%	21,178	62%	48,739	59%	74,222	57%	0.003829859	63%
1969-70	26,919	32%	37,932	28%	12,327	56%	19,247	52%	40,723	39%	62,719	37%	0.012457448	41%
1970-71	38,671	78%	51,645	69%	17,828	97%	27,386	95%	58,732	84%	85,263	76%	0.012519274	83%
1971-72	44,220	100%	59,313	92%	15,786	82%	26,737	92%	61,484	91%	93,061	90%	0.003087441	91%
1972-73	22,445	14%	32,942	13%	6,473	13%	13,236	19%	30,083	13%	50,695	16%	0.000695499	15%
1973-74	44,316	100%	62,045	100%	18,171	100%	28,258	100%	65,406	100%	98,867	100%	0	100%
1974-75	33,609	58%	44,259	47%	15,355	79%	22,176	67%	51,290	66%	73,018	55%	0.012438731	62%
1975-76	38,082	75%	56,228	83%	15,056	77%	24,497	80%	55,265	76%	87,780	81%	0.000889463	78%
1976-77	18,901	0%	28,550	0%	4,768	0%	9,596	0%	24,984	0%	41,540	0%	8.61969E-07	0%
1977-78	33,687	58%	45,644	51%	12,151	55%	20,031	56%	48,360	58%	73,517	56%	0.000683163	56%
1978-79	25,340	25%	36,112	23%	9,151	33%	15,466	31%	36,621	29%	57,005	27%	0.001409135	28%
1979-80	31,148	48%	40,482	36%	10,981	46%	16,259	36%	44,411	48%	62,762	37%	0.00405968	42%
1980-81	33,232	56%	49,602	63%	9,870	38%	16,769	38%	44,341	48%	71,484	52%	0.009823789	49%
1981-82	37,191	72%	52,161	71%	16,533	88%	25,616	86%	56,693	79%	86,137	78%	0.004887015	79%
1982-83	32,451	53%	48,054	58%	13,683	67%	24,300	79%	49,643	62%	82,107	71%	0.008311837	65%
1983-84	30,366	45%	44,642	48%	17,492	95%	27,757	97%	51,233	65%	81,375	69%	0.049549191	70%
1984-85	28,055	36%	37,390	27%	10,475	43%	17,876	44%	41,179	40%	61,808	35%	0.004139549	38%
1985-86	29,003	40%	43,471	45%	12,624	59%	23,072	72%	42,981	45%	72,396	54%	0.014099754	52%
1986-87	25,871	27%	37,025	25%	5,769	7%	12,366	15%	32,876	20%	53,701	21%	0.005358115	19%
1987-88	25,931	28%	34,154	17%	6,812	15%	11,065	8%	34,218	23%	49,015	13%	0.005038605	17%
1988-89	29,083	40%	40,690	36%	9,874	38%	15,370	31%	40,946	40%	60,951	34%	0.001299286	37%

Table 4.3: Historical Flow Volumes (ksfd) for Anatone on Snake River (from USGS Daily Values)

Water Year	Annual Flow(a)	Rank - All Years	Rank for Last 20 Years	April through August Flows (a)	Rank all Years	Rank for Last 20 Years
1959	10,956	15		5,940	14	
1960	11,176	16		5,943	15	
1961	9,323	8		4,609	10	
1962	10,877	14		6,342	18	
1963	12,288	20		6,807	20	
1964	12,589	22		7,831	24	
1965	18,770	34		10,356	33	
1966	9,365	9		4,008	6	
1967	11,280	17		6,695	19	
1968	10,273	11		5,010	11	
1969	14,659	27		7,979	25	
1970	13,518	26		7,783	23	
1971	19,945	37		11,904	38	
1972	18,144	31		9,045	29	
1973	10,177	10		4,169	7	
1974	19,339	35		11,804	37	
1975	15,825	28		9,877	31	
1976	16,597	29		9,565	30	
1977	6,904	2		2,652	1	
1978	13,297	24	13	7,701	22	12
1979	10,564	13	8	5,384	12	7
1980	11,736	19	10	7,298	21	11
1981	11,347	18	9	6,245	17	10
1982	18,436	33	17	11,254	35	18
1983	19,349	36	18	10,540	34	17
1984	21,309	38	19	12,815	39	20
1985	13,024	23	12	6,231	16	9
1986	16,993	30	15	8,981	28	15
1987	9,042	7	6	3,568	3	2
1988	7,422	3	2	3,788	4	3
1989	10,364	12	7	5,869	13	8
1990	8,384	6	5	4,468	8	5
1991	8,304	5	4	4,555	9	6
1992	6,605	1	1	3,051	2	1
1993	12,321	21	11	8,257	26	13
1994	7,687	4	3	4,006	5	4
1995	13,422	25	14	8,581	27	14
1996	18,255	32	16	10,276	32	16
1997	21,547	39	20	11,739	36	19

Table 4.4: Historical Flow Volume (ksfd) for The Dalles on Lower Columbia River (from USGS daily values).

Water Year	Annual Flow(a)	Rank - All Years	Rank for Last 20 Years	April through August Flows (a)	Rank all Years	Rank for Last 20 Years
1901	79,821	81		51,055	76	
1902	72,059	62		51,261	77	
1903	76,994	73		55,667	90	
1904	88,601	93		61,154	96	
1905	51,067	13		34,055	27	
1906	57,201	23		39,093	37	
1907	83,632	87		55,206	88	
1908	71,816	61		51,393	80	
1909	69,224	53		48,792	70	
1910	77,664	77		49,178	72	
1911	68,504	51		46,693	62	
1912	66,917	45		47,681	66	
1913	77,748	78		57,992	92	
1914	68,206	48		45,821	57	
1915	53,576	16		33,510	25	
1916	87,104	92		62,701	97	
1917	76,104	71		58,292	93	
1918	74,701	67		47,332	65	
1919	62,781	35		43,034	49	
1920	57,387	24		40,477	41	
1921	83,982	88		45,727	91	
1922	66,866	44		46,555	60	
1923	65,495	41		46,745	63	
1924	50,067	12		31,338	16	
1925	73,505	65		51,674	81	
1926	43,109	1		25,657	8	
1927	75,210	69		50,954	75	
1928	84,624	89		51,704	82	
1929	48,461	9		32,368	18	
1930	47,958	7		32,767	22	
1931	44,502	4		29,717	13	
1932	67,900	47		49,855	73	
1933	72,268	63		52,456	84	
1934	77,190	74		44,704	54	
1935	62,130	33		41,977	42	
1936	58,165	25		42,716	48	
1937	46,982	5		33,600	26	
1938	69,406	55		48,570	67	
1939	54,649	18		37,122	35	
1940	54,334	17		34,606	28	
1941	47,459	6		27,407	12	
1942	65,182	38		39,632	38	
1943	75,666	70		53,728	87	
1944	43,775	2		26,129	9	
1945	55,047	19		36,929	34	
1946	71,576	60		50,218	74	

Table 4.4: Historical Flow Volume (ksfd) for The Dalles on Lower Columbia River (from USGS daily values).

Water Year	Annual Flow(a)	Rank - All Years	Rank for Last 20 Years	April through August Flows (a)	Rank all Years	Rank for Last 20 Years
1947	70,690	57		46,577	61	
1948	86,181	90		60,592	95	
1949	65,752	42		43,972	50	
1950	79,256	80		55,640	89	
1951	82,647	85		52,114	83	
1952	72,530	64		46,842	64	
1953	64,458	40		42,521	47	
1954	76,305	72		51,269	78	
1655	65,325	39		42,059	43	
1956	89,081	94		60,209	94	
1957	70,854	58		46,303	58	
1958	65,972	43		42,149	45	
1959	77,230	75		48,741	69	
1960	71,497	59		42,309	46	
1961	68,996	52		44,285	52	
1962	61,803	32		40,024	39	
1963	63,564	36		36,914	33	
1964	67,415	46		46,459	59	
1965	81,925	83		48,687	68	
1966	59,138	27		34,996	29	
1967	69,821	56		45,174	56	
1968	60,647	29		32,754	21	
1969	75,127	68		44,050	51	
1970	60,765	30		32,716	20	
1971	82,622	84		51,274	79	
1972	89,355	95		53,027	86	
1973	49,689	10		21,192	2	
1974	86,775	91		49,000	71	
1975	68,260	49		36,023	31	
1976	80,620	82		42,085	44	
1977	43,961	3		16,700	1	
1978	62,244	34	11	31,482	17	10
1979	55,656	20	5	25,422	7	5
1980	58,207	26	8	29,809	14	8
1981	68,405	50	13	35,365	30	14
1982	83,550	86	18	44,782	55	19
1983	79,070	79	17	38,767	36	16
1984	77,421	76	16	40,372	40	17
1985	60,248	28	9	26,195	10	6
1986	69,371	54	14	33,068	24	13
1987	52,958	15	4	23,238	4	2
1988	49,706	11	2	21,750	3	1
1989	56,914	22	7	26,649	11	7
1990	64,287	37	12	32,797	23	12
1991	74,258	66	15	36,673	32	15
1992	52,495	14	3	23,784	5	3

Table 4.4: Historical Flow Volume (ksfd) for The Dalles on Lower Columbia River (from USGS daily values).

Water Year	Annual Flow(a)	Rank - All Years	Rank for Last 20 Years	April through August Flows (a)	Rank all Years	Rank for Last 20 Years
1993	56,666	21	6	29,984	15	9
1994	48,441	8	1	24,270	6	4
1995	61,032	31	10	32,502	19	11
1996	92,185	96	19	44,427	53	18
1997	96,255	97	20	52,918	85	20

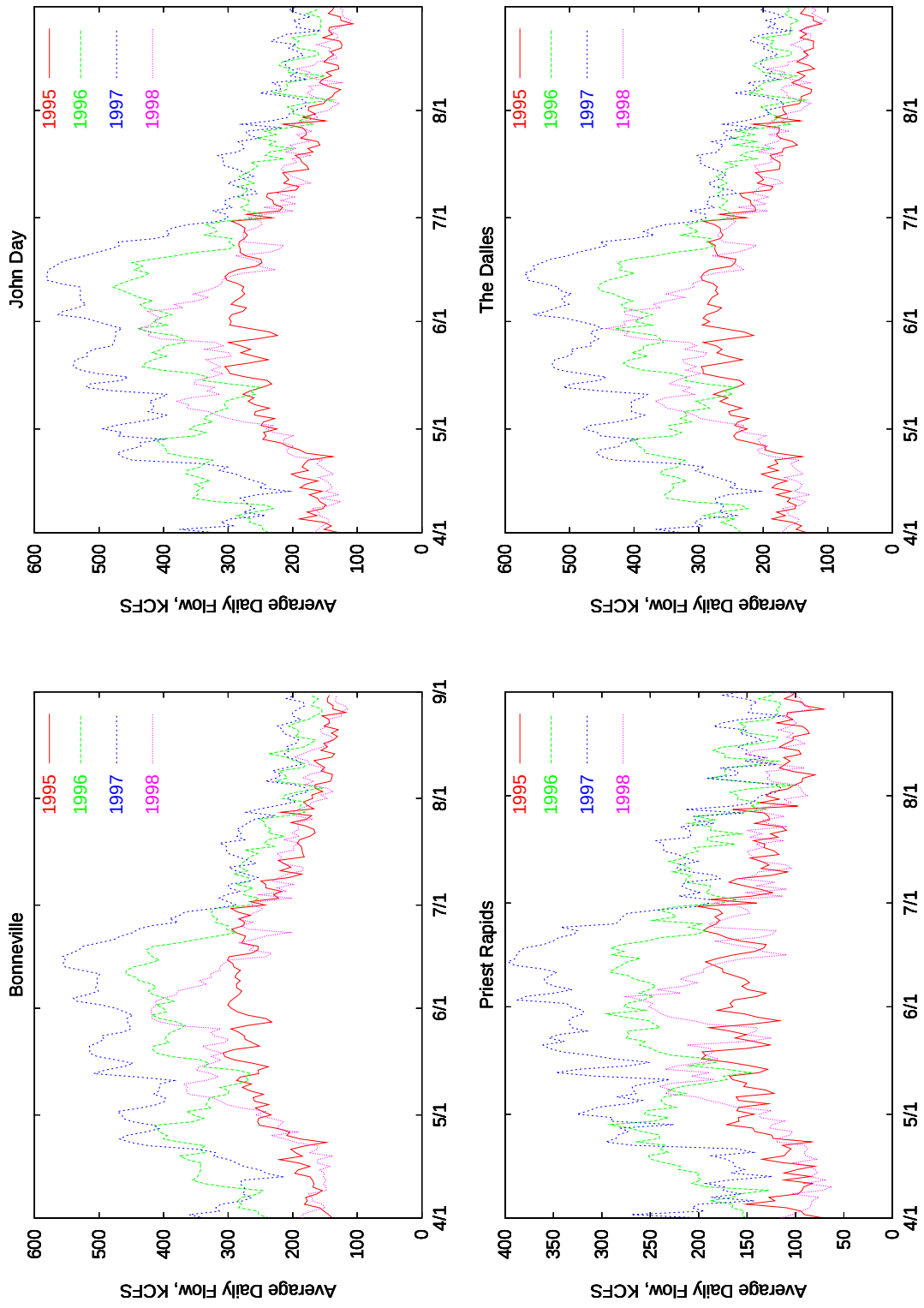

Figure 4.1: Average Daily Flows - Columbia River

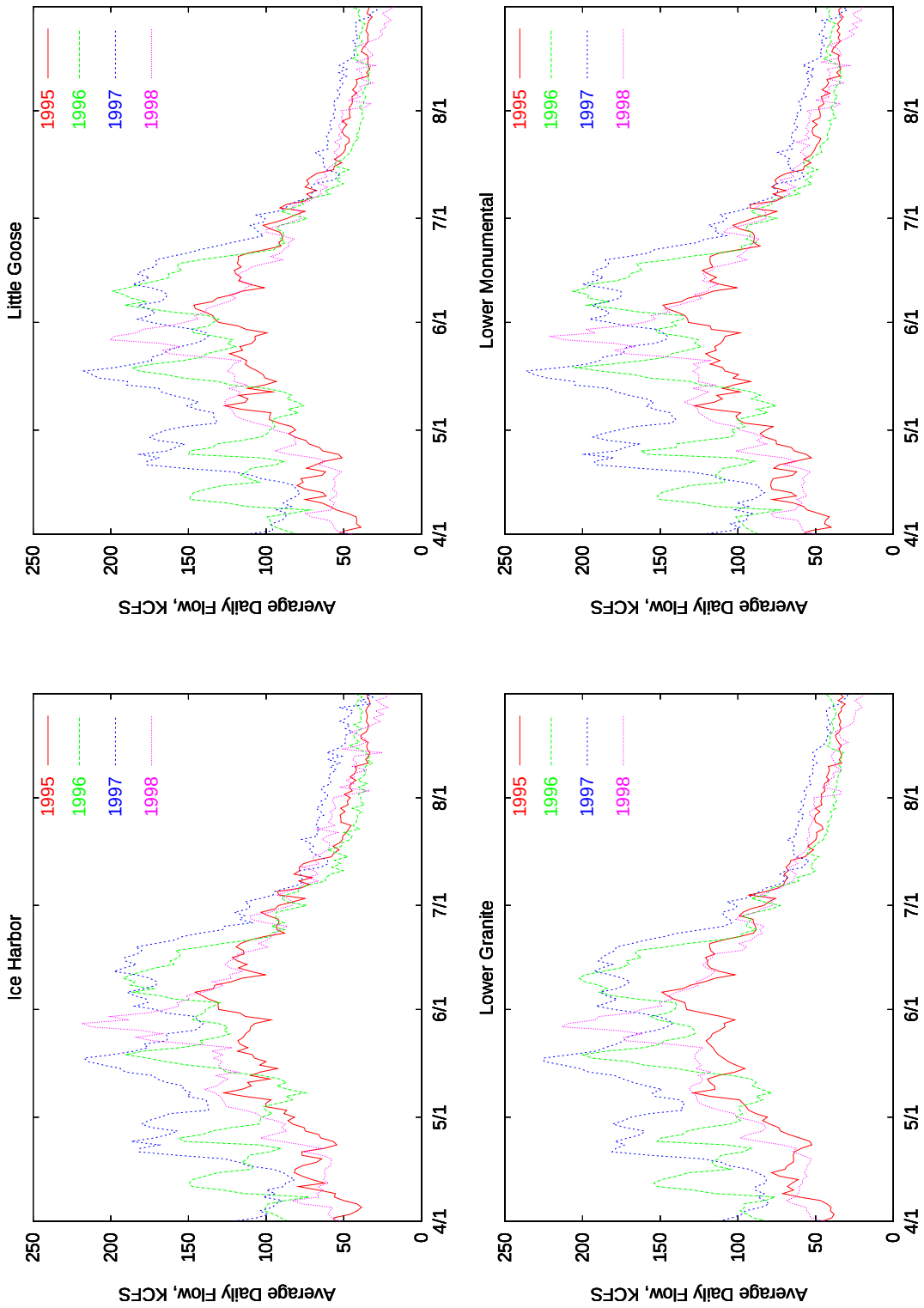

Figure 4.2: Average Daily Flows - Snake River

5 Selection and Selection Rationale

Only years with recent hourly flow records were selected. These years have complete records at a small enough timescale to ensure any analyses can be performed without extensive temporal downscaling efforts. This data also provides the additional benefit of supporting model calibration with the dissolved gas data that has been collected in the recent past years. The years selected are discussed below:

- 1997 was selected for the high flow case. This year was consistently high for both the Columbia and the Snake. It the highest year of record for the entire period of record. It is only slightly less than the estimated unregulated flow for WY 1974. The peak daily flow for the past 20 years at The Dalles (USGS gauge) occurred on 6/15/97.
- 1994 was selected for the low flow case. This year had the lowest annual flow at The Dalles for the past 20 years. Of the entire record of 97 years, it was very low at number 8 (i.e. 8/97). For the period of April through August it ranked (4/20) and (6/97) at The Dalles. The Snake River gauge reported (3/20) or (4/39) for the annual flows and (4/20) or (5/39) for April through August flows.
- 1996 and 1991 were classed as medium high years.
- 1995 was classified as a medium year.

The three hydrologic periods of record to be used in the DGAS alternatives modeling are 1994, 1996, and 1997. The 1996 year was added after the FFDRWG meeting to coordinate other studies being done by the USACE Seattle District.

A Special FFDRWG Meeting Minutes

This appendix contains the minutes of the special FFDRWG meeting held on March 5, 1999 at the US Army Corps of Engineers offices in Portland, Oregon. The following people were in attendance:

Rick Emmert	USACE - Walla Walla	509-527-7536
Karl Weist	NPPC-OR	503-229-5171
Tom Carlson	USACE-WES	503-808-4770
Bob Buchholz	USACE-NWP-EC	503-808-4877
Chris Goodell	USACE-NWP-EC-HD	503-808-4896
Marshall Richmond	Battelle-PNWD	509-372-6241
Mark Schneider	NMFS	503-231-2306
Jim Nielsen	WDFW	360-902-2812
Gary Fredricks	NMFS	503-231-6855

Rick Emmert started the meeting off by reviewing the DGAS project status. The 60% completion report is out for review by the region. There will be no 90% completion report; a final report will be produced in FY2000. The alternatives investigations are about 90% complete. Prototype testing has been deleted from the current tasks; testing will be done in the implementation phase. Field TDG measurements are 95% complete. The numerical model development is 95% complete. No further biological field or laboratory research is currently planned.

A short overview of the 2D numerical model was presented to brief attendees not familiar with the model. The overview slides are attached.

The recommendations for the hydrologic input (or period of record) for the baseline and alternatives modeling was presented by Marshall Richmond. It was recommended to use historical total hourly river flows at each project for use in the alternatives analysis. The historical ranks of several recent years for which hourly records are readily available are summarized on the attached ”Typical Years” slide. The decision was reached that the modeling should start off using two hydrologic periods: a ”high-flow” period that represents an out-of-control, involuntary spill dominated scenario and a ”low-flow” period that represents a scenario where the amount of spill can be controlled. It was proposed to use 1997 as the high-flow record and 1994 as the low-flow record. The option remains to select another period of record at a later date.

The baseline simulations will use 1998 operations and configurations combined with the selected hydrologic records.

In addition to the baseline simulation, the following simulations (listed in Table A.1) were selected by the group to be part of the fast-track analysis. Note that the modeling contract allows for the selection of another set of simulations that can be specified at a later date following completion of the first set listed below.

There are 32 individual pool alternatives specified in Table A.1. The modeling contract allows for the selection of up to 72 individual pool simulations.

Table A.1: Simulations for the Fast-Track Alternatives

Project		**Number of Simulations (option* 2 hydrologic periods)**
Bonneville	Deflectors Installed	2
	Raised Tailrace	2
The Dalles	Deflectors	2
John Day	2 Additional Deflectors	2
McNary	4 Additional Deflectors plus raised tailrace	2
	Divider wall plus above option	2
	4 additional deflectors only	2
Ice Harbor	No fast-track options	
Lower Monumental	2 additional deflectors	2
	8 deflectors	2
	divider wall only	2
Little Goose	2 additional deflectors	2
	all modified deflectors	2
	all modified deflectors plus divider wall	2
Lower Granite	Modified deflectors	2
	Divider wall plus modified deflectors	2
	Raised tailrace	2