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Sent: Wednesday, March 05, 2008 1:25 PM
To: Kolosseus, Andrew (ECY); LUT Agnes
Cc: Hamilton, Laura J NWD; Piccininni,John P - KEWR-4
Subject: AMT: Corps technical review of FPC spill volume analysis.
Attachments: FPC_COE spill vol analysis_no forebaygages_final.pdf

<<FPC_COE spill vol analysis_no forebaygages_final.doc>>

Andrew and Agnes:

As requested, the Corps' technical comments on the FPC spill volume analysis are attached.

Contact me if you have questions.

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March 4, 2008

Comments on the Fish Passage Center's (FPC) February 6, 2008 memo
US Army Corps of Engineers, Northwestern Division

The following are the Corps comments on the Fish Passage Center's (FPC) February 6, 2008 memo.

Methodology to Evaluate TDG Standard Change Impacts: The FPC's February 6, 2008 Spill Volume Analysis does not sufficiently describe the methodology used to calculate the additional spill that would occur if the 115% forebay TDG standards are removed. However, at the Adaptive Management Team (AMT) meeting on December 13, 2007, the FPC described the methodology utilized as an excel spreadsheet with the Corps flow and spill data. A regression equation was developed from the historical high 12 hour average TDG data to estimate the TDG production at each project and to establish spill caps. The spill caps and regimes were applied to the data to calculate the spill volumes for each scenario. It would be useful for FPC to describe their methodology, data source and assumptions so others could understand the spill volume calculations.

Since the FPC's methodology was able to get within 16 % of the Corps SYSTDG model results for the 2007 120% limited scenario, it was effective in a limited way because the TDG levels were indirectly considered during spill cap changes. Because a spill regime change is a much larger change and it can produce wide variations in TDG production, fate, and transport, the use of an excel spreadsheet to calculate the spill volumes has limitations for several reasons.

- The use of a regression equation based on the historical high 12 hour average TDG levels enters a significant percentage of error when the spill regime and spill pattern changes significantly since the regression equation is based on TDG data generated by that spill regime and that spill pattern. Spill caps generated with these regression equations are unreliable.
- The use of a regression equation based on the historical high 12 hour average TDG levels enters a significant percentage of error because it is based on the selection of the high 12 hour averages and omitting the hourly TDG levels.
- The excel spreadsheet does not calculate the amount of TDG that would be generated if a specific spill regime and spill cap changes occurred.
- The excel spreadsheet does not assess the effects of TDG levels from one project to the next. As it is well known, TDG levels generated at one project raises the TDG levels in the forebay of the next project, which affects the tailwater TDG levels.
- The excel spreadsheet is not able to take into consideration the various factors that effect TDG production.

Since the Corps' SYSTDG model was designed with regression equations based on many water quality research studies with multiple transect gages, it more accurately represents TDG production with the various spill regime and spill cap changes. It is also designed to take into consideration the various factors that effect TDG production such as wind, climate (weather conditions), water temperature, pool elevations, travel time for TDG levels to arrive at next project, spill patterns, unique physical features of specific projects and the physical limitations of specific projects.

The inaccuracy of this methodology can be seen best with the 120% (unlimited) scenario where spill regimes are changed and the 115% TDG standard removed. The FPC calculated that

additional spill range from 41 to 58 MAF while still in compliance with the 120% TDG standards (see Table 3, page 7). This calculation is unreliable. Based on SYSTDG modeling, the maximum range for additional spill varies from 23.4 to 34.8 MAF depending on the water year. For a high water year like 2006, 34.8 MAF is the maximum amount of additional spill that could occur if actions were taken so that all limitations except the 120% TDG standard were removed. Under the same scenario, except for a low water year like 2007, 23.4 MAF is the maximum amount of additional spill that could occur (see Table 3).

The Location of Largest Spill changes: Fish Passage Center's (FPC) February 6, 2008 memo states, "The analysis suggested that the volume of spill that was limited by the 115% TDG forebay management could be significant with the largest changes expected at Little Goose, Lower Monumental and the Lower Columbia projects." The Corps' SYSTDG modeling simulation of the 2007 spill season yields different results than the FPC's spill analysis. The largest spill volume changes, if the 115% TDG standard was removed, would occur at three projects: Using SYSTDG, Lower Monumental resulting in an additional 2.2 MAF, John Day resulting in an additional 1.4 MAF and Bonneville dam resulting in an additional 1.3 MAF. The increased spill at these three projects total 4.9 MAF with the remaining five projects providing a total of 0.25 MAF additional spill. These model results match what we see in real time operations: Lower Monumental tailwater with Ice Harbor forebay is river reach where the 115% forebay requirement primarily restricts spill on the Snake River, so it should be expected to see the largest spill volume increase if the 115% TDG standard is removed which is what the SYSTDG model shows. McNary dam low powerhouse capacity restricts spill on the Columbia River with more involuntary spill than any other project. Because 2007 was a lower than average water year (89% of normal at The Dalles), with very little involuntary spill, McNary's characteristic low powerhouse capacity for the Columbia River didn't have an effect in the 2007 SYSTDG model simulations.

Assumptions: The FPC made several assumptions which significantly affect their spill volume calculations and the extent to which the Corps' SYSTDG model results of the 2007 spill season and FPC's 2007 spill volume analysis can be compared. The Corps considers the following assumptions to be unrealistic and therefore unreliable. The assumptions and the Corps perspective on them are:

- **The Spill Regime was not considered**: The FPC's analysis states, "The volume of spill provided at each project was estimated as if spill were managed to the 120% spill cap whenever possible, but <u>was not limited to planned operations</u> if the planned spill volume was less than the 120% volume." To take the liberties of changing the regionally agreed upon spill regime, and use an excel spreadsheet to assess the additional spill that would occur without knowing the TDG levels that would be produced, could result in the extremely large spill volume (41 - 58 MAF) changes that the FPC suggest would happen in the 120% unlimited scenario. This skewed the spill volume increases as a whole, especially at Lower Monumental where the spill regime called for spilling up to the spill cap of 27 kcfs.

- **Unit Outages:** No where in the FPC's analysis do they mention what units are out of service so there is an assumption that projects have full powerhouse capacity, which is erroneous. There are many units out of service for repair or maintenance each spill season

system-wide. For example, in 2007, there were 23 units out of service for weeks to months system-wide, which is slightly higher than average. In 2006, there were 19 units out of service for weeks or months system-wide, which is about average. Use of this assumption will result in significant underestimation of spill quantities, especially in high volume flow years where substantial involuntary spill occurs.

- **Removal of Involuntary Spill**: The FPC's analysis states, "In the base case any involuntary spill was removed from the hourly spill volume. Involuntary spill was considered to be any volume of spill over the planned spill operation for that project and year." Then two sentences later, it states, "If the planned operation called for 12 hours of spill but the project spilled in excess of 12 hours, these additional hours of spill were not removed, unless the spill volume was over the 120% spill cap." This is a contradiction and makes the base case not truly a base case. Because involuntary spill occurs frequently because of unit outages and high flows, assuming all units are operating would exaggerate the effects of these two assumptions and affect the FPC's analysis of how much spill would be gained by the removal of the 115% TDG standard.

Difference in Spill Caps: In general, the spill caps that the FPC used for the 2007 base case (115% and 120% TDG standards applying) excel calculations were higher that the 2007 spill caps that the Corps used in the SYSTDG model simulation. This would result in higher spill volumes for the FPC's base case. In general, the spill caps that the FPC used for the 2007 only 120% TDG standard applying scenario were lower than the spill caps the Corps used in the 2007 SYSTDG model simulation. The difference in spill caps would result in a significant difference in the amount of estimated additional spill volume that would result from the removal of the 115% TDG standard. Table 1 provides spill cap comparison between the FPC and Corps spill caps.

TABLE 1
2007 Spill Cap Comparison
Between The FPC and COE

	Fish Passage Center Excel Calculations	COE SYSTDG model results	Difference (KAF)
	115% & 120% TDG standards applying (KAF)	115% & 120% TDG standards applying (KAF)	
Lower Granite	5,263	5,266	-3
Little Goose	4,017	4,153	-136
Lower Monumental	5,446	5,458	-11
Ice Harbor	7,904	7,950	-46
McNary	25,897	26,017	-119
John Day	15,273	15,342	-69
The Dalles	21,890	22,010	-120
Bonneville	25,798	26,990	-1,192

Difference in Spill Volumes: Table 2 is a comparison of the spill volumes for 2007 for two of the three scenarios that the FPC calculated and the Corps SYSTDG modeling of 2007. As Table 2 shows, there was a difference of about 1 MAF for these two scenarios. Since the individual project

spill volumes were not provided with each scenario, it is not possible to identify the difference between the Corps and FPC's spill volumes.

TABLE 2

2007 Additional Spill Volume Comparisons				
	115% & 120% TDG standards applying in (MAF)	Only 120% TDG standards applying (in MAF)	Only 120% TDG standards applying with maximum spill regime changes (in MAF)	Difference in MAF
Fish Passage Center Excel Calculations	1.45	5.98	58.07	4.53
Corps SYSTDG model results	0	5.15	5.33	5.15

Spill Volumes in SYSTDG Model Simulations: Although the third scenario discussed in the FPC's spill volume analysis was not modeled, the Corps has extensive SYSTDG model simulations that are useful in understanding the magnitude of spill volume change that may occur, providing the book ends. Since the FPC used 2003, 2005, 2006 and 2007 water years, it is best to compare the lowest water year (2007 which was 89% of normal at The Dalles) and the highest water year (2006 which was 131% of normal at The Dalles). Since the Corps performed SYSTDG modeling for these two years, a summary of the SYSTDG modeling results are provided in Table 3. Based on this information, the Corps considers FPC's calculations of 52 to 58.8 MAF additional spill in the 120% spill scenario as unrealistic and unreliable. A close review of Table 3 shows several important SYSTDG modeling results and conclusions:

- If the spill regimes at all eight Corps projects were changed to a minimum generation regime so that the maximum amount of spill possible could occur during a high water year, there would be an increase of approximately 29.6 MAF. If the 115% TDG standard was also removed then there would be an additional 5.2 MAF spill, making the total additional spill to be 34.8 MAF.
- If the 115% TDG standards were removed during a HIGH water year but the regionally agreed upon spill regimes were intact, there would be 6.0 MAF additional spill occurring compared to the usual spill volume associated with spilling to 115%/120% with the regionally agreed up spill regime.
- If the 115% TDG standards were removed during a LOW water year but the regionally agreed upon spill regimes were intact, there would be 5.2 MAF additional spill occurring compared to the usual spill volume associated with spilling to 115%/120% with the regionally agreed up spill regime.
- The kind of water year (low vs. high) makes approximately 11.4 MAF difference in the additional spill volume that would occur.
- The maximum amount of spill volume that can occur is an additional 34.8 MAF, which is due to change in the spill regime to minimum generation, removal of the 115% TDG standard and have a high water year instead of a low water year.

In conclusion, the Corps believes that SYSTDG accurately calculates the spill volumes that would result from any changes to the hydrosystem, because of the way it was designed. The use of

SYSTDG becomes especially important when the changes to the hydrosystem are significant enough that the FPC regression equations are no longer applicable. This can be seen in the 120% unlimited scenario where the FPC calculates an additional 41 to 58 MAF when SYSTDG modeling shows the maximum additional spill could vary from 23.4 to 34.8 MAF.

TABLE 3

Summary of Corps SYSTDG Model Simulations		
Scenarios	**Cause of Spill Volume Increase**	**Spill Volume in MAF**
Spilling to 2006 FPIP spill regime within 115% and 120% with 2006 forecasted flows		124.6
Spilling to 2006 FPIP spill regime within only 120% TDG standards with 2006 forecasted flows		130.6
	Increase in spill volume due to removal of the 115% TDG standard during a high water year (131% of normal)	6.0
Spilling to Minimum Generation spill regime with in 115% and 120% TDG standards with 2006 forecasted flows		154.8
Spilling to Minimum Generation spill regime within only 120% TDG standards with 2006 forecasted flows		189.6
	Increase in spill due to removal of all spill regimes and 115% TDG standard during a high water year	34.8
Spilling to 2007 FOP spill regime within 115% and 120% with 2007 actual flows		113.2
Spilling to 2007 FOP spill regime within only 120% TDG standards with 2007 actual flows		118.4
	Increase in spill volume due to removal of the 115% TDG standard during a low water year (89% of normal)	5.2
Spilling to 2006 FPIP spill regime within 115% and 120% with 2006 forecasted flows		124.6
Spilling to 2007 FOP spill regime within 115% and 120% with 2007 actual flows		113.2
	Increase in spill volume due to difference in water year	11.4
Maximum spill volume change possible	Increase in spill volume due to removal of spill regimes = 28.8 115% TDG standard = 6.0	34.8