2012 CORPS SPILL CHANGE GUIDANCE
For Columbia and Snake Rivers

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Updated on April 13, 2012

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1. Introduction:

The voluntary spill program first began at the John Day dam in 1977, an extremely low water year. It was thought that spill would assist fish passage through the dam and increase fish survival. In 1981, spill began at Lower Monumental dam and the use of sonar to detect fish passage. The time and amount of water to be spilled was based on the numbers of fish detected with the sonar and the dam biologist's judgment. In 1989, there was a 10-year agreement established between Bonneville Power Administration (BPA), state and federal fish agencies and environmental organizations that called for daily spill at John Day, Lower Monumental, Ice Harbor, and The Dalles dams. The US Army Corps of Engineers (Corps) did not sign onto the agreement but agreed to implement the actions it described. This agreement stayed in effect for 3 years, through 1991 when Snake River sockeye salmon was declared endangered under the Endangered Species Act (ESA). As a result, the Corps went into consultation with NOAA Fisheries on how to protect listed salmon. Through the subsequent years, more fish were listed as endangered. In 1992, the spring/summer Chinook and fall Chinook were listed. In 1998, chum and steelhead were listed. By 2000, 12 Evolutionarily Significant Units (ESU) of fish were listed as endangered. In 2005 19 more ESU were listed.

The spill program with daily spill was further developed and was written into the first Biological Opinion issued in 1995 and all the subsequent Biological Opinions. The 2004 Updated Proposed Actions required the Action Agencies (The Corps, BPA, and Bureau of Reclamation) to provide a certain amount of spill from the various dams to aid juvenile fish migration. Judge Redden issued a December 29, 2005 court decision that declared the 2004 Biological Opinion as inadequate and the federal agencies were ordered to remand it. The new Biological Opinion is under litigation so the Corps developed the Fish Operations Plan (FOP) which can be found at http://www.nwd-wc.usace.army.mil/tmt/wqnew/

As further fish operation decisions are made through court cases and as fish research provides more information about fish migration and technologies to assist it, the amount, method and approaches toward spill changes too. These changes are discussed and agreed upon through regional forums and incorporated into the Water Management Plan. As a result, this spill change guidance document is updated annually to reflect the various changes that were agreed upon regionally and that affect the Corps spill program.

2. List of Factors that Affect Spill Levels:

There are five main categories with a total of 27 factors that influence how much water will be spilled at the Corps dams and the documentation of the spill rate:

Legal Factors that Influence Spill

1. Fish Operations Plan Spill Operations
2. Fish Test Spill Operations
3. 115 and 120% Gas Caps:
4. Bonneville Daytime Spill Schedule:
5. Minimum Operating Pool:
6. Minimum Spill and Generation During Low Flows:
7. Chum Redds Emergence

Physical Factors that Influence Spill

1. Spill Patterns
2. Unique Physical Designs:
3. Physical Limitations
4. Turbines Out of Service
5. Unit Availability Assumption:
6. Full Powerhouse Information:
7. Actual Powerhouse Generation Capacity Limitations:

Guidance Factors that Influence Spill

1. General Rule of Thumb Guidance:
2. DGAS or Research Project-by-Project Guidance:
3. Travel Time Guidance:
4. Weekend Flow Guidance:
5. Monday Flow Guidance
6. Holiday Flow Guidance:
7. Wind Degassing Guidance::
8. Flow Deflector Degassing Guidance:
9. Water Temperature Guidance:

Model Forecasting that Influence Spill

1. 10 Day Flow Forecast
2. SYSTDG Model:

Tracking Spill Rates

1. Instance Types:
2. Weekly project Plots
3. Spill Variances

These factors are discussed in sections 3 through 7.

3. Legal Factors that Influence Spill

3.1 Fish Operations Plan Spill Operations:

The spill guidance table shown as Table 1 provides spill amounts, times, planning dates, and minimum generation requirements for the projects that provides voluntary spill for juvenile fish passage. This table is derived from either the FOP or BiOP or other agreements the Corps has with the local federal court.

Table 1
2012 FOP Spill Table

Project	Planning Dates	Spill Flow Rates [C]	Minimum Generation Range [A] in kcfs
Lower Granite	April 3[E] – June 20	20 kcfs	11.3 – 14.5
Lower Granite	June 21 - August 31	18 kcfs	11.3 – 14.5
Little Goose	April 3[E] – June 20	To the spill cap or to 30% of project outflow, whichever is less	11.3 – 14.5
Little Goose	June 21 - August 31	To the spill cap or to 30% of project outflow, whichever is less	11.3 – 14.5
Little Goose	During flows < 32 kcfs	Constant spill of 7-11 kcfs	11.3 – 14.5
Lower Monumental	April 3[E] – June 20	To the spill cap	11.3 – 14.5
Lower Monumental	June 21 - August 31	To the spill cap or up to 17 kcfs, whichever is less	11.3 – 14.5
Ice Harbor	April 3 - April 28	45 kcfs from 0500 - 1800 hr	8.5 – 13.1
Ice Harbor	April 3 - April 28	To the spill cap from 1800 to 0500 hr	8.5 – 13.1
Ice Harbor	April 28 - July 13	Test alternating between 2 treatments of: To the spill cap or up to 30% of project outflow whichever is less VS. 45kcfs during the day/ spill cap at night	8.5 – 13.1
Ice Harbor	July 13-August 31	45 kcfs from 0500 - 1800 hr	8.5 – 13.1
Ice Harbor	July 13-August 31	To the spill cap from 1800 to 0500 hr	8.5 – 13.1
McNary	April 10[B] - June 19	To the spill cap or up to 40% of project flow whichever is less	50 - 60
McNary	June 20 - August 31	To the spill cap or up to 50% of project flow whichever is less [F]	50 - 60
John Day	April 10 – April 27	To the spill cap or up to 30% of project flow whichever is less	50 - 60
John Day	April 27 – July 20	Test alternating between 2 treatments: To the spill cap or up to 30% of project outflow whichever is less VS. to the spill cap or up to 30% of project flow whichever is less [F]	50 - 60
John Day	July 20-August 31	To the spill cap or up to 30% of project flow whichever is less	50 - 60
John Day	April 3-August 31	Minimum spill is 25% of project outflow	50 - 60
The Dalles	April 10 - August 31	To the spill cap or up to 40% of project flow whichever is less	50 - 60
Bonneville	April 10 - June 16	To the spill cap up or to 100 kcfs whichever is less	30 - 40
Bonneville	June 16 – July 20	Test alternating between 2 treatments of: To the spill cap up to 95 kcfs [F] vs. 85 kcfs day/121 kcfs night [D,F]	30 - 40
Bonneville	July 21 – August 31	75 kcfs day/spill cap night [D]	30 - 40
Bonneville	April 10 - August 31	Minimum spill is 50 kcfs	30 - 40

A - Minimum generation requirements at the Lower Snake River projects depend on the status of generation at other projects and the transmission system.
B - No voluntary spill from April 10 to June 14 in years when forecasted seasonal average flows are less than 125 kcfs.
C - Spill cap is defined as the maximum spill amount that will keep the High 12 hr %TDG average within 115% in the forebay or 120% in the tailwater.
D - Daytime and nighttime for Bonneville vary during the spill season and are set in the Fish Passage Plan.
E - No voluntary spill from April 3 to May 31 in years when forecasted seasonal average flows are less than 65 kcfs on the Snake River.
F - Regionally coordinated test operations differ from 2010 Supplemental BiOp RPA Table 2 operations.

3.2 Fish Test Spill Operations:

The spill levels established in the 2012 Fish Operation Plan reflect the proposed fish tests planned for the 2012 spill season. When fish tests are planned, they are included in the Water Management Plan and the Fish Passage Plan. There are two fish tests that will affect 2012 spill operations are:

- **John Day:** *Fish Passage and Survival Evaluation Test* – Test conditions will include spill of either 30% or 40% of project outflow for 24 hours per day. The objectives of the test are to assess passage distribution and efficiency metrics, forebay retention and

tailrace egress times, and dam survival for yearling Chinook, juvenile steelhead, and subyearling Chinook to determine if juvenile dam survival at 30% and/or 40% spill under the current project configuration meets or exceeds the juvenile dam survival performance standard for spring (96%) and summer (93%) migrants specified in the 2010 Supplemental BiOp.

- **Bonneville:** Performance standard testing at 85 kcfs/121 kcfs and 95 kcfs spill 24 hours per day will begin at 0430 hours approximately June 16 and continue through July 20. The objectives of the test are to assess passage distribution and efficiency metrics, forebay retention and tailrace egress times, and dam survival for subyearling Chinook to determine if juvenile dam survival at either 85 kcfs/121 kcfs and/or 95 kcfs 24 hours per day spill under the current project configuration meets the juvenile dam survival performance standard for summer migrants (93%) specified in the 2010 Supplemental BiOp.

3.3 The 115% and 120% Gas Caps:

The Washington rule adjustment establish TDG limits of 115% for next downstream forebay gauges and 120% for tailwater gauges and the Oregon TDG waiver establish TDG limits of 120% for tailwater. These TDG limits are called gas caps. Because of the 2012 rollover of spill operations, the Corps will continue to use the Oregon method of calculating the high 12 hour average and both the forebay and tailwater gauges will be used for spill management. See Section 8 list of websites that provide the high 12 hour average reports.

3.4 Daily Spill Caps:

All of the factors described in this document are embodied in the daily spill caps that are issued in TDG production estimates. There are two types of spill caps: fish passage spill caps and lack of load spill caps. The fish passage spill caps are associated with voluntary spill and are designed to ensure that TDG levels achieve 120% TDG in the tailwater or 115% in the next downstream forebay, whichever is more restrictive. The lack of load spill caps are associated with involuntary spill and are designed to ensure that a desired TDG level of 110% or 115% or 120% etc is achieved in the tailwater only. The historical record of fish passage spill caps are found on the spill cap website listed in Section 8. These historical fish passage spill caps can provide a range of spill rates that are typical for each project, although changes in physical structures and spill operations would affect their usefulness.

3.4 Bonneville Daytime Spill Schedule:

The definition of daytime and nighttime effects how long the spill levels are maintained. At Bonneville, the definition changes frequently throughout the spill season and the definitions are listed in Table 2 taken from Table BON –5 of the Fish Passage Plan, page BON-12

Table 2
Bonneville Daytime Spill Schedule

Date	Daytime Spill	
	Begin	End
Mar 02 – Apr 02	0600	1930
Apr 03 – Apr 20	0500	2030
Apr 21 – May 16	0500	2100
May 17 – May 31	0430	2130
Jun 01 – Jun 30	0430	2130
Jul 01 – Jul 31	0430	2200
Aug 01 – Aug 15	0500	2145
Aug 16 – Aug 31	0500	2030

3.5 Minimum Operating Pool:

The Minimum Operating Pool (MOP) is maintained as required in the Biological Opinion. The MOP operations typically begin on the first day of spill season and ends in September to October for the Lower Snake River projects. In Table 3, MOP forebay elevations are:

Table 3

MOP and MOP + 1		
Project	MOP in ft	MOP + 1 in ft
Lower Granite	733	734
Little Goose	633	634
Lower Monumental	537	538
Ice Harbor	437	438

To accommodate safe navigation in 2012, the Lower Granite pool will be operated up to MOP+2 ft. depending on river flow consistent with operations coordinated in 2011.

3.6 Minimum Spill and Generation during Low Flows:

When the total river discharges are low then low flow conditions exist and minimum generation and minimum spill are issues. The various projects are entitled to a certain amount of flow for power generation at all times if they choose to use it. Table 4 shows the amount of flow (kcfs) associated with the minimum generation requirements. The information in Table 4 is taken from the 2012 FOP. (LWG unit 1 is newly welded and will not appear in the FOP with this range.)

Table 4
Minimum Generation and Minimum Spill

Project	Turbine Units	Minimum Generation Requirements flows kcfs *	Minimum spill in kcfs
Lower Granite	1 (Welded)	16.5 - 19.5	N/A
	2-3	11.3 - 13.1	
	4 - 6	13.5 - 14.5	
Little Goose	1-3	11.3 - 13.1	7.2
	4 - 6	13.5 - 14.5	
Lower Monumental	1 (Welded)	16.5 - 19.5	N/A
	2-3	11.3 - 13.1	
	4 - 6	13.5 - 14.5	
Ice Harbor	1 & 3	8.5 - 10.3	8.4
	2 (Welded)	11.3 - 13.1	
	4 - 6	8.5 - 10.3	
McNary	N/A	50 - 60	N/A
John Day	N/A	50 - 60	N/A
The Dalles	N/A	50 - 60	N/A
Bonneville	N/A	30 - 40	50
*at typical head			

3.7 Chum Redds Emergence:

During low flow years, the Chum Redds emergence presents a limitation on the amount of spill that can occur at Bonneville Dam and the levels of TDG that the redds can endure. The % TDG that redds can endure is influenced by the Bonneville tailwater elevation. The effects of TDG on Chum Redds are estimated to be 3% less for each 1 ft depth. This is considered to be the depth compensation.

Two graphs are used together to determine the amount of spill that can occur with a specific tailwater elevation. Figure 1 is the Bonneville Powerhouse Tailwater rating curve from the Bonneville Water Control Manual and it illustrates the relationship between project outflow to tailwater elevation. Figure 1 is used in conjunction with Figure 2, which is a graph that shows the % TDG to outflow that can be used to establish spill levels. Usually this graph or the data is provided to us, which we use to regulate spill levels.

Figure 1
Bonneville Powerhouse Tailwater
Rating Curve

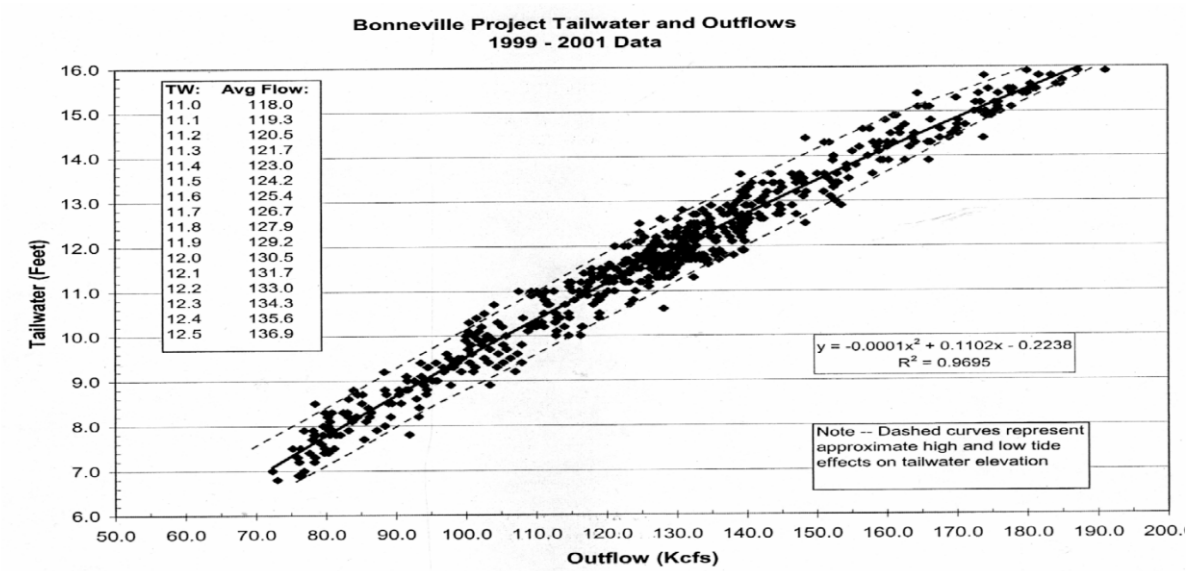
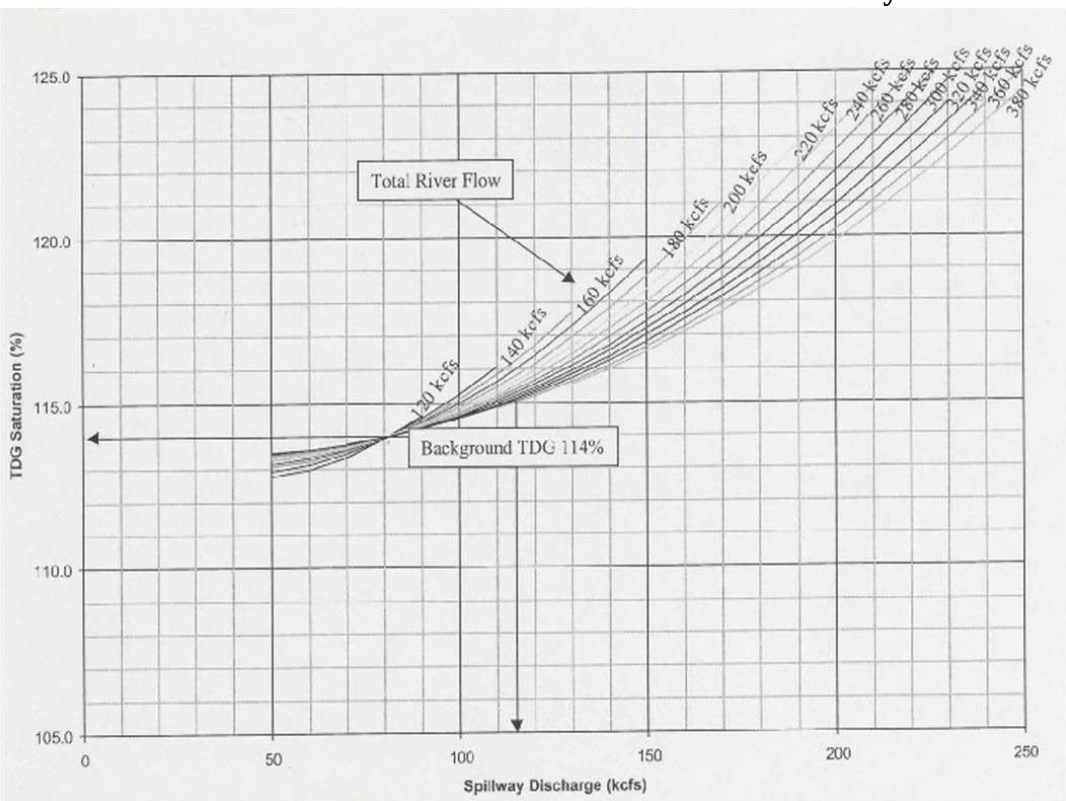


Figure 2
Bonneville TDG Production Curve from DGAS Study



4. Physical Factors that Influence Spill

4.1 Spill Patterns:
Each project has at least one spill patterns but can have as many as three. These spill patterns describe how much water will go through each spillbay. The bulk spill patterns produce higher TDG levels than the uniform spill pattern. These spill patterns are developed through regional modeling teams consisting of NOAA and Corps using the physical models at ERDC. These spill patterns are found in the annual Fish Passage Plan.

These spill patterns can have a significant impact on the spill caps, so if the TDG levels significantly change without a significant change in spill levels, investigate if there was a change in the spill pattern.

4.2 Unique Physical Designs:
There are physical designs and system features that have unique affects on spill decisions and spill caps. The spill patterns at John Day and the bottleneck influence at Camas/Washougal are two examples.

- Lower Monumental Spill Pattern – The spill patterns at Lower Monumental are bulk spill patterns with much of the spill going through bays 6 and 8. The patterns are unusual in that there is an increase in spill through those bays and then backing off. This causes the project to be very sensitive to spill cap changes.

- John Day Spill Pattern – The spill patterns at John Day are such that to spill at low levels (80 kcfs) generate the same amount of TDG as spill at high levels (140 kcfs). Spill at about 108 kcfs generate much higher TDG levels than at 80 or 140 kcfs. This anomaly causes difficulty in regulating spill levels. It is recommended that you avoid spilling between 102 and 115 kcfs, especially at 108 kcfs. Spilling at 130 kcfs generates more TDG than 140 kcfs.

- Bottlenecks in the Rivers: –Many of the projects can be operated at 120% TDG in their tailwater but certain projects cannot because if they did, it would cause the next downstream forebay to exceed 115%. As a result, these projects act as a bottle neck in spill. Lower Monumental and Little Goose are bottle necks in spill. Lower Monumental at 120% TDG in its the tailwater will cause Ice Harbor forebay to exceed 115% and Little Goose at 120% TDG in its the tailwater will cause Lower Monumental forebay to exceed 115%.

- Bonneville's Uniqueness: There are several factors that are unique to Bonneville Dam which play a significant role in producing high number of TDG exceedances at Cascade Island and Camas/Washougal. The factors are:

    1. Flow Deflectors: There are flow deflectors at two different levels; both need 12 feet of head to be fully functional as designed. Flow deflectors on bays 1-3 and 16-18 were built at 7 ft, so at a 19ft tailwater elevation or higher; these flow deflectors are not functioning. Flow deflectors on bays 4 -15 were built at 14 ft, so at a 26ft tailwater elevation or higher, these flow deflectors are not functioning. Since tailwater

elevations during May and June are above 19ft most of the time and above 26 ft some of the time, some or all flow deflectors were not functioning resulting in numerous TDG exceedances.

2. Topography: The topography of the reach below Bonneville Dam is shallow (15 to 20ft) which is much different than other dams where the reach is much great deeper (100ft). This shallow reach characteristic results in more gas being produced and is more sensitive to solar radiation.
3. Stage Elevation: The stage elevation can experience huge changes, between 6 and 30 ft. This is much more than other projects where the elevation change is between 4 and 6ft.

4.3 Physical Limitations:

There are three physical limitations that effects how the fish move or the amount and manner of spill distribution across the channel. These physical limitations are:

- **Screen Lengths**: Because of the screen lengths at Lower Monumental; Little Goose and Lower Granite, it is helpful to fish survival to have a balance of spill amounts between the three projects. Lower Monumental has standard length submersible traveling screens, which are 20 ft long. More fish are able to get under them and end up going through the turbines, resulting in higher fish mortality. Little Goose and Lower Granite has extended length screens, which are about 40 ft long. Less fish are able to get under them

- **Grand Coulee RO vs drumgate Spill**: There are physical limitations to how much water can be spilled through the Grand Coulee outlet tubes. They can release only in increments of about 5 kcfs per tube and it depends on the head. Spilling through the RO produce considerably more TDG than through the drumgates, so it is preferred to spill through the drumgates if it is possible. But drumgate spill occurs only when the forebay elevation reaches 1265.5 ft and higher.

4.4 Turbines Out of Service:

On a weekly or daily basis, there are unit outages that will affect the spill volume at the projects. During 2012 spill season, there will be 33 units out of service for a month or longer: 5 units on the lower Snake River; 14 units on the lower Columbia River and 13 units on the mid-Columbia River. Table 5 shows the turbines on the Columbia or Snake Rivers that will be out of service for month or longer: See Section 8 for website on outages or go to Appendix B of the FOP which provides major unit outages.

Table 5
2012 Planned Long Term Unit Outages

OUTAGES ARE NOT SHARED WITH THE PUBLIC SO THIS TABLE IS NOT INCLUDED.

4.5 Unit Availability Assumption:
During an average spill season, there are many units that are out of service for various reasons. Table 6 provides the percentage of turbine capacity available after adjustment for unit outages, 1% peak efficiency requirement, and system reserve obligations. BPA developed these percentages and the Corps reviewed and approved them so that the federal agencies had representative unit outage percentages. These unit outages percentages are the average of the actual month averages in 1999-2001 by project. BPA's Federal Hydro Resources determined those years to be more representative of the future expectation than any periods since due to increased investments in recent years to accomplish more routine maintenance that will pay dividends in reducing forced outage rates in the future.

Table 6

Unit Availability Assumptions During Spill Season in %

PROJECT	APR 1-15	APR 16-30	MAY	JUN	JUL	AUG 1-15	AUG 16-31
Lower Granite	71	80	80	72	59	56	53
Little Goose	71	77	80	78	71	61	54
Lower Monumental	77	82	78	81	75	65	61
Ice Harbor	83	85	85	81	74	72	62
McNary	68	68	69	69	66	64	65
John Day	85	87	86	89	92	88	87
The Dalles	69	71	73	71	70	69	69
Bonneville	72	76	77	74	66	68	68

4.6 Full Powerhouse Information:
Table 7 provides the turbine capacity available for outside and within the 1% peak efficiency requirement if a project has a full powerhouse available. The Fish Passage Plan proscribes that project turbines are operated within 1% during spill season. Operation outside of 1 % generates more TDG so it is not as fish friendly and is allowed during non-spill season months

Table 7

Full Powerhouse Capacity

Project	Powerhouse capacities outside of 1% (kcfs)	Powerhouse capacities within 1% (kcfs)	One unit capacity (kcfs) - avg	# of Units	Flows that involuntary spill begins	Typical spill cap
Bonneville	288	257	14.3	18	357	100
The Dalles	281	288	13.1	22	408	120
John Day	322	331	20.7	16	491	160
McNary	232	172	12.3	14	312	140
Ice Harbor	106	92	15.3	6	184	92
Lower Monumental	130	115	19.2	6	139	24
Little Goose	130	112	18.7	6	142	30
Lower Granite	130	112	18.7	6	150	38

4.7 Actual Powerhouse Generation Capacity Limitations:

There are limitations on how much water the powerhouse generators can physically handle. The full (maximum) powerhouse generation capacity, with all units in operation, is listed below in Table 8. The percentage unit availability shown in Table 8 is multiplied by maximum powerhouse capacity to give the true actual powerhouse capacity. These capacities are lower than full powerhouse and are used to calculate a realistic volume of involuntary spill. These powerhouse generator capacities are shown in Table 8 for the Columbia and Snake Rivers projects. It is important to note that McNary has the lowest generator capacity of the projects on the Lower Columbia and as a result, it will have involuntary spill during June and/or July when other projects are not.

Table 8

Actual Powerhouse Capacity after Adjustments for Outages (in kcfs)

PROJECT	APR 1-15	APR 16-30	MAY	JUN	JUL	AUG 1-15	AUG 16-31
Lower Granite	92	104	104	94	77	73	69
Little Goose	92	100	104	101	92	79	70
Lower Monumental	100	107	101	105	98	85	79
Ice Harbor	88	90	90	86	78	76	66
McNary	158	158	160	160	153	148	151
John Day	276	283	280	289	299	286	283
The Dalles	259	266	274	266	263	259	259
Bonneville	207	221	222	213	190	196	196

5. Guidance Factors that Influence Spill

5.1 General Rule of Thumb Guidance:

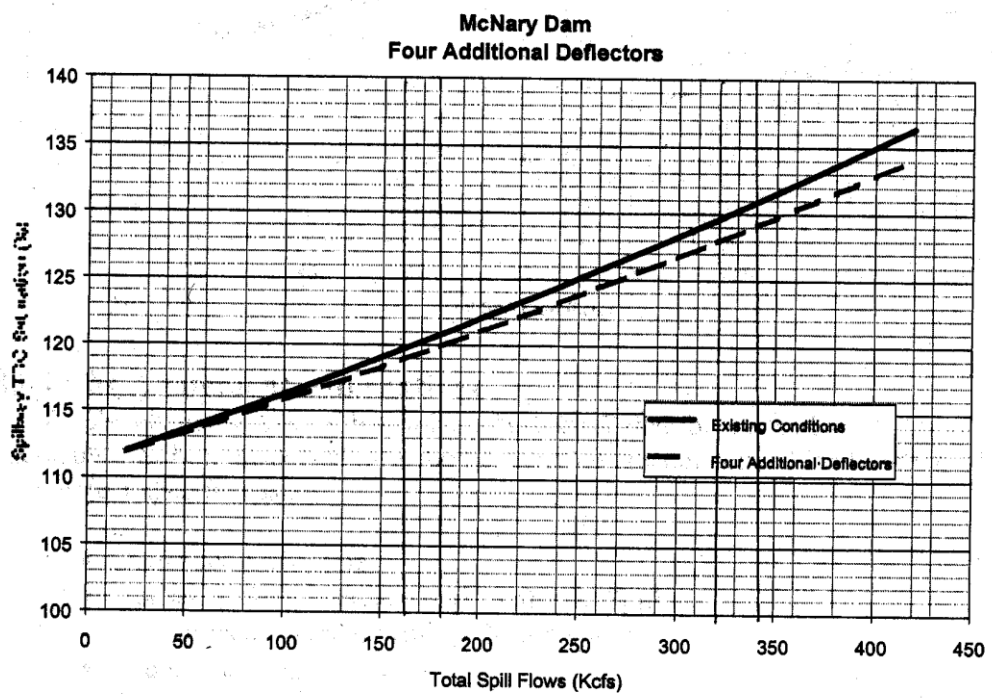
The following basic adjustment guidance is a rule-of-thumb method used in a general way.

- Snake projects – 5 kcfs change in spill results in about 2% change in TDG.
- Columbia projects – 10 kcfs change in spill results in about 2% change in TDG.

- Little Goose tailwater TDG levels need to be at about the same as Lower Monumental forebay because there is no degassing in this reach. There are times when the % TDG in the Lower Monumental forebay can be higher than the Little Goose tailwater.

5.2 DGAS Report Project-by-Project Guidance:
Project TDG Performance Graphs, derived from the DGAS studies, provide the relationship between spill flows and TDG levels at a constant temperature. Figure 3 is an example of one of the graphs that exists for the eight Corps projects on the Lower Columbia and Snake Rivers (use existing conditions).

Figure 3



5.3 Travel Time Guidance:

Knowing the amount of time it takes for water to travel from one project to the next is important in making TDG decisions. Table 9 provides estimated travel times for water to travel from one project to the next on the Columbia and Snake Rivers.

Table 9

COLUMBIA/SNAKE RIVER TRAVEL TIMES							
Days for Water to Travel through Reservoirs							
	VARIABLE RIVER FLOW RANGES						
PROJECT	50K*	75K*	100K*	150K*	200K*	250K*	300K*
From Grand Coulee to Chief Joseph	4.6	3.8	2.9	2.1	1.6	1.3	1
From Chief Joseph to Wells	2.50	2.00	1.50	1.00	0.75	0.54	0.45
From the Confluence of the Snake and Clearwater Rivers to Lower Granite Dam	4.44	2.96	2.22	1.48	1.11	0.89	0.74
River and the beginning of the Lower Granite pool) to Lower Granite Dam	4.72	3.15	2.36	1.57	1.18	0.94	0.79
From Lower Granite to Little Goose	5.35	3.57	2.68	1.78	1.34	1.07	0.89
From Little Goose to Lower Monumental	3.73	2.49	1.86	1.24	0.93	0.75	0.62
From Lower Monumental to Ice Harbor	4.02	2.68	2.01	1.34	1.00	0.80	0.67
From Ice Harbor to McNary	13.05	8.70	6.53	4.35	3.26	2.61	2.18
From Ice Harbor to McNary	13.05	8.70	6.53	4.35	3.26	2.61	2.18
From McNary to John Day	22.86	15.24	11.43	7.62	5.72	4.57	3.81
From John Day to The Dalles	3.11	2.08	1.56	1.04	0.78	0.62	0.52
From The Dalles to Bonneville	7.18	4.79	3.59	2.39	1.80	1.44	1.20
From Bonneville to Camas/Washougal	----	1.3	1	0.8	0.6	0.56	0.49

* These are estimated travel times determined from the theoretical residence time in each pool (volume/discharge). Mike Schneider is the author of these times and they are in agreement with TDG fronts observed with actual data.

In order to know the travel time for water to flow from Dworshak to Lower Granite, it is necessary to calculate it in two parts and add them together. The two parts are the travel time from Dworshak to the confluence of the Snake River and the travel time from the confluence of the Snake River to Lower Granite. Tables 10 and 11 show the information used to get the travel time for the Dworshak to Lower Granite reach.

Table 10

DWORSHAK TO CONFLUENCE RIVER TRAVEL TIMES						
Days for Water to Travel through Reservoirs						
PROJECT	VARIABLE RIVER FLOW RANGES					
	5K*	10K**	20K*	30K**	40K*	50K**
From Dworshak Dam to Confluence of the Snake and Clearwater Rivers	19 hrs	15.6 hrs	12.6 hrs	11.1 hrs	10.2 hrs	9.5 hrs
From Dworshak Dam to Confluence of the Snake and Clearwater Rivers	0.79	0.65	0.53	0.46	0.43	0.40

Note: These are estimated theoretical retention times based on information from Mike Schneider.

Table 11

DWORSHAK TO LOWER GRANITE RIVER TRAVEL TIMES						
Days for Water to Travel through Reservoirs						
PROJECT	VARIABLE RIVER FLOW RANGES					
	50K on Snake & 5K on Clearwater	75K on Snake & 10K on Clearwater	100K on Snake & 20K on Clearwater	150K on Snake & 30K on Clearwater	200K on Snake & 40K on Clearwater	250K on Snake & 50K on Clearwater
From Dworshak Dam to Lower Granite Dam	5.23	3.33	2.53	1.80	1.43	1.20

* These are estimated travel times determined from the theoretical residence time in each pool (volume/discharge). Mike Schneider is the author of these times and they are in agreement with TDG fronts observed with actual data.

5.4 Weekend Flow Guidance:

Total River Flow can significantly decrease on weekends, resulting in an increase in TDG. As a result, the spill caps may need to be decreased slightly on Friday. It is good to check what the flow forecast shows. See Section 8 list of websites.

5.5 Monday Flow Guidance:

Beginning-of-the-Week Total River Flows on Monday increase, causing the TDG level to decrease. As a result, the spill caps may be increased slightly on Monday. It is good to check what the flow forecast shows. See Section 8 list of websites.

5.6 Holiday Flow Guidance:

Total River Flow can significantly decrease on holidays, causing a resulting increase in TDG. As a result, the spill caps are usually decreased on before a holiday. It is good to check what the flow forecast shows. See Section 8 list of websites.

5.7 Wind Degassing Guidance:

- Winds above 10 mph enhance degassing in Columbia Gorge. See Section 8 list of websites.
- At flows **above** 200 kcfs at BON, little degassing occurs between BON and Camas.
- At flows **below** 200 kcfs at BON, significant degassing occurs between BON and Camas.

5.8 Flow Deflectors Degassing Guidance:

As a general principle, the project's flow deflectors' ability to degassing is dependent on how high the TDG levels are in the projects forebay. The higher the forebay TDG levels are, the more TDG that the flow deflectors can remove. The Chief Joseph and Lower Monumental dams are the two projects that can have high forebay TDG levels and degassing rates.

Chief Joseph Dam – The CHJ flow deflectors are especially effective removing TDG during specific circumstance which includes: 1)GCL is spilling through the ROs so TDG levels in the CHJ forebay reach 125% to 140%, 2) total river flow exceed 175 kcfs and 3)the tailwater elevation is 786 ft or greater. Under these conditions, CHJ flow deflectors can reduce TDG levels up to 22% which is every high compared to the lower Columbia and Snake River projects. This understanding is based on the 2011 spill season and it is still being studied.

Lower Monumental – Lower Monumental forebay TDG levels can reach up to 131% and when this occurs, the flow deflectors can remove up to 15%.

Other Lower Columbia and Snake River Projects – Typically, the forebay TDG levels at the lower Columbia and Snake river projects don't get high enough to have sustained degassing occur. Based on a review of the data, the forebay TDG levels must be high, at least 122% to 127% for the flow deflectors to remove TDG. We have seen the JDA and IHR flow deflectors remove 1 to 5% TDG during high forebay TDG conditions.

5.9 Water Temperature Guidance:

Climatic conditions can cause increases in water temperatures, which in turn can cause increases in TDG levels. Using Boyle's gas law, a rule of thumb was developed that 1°C or 1.8^{o}F water temperature change can result in a 2 to 3 % change in TDG saturation. Since we do not have tools at this time to predict water temperature, we use air temperature as found in weather forecast, as a surrogate. See Section 8 list of websites, the National Weather Service, the Northwest River Forecast Center website and the real-time and historical water temperatures at the projects external websites.

5.10 Grand Coulee Spill Caps Guidance:

Grand Coulee can spill through outlet tubes or drumgates and the elevation determines which one is used. When the elevation is at 1266.0 ft or higher, then the drumgates are used which generates less TDG than the outlet tubes. The out let tubes are used when the elevation is less than 1266.5 ft. Table 12 provides the general relationship between spill and TDG.

TABLE 12
USBR's Proposed Grand Coulee spill Caps (kcfs) with flashboards in place
(Estimated using recommended spill caps, forebay elevation and max spill physical constraints)

		outlet tubes only _ lots of TDG produced				
		drumgates only				
			TDG%			
FB Elevation (ft)	**110**	**115**	**120**	**125**	**130**	**135**
< =1260.0	0	5	10	20	35	50
1265.0	0	5	10	20	35	50
1265.5	0	5	10	20	35	50
1266.0	0	5	10	20	35	50
1266.5	0	10	10	20	35	50
1267.0	0	15	15	20	35	50
1267.5	0	15	20	20	35	50
1268.0	0	15	25	25	35	50
1269.0	0	15	30	35	35	50
1270.0	0	15	30	45	45	50
1271.0	0	15	30	65	65	65
1272.0	0	15	30	75	85	85
1273.0	0	15	30	75	105	105
1274.0	0	15	30	75	120	120
1275.0	0	15	30	75	120	120
1280.0	0	15	30	75	120	130
1290.0	0	15	30	75	120	130

In 2009, the US Bureau of Reclamation approved this table of proposed spill caps. It is included in this document to provide the USBR's perspective. Actual spill caps are adjusted daily based on real time data and may be different than USBR's recommended spill caps.

6. Model Forecasting that Influence Spill

6.1 10 Day Flow Forecast:

The NWD RCC reservoir regulators generate a 10 day flow forecast for the Columbia and Snake Rivers. See Section 8 list of websites.

6.2 SYSTDG Model:

The Corps uses the SYSTDG model to run daily simulations forecasting the TDG levels. It is used as a real time operations tool forecasting and hind casting to see what the TDG levels will be or would have been if conditions for a day in the past were entered.

7. Tracking Spill Rates

7.1 Weekly Project Plots:
The Corps has developed a set of programs that summarize spill data, which are used in spill level change decisions. The Corps Project Plots program tracks of the amount of voluntary spill required according to the FOP spill operations for fish and how much spill actually happened. These project plots are included in the court report

7.2 Spill Variance Tracking
The Corps is required to track and document when there is an hourly variance from the court order spill rates, which are called spill variances. The definition of what a spill variance is can be found in the document called Redefining Variances_Apr09-final.doc stored at V:\Water_Quality\Litigation_Spill Season Reports\Process for Court Report development.

The Corps is required to track and classify the spill variances that occur during the fish passage spill season and include the spill variance tracking information in the monthly court reports. The Corps and BPA worked together to establish a system for classifying spill variances that includes types of spill variances; internal sub-category of types and approved language for the "reason". The Types are classified as.

1. Operational limitations
2. Maintenance
3. Research Related
4. Transmission Stability
5. Navigation
6. Human/Program Error

The guidance document for classifying spill variances is called the Variance Classification_Type_reason-Sept 2011 which can be found at V:\Water_Quality\Litigation_Spill Season Reports\Process for Court Report development.

7.3 Instance Tracking:
When TDG levels exceeded the state water quality standards it is considered an "instance". The Corps tracks the date, number, reason and actions taken for the days for instances. The classifications of the instance types are listed in Table 13 and are documented in the annual TDG and Temperature report. There is a spreadsheet called (The current year) Instance Types found in the current year's spill season information folder that summarize this information. The instance tracking summary is discussed at the TMT meetings.

Table 13
Types of Instances

Type 1 Condition	**TDG levels exceed the TDG standard due to exceeding powerhouse capacity at run-of-river projects resulting in spill above the BiOp fish spill levels. This condition type includes:**
• High runoff flows and flood control efforts.	
• BPA load requirements are lower than actual powerhouse capacity.	
• Involuntary spill at Mid Columbia River dams resulting in high TDG levels entering the lower Columbia River.	
• Involuntary spill at Snake River dams resulting in high TDG levels entering the lower Columbia River.	
Type 1a Condition	**Planned and unplanned outages of hydro power equipment including generation unit, intertie line, or powerhouse outages.**
Type 2 Exceedance	**TDG exceedances due to the operation or mechanical failure of non-generating equipment. This exceedance type includes:**
• Flow deflectors unable to function for TDG abatement with tailwater elevations above 19 - 26 feet at Bonneville Dam.	
• Spill gates stuck in open position or inadvertently left open.	
• Increased spill in a bulk spill operation to pass debris.	
• Communication errors, such as teletype were transmitted but change was not timely made or misinterpretation of intent of teletype by Project operator.	
Type 2a Exceedance	**Malfunctioning FMS gauge, resulting in fewer TDG or temperature measurements when setting TDG spill caps.**
Type 3 Exceedance	**TDG exceedances due to uncertainties when using best professional judgment, SYSTDG model and forecasts. This exceedance type includes:**
• Uncertainties when using best professional judgment to apply the spill guidance criteria, e.g., travel time, degassing, and spill patterns.	
• Uncertainties when using the SYSTDG model to predict the effects of various hydro system operations, temperature, degassing, and travel time.	
• Uncertainties when using forecasts for flows, temperature and wind.	
• Unanticipated sharp rise in water temperature (a 1.5 degree F. or greater change in a day).	
• Bulk spill pattern being used which generated more TDG than expected.	

8. Web Reports Used in Spill Review

The following web reports are used to look at the various different aspects of spill review:

1. High 12-Hour Average TDG: Oregon waiver sets TDG standards based on the average of the 12 highest TDG levels measured in a given calendar day. Calculated High 12-Hour Averages for TDG are posted on the web at: http://www.nwd-wc.usace.army.mil/ftppub/water_quality/12hr/or/

2. High Consecutive 12 hour TDG Average: Washington waiver sets TDG standards based on the average of the 12 highest consecutive TDG levels in a 12 hour period. Calculated High 12-Hour Averages for TDG are posted on the web at: http://www.nwd-wc.usace.army.mil/ftppub/water_quality/12hr/wa/ .

3. Combined Oregon and Washington methods for High 12 Hour Average: A web report that combines both the Oregon and Washington method for calculating the high 12 hour average can be found at http://www.nwd-wc.usace.army.mil/ftppub/water_quality/12hr/

4. Flow Forecast: The 10 day flow forecast for the Columbia and Snake Rivers can be found on an internal server location https://npr71.nwd-wc.usace.army.mil/rccweb/RFS/. The mcol.out.txt is the forecast on the middle Columbia River and the lsnake.out.text is the forecast on the lower Snake River. In these documents, you will see QIQF, which stands for discharge, inflow forecast. QRQF stands for river discharge forecast. HFQF is forebay elevation forecast. To know the meaning of the different abbreviations, see CBT user's manual on https://npr71.nwd-wc.usace.army.mil/

5. Comprehensive Project Data Reports: The comprehensive project data reports summarizes project data for **13 projects** and they can be found at http://www.nwd-wc.usace.army.mil/tmt/wq/historical/

6. Detailed Project Data Reports: The detailed project data reports that summarize TDG and project data for 53 TDG gauges and all projects on the lower Columbia and Snake River. This reports are TDG gauge focused instead of project focus as the comprehensive project data reports are.These reports can be found at https://npr71.nwd-wc.usace.army.mil/rccweb/rccgas/tdg/ .

7. List of Daily Spill Caps: An annual summary of the spill caps for all the projects can be found at https://npr71.nwd-wc.usace.army.mil/rccweb/rccgas/spill/caps/

8. Percent Spill: There is a program that calculates the percent of total river flow that is spilled at Little Goose; Ice Harbor; McNary; John Day and The Dalles. The results of this calculation can be found on the percent spill report shown on: http://www.nwdwc.usace.army.mil/tmt/documents/ops/spill/

9. Tributary Data Reports: These are 3 reports that shows the flow and water temperature for the tributaries that flow into the Lower Snake and Columbia Rivers that go back three days. The Tributary Data reports with 25 tributary gauges can be found at: http://www.nwd-wc.usace.army.mil/tmt/documents/ops/tribs/. This data was added to the SYSTDG model so the tributary influences to TDG levels on the Lower Snake and Columbia Rivers will be considered.

10. Hood River Wind Data: http://www.wunderground.com/US/OR/Hood_River/KDLS.html
To get wind data, go to Personal Weather Station: Hood River (near bottom of the webpage)

11. Forecasted Air Temperatures: The National Weather Service, the Northwest River Forecast Center posts information daily on the forecasted temperatures, which are available at http://137.161.65.209/weather/10_day.cgi.

12. Real-time and historical water temperatures: Real-time and historical water temperatures at the projects can be found at the external website: http://www.nwd-wc.usace.army.mil/tmt/documents/ops/temp/ and the temperature string for Dworshak can be found at the internal location: http://www.nwd-wc.usace.army.mil//tmt/documents/ops/temp/carroll/DWR_S1_2005_12.html

13. Turbines Out of Service: The unit outages that will affect the spill volume at the projects are posted at https://npr71.nwd-wc.usace.army.mil/rccweb/RCCLIST/ , under BPA Unit Outages.

14. % TDG Court Reports Plots: These are plots that show the high 12 hour average % TDG for each gauge and they are included in the monthly court reports. https://npr71.nwd-wc.usace.army.mil/rccweb/rccgas/graphs/tdg/

15. Maximum Hourly Report of 110 % TDG: This report provides the highest hourly % TDG for the gauges that are regulated to 110%. https://npr71.nwd-wc.usace.army.mil/rccweb/rccgas/max_tdg/110/

16. Maximum Hourly Report of 115/120 % TDG: This report provides the highest hourly % TDG for the gauges that are regulated to 115/120%. https://npr71.nwd-wc.usace.army.mil/rccweb/rccgas/12hr/2011/

17. Maximum Hourly Report of 125 % TDG: This report provides the highest hourly % TDG for the gauges that are regulated to 125%. https://npr71.nwd-wc.usace.army.mil/rccweb/rccgas/max_tdg/125/

18. 14 Days Back Unit Generation and Spillbay Reports: This GDAC report provides detailed information back for 14 days about how many MW each turbine is generation and how much water is passing through the individual spillbays. https://npr71.nwd-wc.usace.army.mil/wq/bays/

19. Monthly Spillbay Reports: This GDAC report provides detailed information about how much water is passing through the individual spillbays. https://npr71.nwd-wc.usace.army.mil/rccweb/rccgas/spillbays/

20. Data Correction Plots: Since the water quality data must be included in the court report plots, it is important that the data is corrected. These plots are used to correct the data https://npr71.nwd-wc.usace.army.mil/rccweb/rccgas/graphs/

21. Water Temperature String Reports by Project: There are water temperature strings installed at the NWW projects since 2004 and the data is shown on https://npr71.nwd-wc.usace.army.mil/rccweb/rccgas/tempstrings/by_project.html

22. Water Temperature String Reports by Date: There are water temperature strings installed at the NWW and NWP projects since 2004 and the data is shown on https://npr71.nwd-wc.usace.army.mil/rccweb/rccgas/tempstrings/by_date.html

23. Water Temperature String Reports by Basin: There are water temperature strings installed at the NWW and NWS projects since 2004 and the data is shown on https://npr71.nwd-wc.usace.army.mil/rccweb/rccgas/temp/daily_by_basin.html

24. Water Temperature String Reports by Basin: There are water temperature strings installed at the NWW and NWS projects since 2004 and the data is shown on https://npr71.nwd-wc.usace.army.mil/rccweb/rccgas/temp/daily_by_date.html