Joint Technical Staff Memorandum

USFWS, NOAA Fisheries, ODFW, WDFW, IDFG, CRITFC

March 11, 2004

Mr. Jim Adams
Water Quality Section
Water Management Division
Northwestern Division, U.S. Army Corps of Engineers
PO Box 2870
Portland, OR 97208-2870

Dear Mr. Adams,

The use of the Camas/Washougal fixed monitoring station (FMS) station for management of voluntary spill at Bonneville Dam has long been a subject of concern. The Camas/Washougal station, the only station specifically mentioned in the 2000 Biological Opinion Reasonable and Prudent Alternatives language, has been problematic since its installation. The Corps of Engineers (COE) investigated several factors influencing measurements of total dissolved gas (TDG) at Camas/Washougal, which resulted in a set of recommendations to the Water Quality Team (WQT) in October 2001. The Corps noted a high degree of temporal variability in TDG saturation at the Camas/Washougal FMS. The variation was attributed to changes in water temperature, dissolved oxygen caused by metabolism, barometric pressure, and wind generated TDG exchange. Attempts to address these issues included investigating the performance of other nearby sites, i.e. Corbett. However, the Corps reported that Corbett and other nearby candidate sites were similarly affected by environmental factors. Therefore, in 2001 the Corps suggested that a spillway channel site would be a better or more consistent location in meeting the requirement of a tailwater TDG FMS than trying to manage spill using TDG measured at Camas/Washougal.

Recent Corps TDG studies (2002) of Bonneville tailrace near-field TDG effects and 2003 data from the Bonneville tailrace monitor (BON TWP1) support the use of the tailrace monitor as a voluntary spill management FMS station. The relation between spill and the tailrace monitor data was strong, $R^2 = 0.91$ in 2002 and 0.79 in 2003. However, for Camas/Washougal the relationship was weaker, $R^2 = 0.53$ in 2002 and 0.35 in 2003. Based on these results as well as increased understandings of the environmental factors effects, e.g., wind, temperature, etc, on TDG in the 25 mile distance between Bonneville and Camas/Washougal, the fisheries managers recommend using the Bonneville tailrace monitor to manage TDG in lieu of the Camas/Washougal site.

A factor that must be considered in relocation of FMS stations is the potential for impact on commitments related to state water quality standards. In the case of Bonneville Dam the Camas/Washougal FMS station is specified as a point of compliance in the existing long-term waiver from the Oregon Department of Environmental Quality (ODEQ). However, the WQT member from ODEQ, now serving as Co-Chair of the WQT, indicated a willingness by the state to consider modification to the waiver. Therefore, the relocation of the monitoring station to the tailrace waters will not be an issue contrary to the state's waiver.

Additionally, the relocation of the Warrendale FMS station to the BON TWP1 site in the tailrace is consistent with the implementation plan of the Lower Columbia River TDG total maximum daily load (TMDL) written by ODEQ and approved by the Environmental Protection Agency (EPA). The monitoring plan in the Implementation Plan of the TMDL calls for near-field studies and compliance monitoring at the end of the aerated zone below each dam. This language appears in the Phase II of the TMDL implementation Plan with a target date of 2011. It seems reasonable to suggest that if the Corps were to propose the retirement of a downstream monitoring station known to cause monitoring problems in favor of a tested tailrace monitor that is consistent with Phase II of the TMDL the ODEQ could find it acceptable.

The fisheries managers believe there is no compelling reason to retain Camas/Washougal as a TDG monitoring station. On the other hand, there are several reasons to begin managing Bonneville spill according to TDG monitoring at BON TWP1 and eliminate the station at Camas/Washougal. These include:

- An increased knowledge of the migration characteristics of fish traveling to the estuary below Bonneville Dam.
- The effects of total dissolved gas on resident species.
- The Corps findings on the influences of environmental factors (wind, water temperature, barometric pressure, and metabolism) on dissolved gas between Bonneville and Camas/Washougal.
- The strong correlation between Bonneville spill and measured TDG shown in the 2002 and 2003 data from the Bonneville tailrace monitor, BON TWP1.
- The significant increase in timeliness of spill management offered by measurements made at BON TWP1 over Camas/Washougal.
- The relatively poor relation between Bonneville spill and measured TDG at Camas/Washougal from 1995-2003 during most average or below average water years.
- The possibility of the ODEQ accepting elimination of a required FMS station at Camas/Washougal in favor of a tailwater station as called for in the TMDL. In addition, Washington Department of Ecology has already removed the Camas/Washougal station as a requirement from the state rule.

In summary, the state, federal and tribal fishery manager's request that the COE communicate with ODEQ requesting a change to the monitoring location for managing gas at Bonneville Dam to the tailrace monitor. The complete rationale and recommendations for requesting that modification are attached to this letter. We request that the COE provide the

Salmon Managers with a response to our request and we ask that you communicate with the ODEQ in a timely manner, in order to implement this change in monitoring locations for the upcoming 2004 waiver period. Thank you for your cooperation in this matter.

Sincerely,

David A. Wills

David Wills, USFWS

Paul Wagner

Paul Wagner, NOAA Fisheries

Raymond R. Boyce

Ron Boyce, ODFW

Cindy Le Fleur

Cindy LeFleur, WDFW

Russell B. Kiefer

Russ Kiefer, IDFG

Thomas K.

Tom Lorz, CRITFC

Technical Rationale for Elimination of Camas/Washougal TDG Monitoring Site

A. The History of the 115/120 Standard and the Monitoring Site Location

In 1994 the Oregon Department of Environmental Quality (ODEQ) and the Washington Department of Ecology (DOE) granted variances from the 110% TDG standard for the first time. The waiver allowed TDG to reach 120%, which was defined as the 12 highest hourly readings measured at monitoring sites about a mile downstream of the dam locations. The maximum instantaneous allowable TDG specified was 125%. At Bonneville Dam the location designated was at Hamilton Island approximately 1.5 miles downstream of the dam. The monitoring locations were not permanent monitoring sites, and data was collected using a manually deployed probe that took readings from 2-4 times in a 24- hour period.

In March of 1995, the National Marine Fisheries Service reissued its 1994-1998 Biological Opinion (BIOP), which included several directives relative to the concentrations and monitoring of total dissolved gas levels that were different from the 1994 program. This BIOP originally developed the 115/120 % standards for monitoring that continue to be implemented today. The BIOP states that "until it can be determined how tailrace monitoring stations relate to the river reaches between monitoring sites and how TDG data collected at these sites relate to fish experience, forebay monitoring data will be used for in-season management"… "Spill will be reduced as necessary when the 12 hour average TDG concentration exceeds 115% of saturation (or as limited by state water quality standard modifications) at the forebay monitor of any Snake or lower Columbia river dam or at the Camas/Washougal station below Bonneville Dam or another suitable location to measure accurately chronic exposure levels. Spill will also be reduced when 12 hour average TDG level exceeds 120% of saturation (or as limited by state water quality modifications) at the tailrace monitor at any Snake or lower Columbia river dams."

It was in this document that the Camas/Washougal site was established to represent a downstream forebay location below Bonneville Dam. The prioritization of the forebay for the measurement was to measure TDG in mixed waters and to prevent the long-term exposure of migrants to TDG levels that exceeded 115%. NMFS (NOAA Fisheries) expresses most concern for migrating juvenile salmonids that are delayed in forebay locations for several hours to days at elevated gas levels. The use of a 12-hour average, rather than a 24-hour average, was chosen to provide a conservative measure of total dissolved gas.

Since 1995 the annual monitoring of TDG has been according to the guidelines established in the 1994-1998 Biological Opinion. However the use of the Camas/Washougal station has been problematic since the beginning of this program. The 2000 Biological Opinion called for a complete review of monitoring sites (Reasonable and Prudent Alternative (RPA) 132) including Camas/Washougal. The site was evaluated and problems were identified in terms of other environmental factors affecting the TDG reading.

The Camas/Washougal site was initially implemented based on mimicking a downstream forebay site. This was because NMFS expressed concern about juvenile salmonids being delayed in forebay areas and being exposed to higher levels of TDG for a prolonged period of time. At the time of the 1995 Biological Opinion limited information was available regarding the migration speed through the lower Columbia, below the hydrosystem. However, since then a trawl has routinely been operated in the lower Columbia for the purpose of recovering PIT tagged juvenile salmonids. Travel time estimates for juvenile salmonids traveling through the lower River to Camas/Washougal (based on migration speed) were calculated for 2003 and 2004 and compared to the average travel time per project in the lower Columbia. The 2002 and 2003 water years were less than average (97% and 82%, respectively). Travel time estimates for juvenile spring chinook averaged 0.37 days from Bonneville Dam to Camas/Washougal. Whereas, on average juvenile spring chinook salmon took about two days to travel between projects in the lower Columbia above Bonneville Dam.

In summary, fish traveling below Bonneville Dam spend significantly less time exposed to elevated levels of TDG than when in the Columbia above Bonneville Dam. Consequently, the model based on the hydrosystem, of delay and need for a TDG monitoring site in a pseudo forebay location, does not appear warranted below Bonneville Dam.

B. Lack of significant relation between TDG and spill coupled with significant relation at spillway monitor (DB)

The following outlines the methods and results of analyses focused on the relation between TDG at the Camas/Washougal (CWMW) location and spill at Bonneville Dam from 1995-2003 and the relation between spill at Bonneville Dam and TDG at the Bonneville Tailrace Monitor (BON TWP1) in 2002 and 2003.

Hourly data was obtained from two sources 1) CWMW TDG and Bonneville Dam spill data was obtained from the COE's online data query at http://www.nwd-wc.usace.army.mil/cgi-bin/dataquery.pl and 2) BON TWP1 TDG data was obtained through the COE. Available hourly data for TDG at CWMW and BON TWP1 and spill at Bonneville Dam varied from year-to-year as did the start dates of spill, therefore the begin and end dates for each yearly dataset varied slightly. The following table lists the time span for each yearly dataset.

Table 1. Date ranges of yearly datasets.

Year	Date Range
2003	4-14-2003 to 8-14-2003
2002	4-11-2002 to 7-10-2002
2001	5-16-2001 to 8-31-2001
2000	4-10-2000 to 8-31-2000
1999	4-13-1999 to 8-31-1999
1998	4-20-1998 to 8-31-1998
1997	4-10-1997 to 8-31-1997
1996	4-10-1996 to 8-31-1996
1995	4-14-1995 to 8-08-1995

Total Dissolved Gas (TDG) at BON TWP1 could be analyzed on a day-for-day basis without any significant lag time between the spillway at Bonneville Dam and the BON TWP1 TDG gauge. However, the lag time between spill at Bonneville Dam and the associated TDG from that spill at CWMW was significant and was accounted for in analyses.

A COE table titled "Columbia and Snake River Travel Times" was utilized to determine the water travel time between Bonneville Dam and Camas/Washougal at various discharges from Bonneville Dam (100, 150, 200, 250, and 300 Kcfs). An asterisk at the bottom of the table indicated "the values are estimated theoretical retention times based on information from Mike Schneider."

Concerning CWMW data, each individual years dataset was divided into weekly data blocks and TDG was lagged backwards in time (in hourly increments) based on the average discharge at Bonneville Dam over the weekly block. Therefore, for each weekly block, the average discharge was first calculated and incorporated into the relation provided in the COE table to obtain a travel time from Bonneville to Camas/Washougal. Next, the entire week of Camas/Washougal hourly TDG was lagged in accordance with the determined water travel time. The resulting dataset allowed for lagged TDG at Camas/Washougal to be compared with corresponding spill at Bonneville Dam. As an example, the following table displays the water travel time from Bonneville Dam to Camas/Washougal based on the average weekly discharge at Bonneville Dam in 2002.

Table 2. Example of 2002 weekly blocks with average total discharges at Bonneville Dam and associated water travel times based on COE information

	Ave Bon Tot. Outflows (Kcfs)	**WTT to CWMW (hr)**
4/11/2002- 4/16/2002	253	13
4/17/2002-4/23/2002	300	12
4/24/2002-4/30/2002	238	14
5/01/2002-5/07/2002	234	14
5/08/2002-5/14/2002	218	14
5/15/2002-5/21/2002	229	14
5/22/2002-5/28/2002	269	13
5/29/2002-6/04/2002	318	11
6/05/2002-6/11/2002	343	11
6/12/2002-6/18/2002	296	12
6/19/2002-6/25/2002	328	11
6/26/2002-7/02/2002	317	11
7/03/2002-7/10/2002	269	13

Once all the CWMW data sets were lagged, the 12-highest hours of TDG (lagged for CWMW datasets and non-lagged for BON TWP1 datasets) were averaged on a daily basis at both BON TWP1 and CWMW. Additionally, for each day, the 12-hours of spill at Bonneville that corresponded to the highest hours of TDG at both respective locations were averaged. The resulting datasets contained daily averages of the 12-highest hours of TDG at either CWMW or BON TWP1 and the 12-hours of spill at Bonneville that corresponded to the highest hours of TDG. Finally, linear regression was used to determine the relation between the 12-highest hours of TDG and corresponding spill at Bonneville for each year. Plots included in Appendix 1 display relations at CMWM between 1995 and 2003 and BON TWP1 for 2002 and 2003.

Overall, the relations between the 12-highest hours of TDG at CWMW and spill at Bonneville Dam were very weak in all but very high water years. Table 3 displays the R^2 for each year's regression between TDG at CWMW and spill at Bonneville Dam as well as the Jan-July Runoff Volume as a percentage of average at The Dalles.

Table 3. R^2 for each year's regression between TDG at CWMW and spill at Bonneville Dam as well as the Jan-July Runoff Volume as a percentage of average at The Dalles.

Year	R^2	Runoff Volume at TDA (% of average)
1995	0.1625	98
1996	0.7356	132
1997	0.9593	150
1998	0.4977	98
1999	0.3519	117
2000	0.2177	93
2001	0.7215	55
2002	0.5313	97
2003	0.3484	82

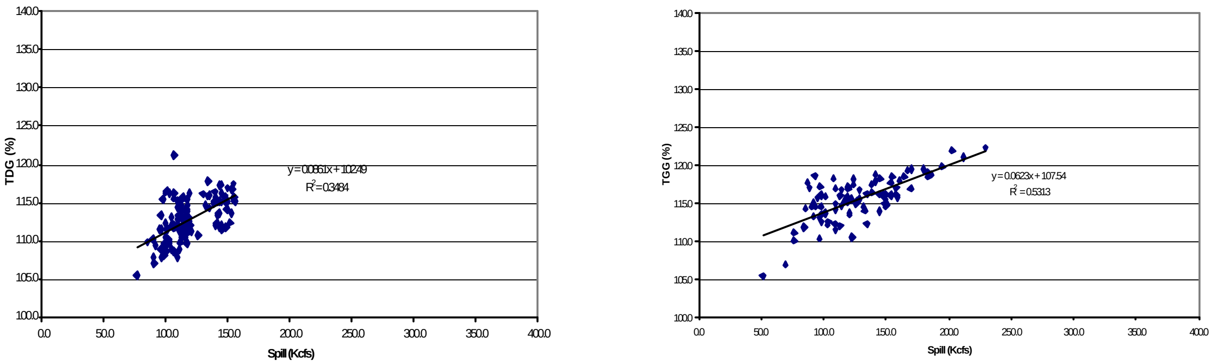
Three of the years between 1995 and 2003 had good to very good relationships between spill at Bonneville Dam and TDG at CWMW relationship; 2001, 1997, and 1996. Two predominant spill levels drive the relationship in year 2001 heavily, either "0 Kcfs" or "50 Kcfs" (Figure 3). This relationship essentially connects two bands of data and one would expect a moderately high R^2 value. More interesting is the relationships between spill at Bonneville and TDG at CWMW during the years of 1997 and 1996. 1997 and 1996 were high water years and therefore contained very high flows with periods of involuntary spill. As a result of periodic spill levels of 300 Kcfs or greater, TDG levels in both years either approached or exceeded 135% (Figures 7 and 8). It is likely that the lag time between Bonneville and CWMW is significantly reduced during high water years, thus allowing environmental variables (wind, temperature, etc.) less time to act on the water body. The result would be a much stronger relationship between TDG and spill during years with high flows and shorter lag times.

However, during most average or lesser water years with longer lag times, the relation between TDG at CWMW and spill at Bonneville is poor. The lack of relation between these variable would make it increasingly difficult to manage spill based on TDG at CWMW. In fact, from visual inspection of Figures 1-9, the 115% Gas cap at CWMW could be reached at Bonneville spill levels anywhere from 80-170 Kcfs.

Relations between Bonneville Spill and TDG at BON TWP1 (R^2) were 0.7868 and 0.9137 for the years of 2003 and 2003, respectively (Figures 10 and 11). For comparison, over the same years, the same coefficients were 0.3484 and 0.5313 for relations between Bonneville Spill and TDG at CWMW. The proximity of BON TWP1 to the Bonneville spillway likely minimizes the impact of environmental factors that may be impacting the relation of CWMW TDG to Bonneville Spill. The relations between BON TWP1 TDG and Bonneville Spill over 2003 and 2002 are generally strong and, more importantly, appear to be a much more reliable management tool for spill at Bonneville Dam.

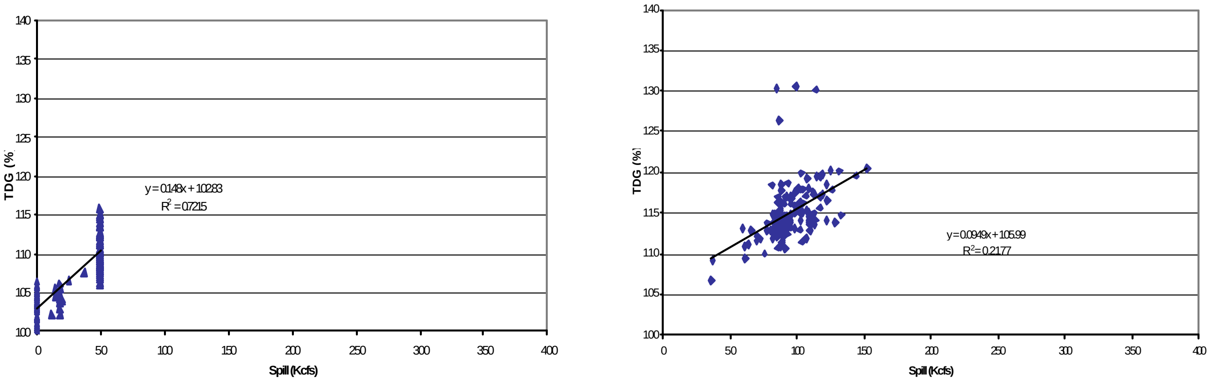
In conclusion, during most average or lesser water years with longer water travel times between Bonneville Dam and CWMW, the relation between TDG at CWMW and spill at Bonneville is poor. The lack of relation between these variables make it difficult to manage spill at Bonneville Dam based on TDG at CWMW, 115% TDG at CWMW could result from spills at Bonneville of anywhere between 80 and 170 Kcfs. The relations between BON TWP1 TDG and Bonneville Spill over 2003 and 2002 are generally strong and are much more reliable for managing spill at Bonneville Dam.

Figure 1. Relation between the average of the 12-highest hours of TDG at CWMW and the average spill at Bonneville over those hours (accounting for lag time) for (A) 2003, (B) 2002, (C) 2001 and (D) 2000.



(A) 2003

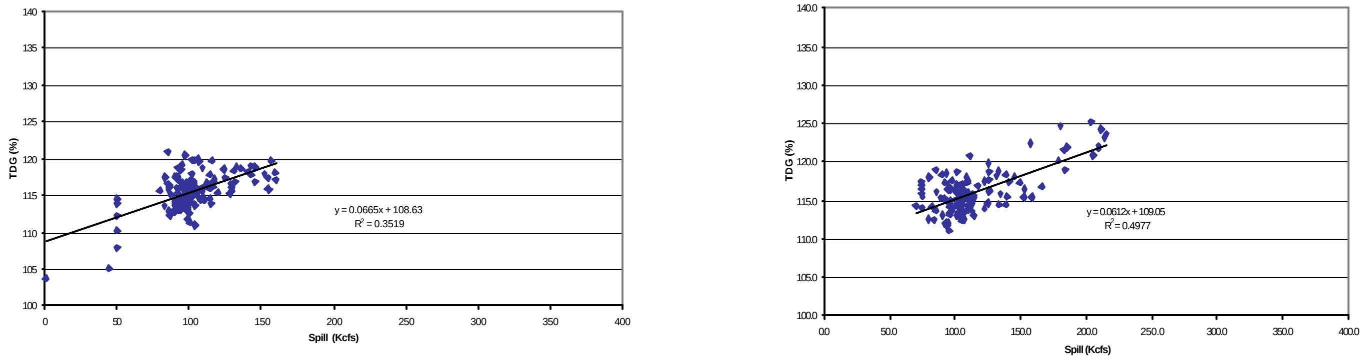
(B) 2002



(C) 2001

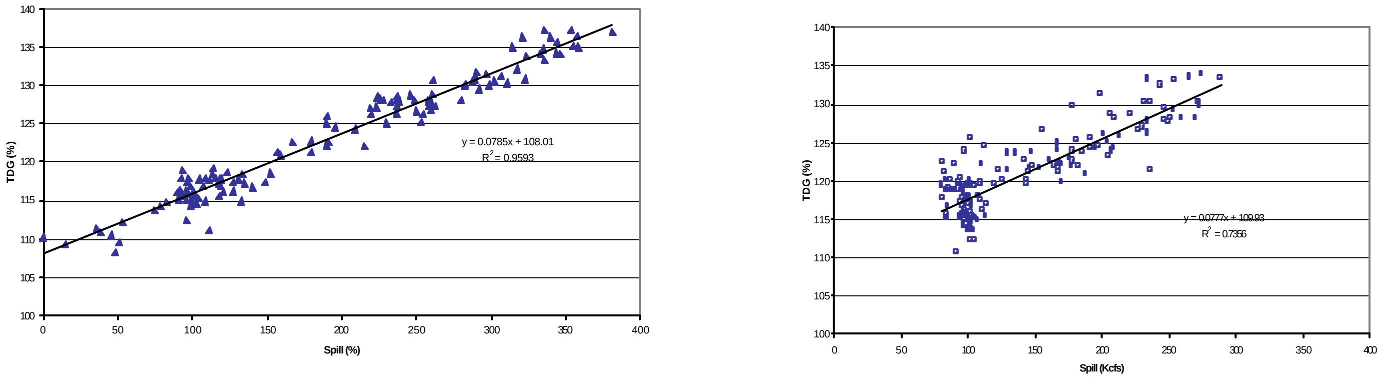
(D) 2000

Figure 2. Relation between the average of the 12-highest hours of TDG at CWMW and the average spill at Bonneville over those hours (accounting for lag time) for (A) 1999, (B) 1998, (C) 1997, (D) 1996 and (E) 1995.



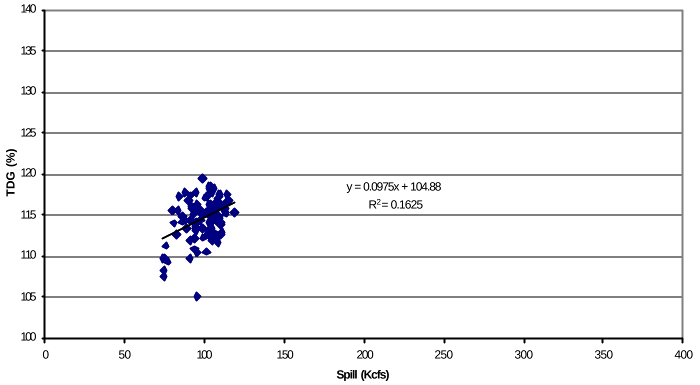
(A) 1999

(B) 1998



(C) 1997

(D) 1996



(E) 1995

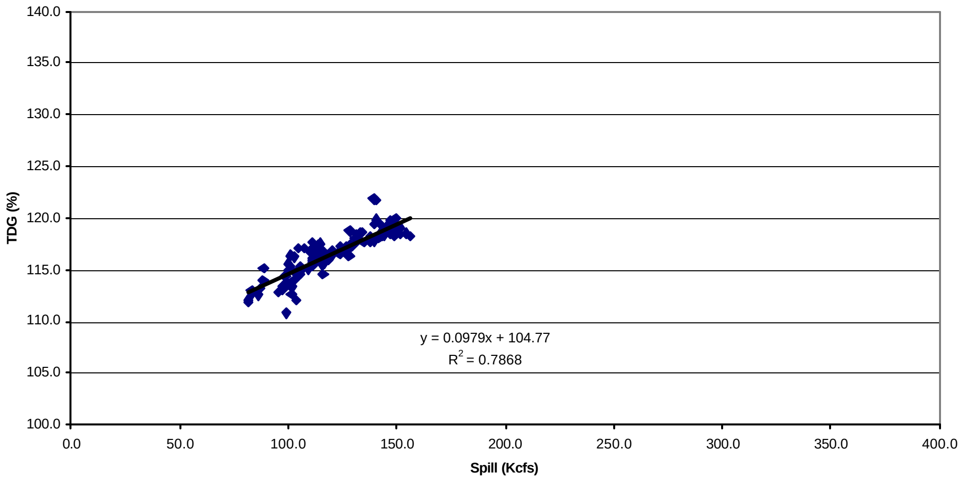


Figure 3. Relation between the average of the 12-Highest hours of TDG at BON TWP1 and the average spill at Bonneville over the same hours from April 14th, 2003 to August 14th, 2003.

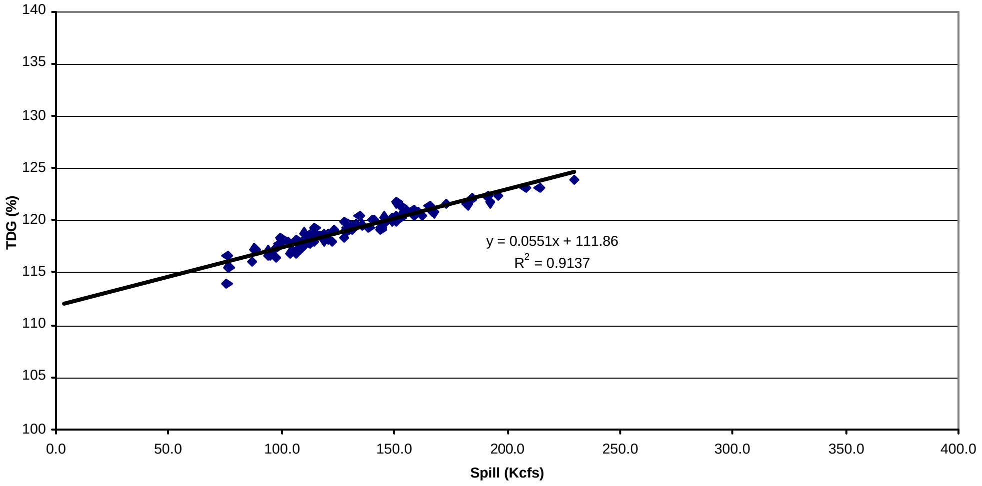


Figure 4. Relation between the average of the 12-highest hours of TDG at BON TWP1 and the average spill at Bonneville over the same hours from April 11th, 2002 to July 10th, 2002.

C. Columbia River Habitat Below Bonneville Dam and Spill Effects on Salmonids , Resident Fish and Benthic Invertebrates

River Habitat Below Bonneville Dam

The habitat below Bonneville Dam will be no different in the future using the more sensitive Bonneville tailrace monitor than it has been using the Camas Washougal FMS. A review of BIOP Spill program biological monitoring of salmonids as well as a review of recent literature reports on the effects of TDG on resident fish and invertebrates should address habitat concerns.

Salmonid Species

Appendix E of the 2000 Biological Opinion was an assessment of risk to juvenile and adult salmonids exposed to dissolved gas supersaturation generated through implementation of the voluntary spill program. The risk analysis was based on the results of the biological monitoring program conducted between 1995 and 1999. During these years the monitoring program collected nearly 200,000 juvenile fish. It has been known for sometime that gas bubble trauma (GBT) (also referred to in the literature as gas bubble disease) in juvenile salmonids may be observed in fish exposed at all gas levels. Even at a relatively low gas supersaturation level of 110%, signs can develop if the exposure is long and the water is shallow. However, based on 5 years of data from the biological monitoring program, the average incidence of GBT signs was low. The accumulated data on GBT in juvenile chinook and steelhead revealed few GBT signs below 120% TDG. The prevalence of signs did not begin to increase until TDG was between 121% and 125%. When fish with signs were exposed to gas levels above120%, the incidence and severity of GBT signs increased. However, severe signs did not begin to appear in monitored fish until TDG approached 130%. It is of significance that these greater levels of TDG were observed only during periods of involuntary spill forced by river conditions that exceeded the hydraulic capabilities of the dams.

The monitoring program for adult salmonids showed a similar relationship between gas bubble signs and TDG. When the inriver TDG level was below 120%, few adult fish (in some cases none) displayed signs of GBT. Investigators observed adult tolerance to TDG and hypothesized that it was attributable to the migration depth of adult salmonids. Depth-sensitive radio tags used in adult migration studies confirmed that adults migrate at depths up to 4 meters and find depth compensation protection from GBT.

The fishery managers note that the Independent Scientific Advisory Board’s evaluation of gas abatement (ISAB 98-8 Review of the U.S. Army Corps of Engineers Dissolved Gas Abatement Program) and the NMFS’ 2000 Biological Opinion for the Federal Columbia River Power System (NMFS 2000) found that dissolved gas levels of 120% saturation were conservative and not harmful to salmon in the river. Further, analysis of three years of research from in-river juvenile salmon sampling in the Columbia River indicates that very low incidences of GBT were found in juvenile salmon that were exposed to dissolved gas levels up to 125% saturation Backman et al.

2002.[1] Backman and Evans (2002) found that in samples of 4,667 adult chinook salmon, salmon were rarely observed with gas bubble trauma, despite sampling large numbers when total dissolved gas exceeded 130% saturation. Specifically, Backman and Evans (2002) found no statistically significant relation between total dissolved gas and gas bubble trauma for chinook salmon. For adult sockeye and steelhead, Backman and Evans (2002) found that most gas bubble trauma symptoms were minor (>5% fin occlusion) with severe bubbles (>26% fin occlusion) being observed only when total dissolved gas exceeded 126%.

Resident Fish

In the last four years the results of resident fish and invertebrates TDG effects research have become available. The results of these studies coupled with the above salmonid monitoring ameliorate concerns regarding the habitat below Bonneville. Ryan et al, 2000 reported on four years of investigations during which resident fish and invertebrates were collected and inspected for signs of gas bubble trauma. In the study nearly 40,000 specimens were analyzed. The objectives of the study were to investigate the impacts of TDG supersaturation due to the BIOP spill program on this segment of the Columbia River biota as well as document any consequences. The resident fish and invertebrates were collected from three sites, i.e., above Priest Rapids Dam, on the Snake River below Ice Harbor Dam, and below Bonneville Dam in the habitat area of particular concern. All of the fish sampled were collected in a depth range of 0 to 3 m. The investigators recognized that any organisms collected below three meters of depth would have been protected from the effects of supersaturation to a surface level of at least 130%. Benthic invertebrates were sampled to a depth of 0.6 m.

The field sampling was conducted from April through June of the years 1994 to 1997. Twenty-eight species of resident fish were collected at the three sampling sites. Of these specimens 3.9% of the fish displayed signs of GBT, most appearing in 1996 and 1997 when involuntary spill was common and TDG was well above BIOP limits. The TDG levels measured during the study reflected the runoff of the water years and the incidence of GBT reflected the gas levels. Table 4 summarizes Ryan et al. results recorded below Bonneville Dam.

The invertebrates sampling efforts produced representatives from 27 taxa. Sampling was conducted only during 1994 and 1995. Of the over 5,400 specimens inspected only 7 showed signs of gas bubble disease.

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[1] These researchers found that Gas Bubble Trauma was not detected in most of in-river migrants sampled from 1996-1999. This included fish sampled during two very high flow years where spill was at uncontrolled levels through the Federal Columbia River Power System.

Table 4. Resident fish and invertebrates collected below Bonneville Dam, sampling year, total dissolved gas levels, number of fish collected and inspected and gas bubble disease signs recorded.

Year	Total Dissolved Gas Level Monitored	Number of Resident Fish Sampled	Gas Bubble Disease Incidence
1994	120%	4955	3 fish with signs
1995	Exceeded 120% four times, never over 123%	1963	2 fish with signs
1996	Daily average peaked over 120% April to mid-May. Over 130% through end of June.	1116	5.1% of specimens
1997	Above 125% for 10 weeks, exceeded 135% for 12 days.	813	18.0% of specimens

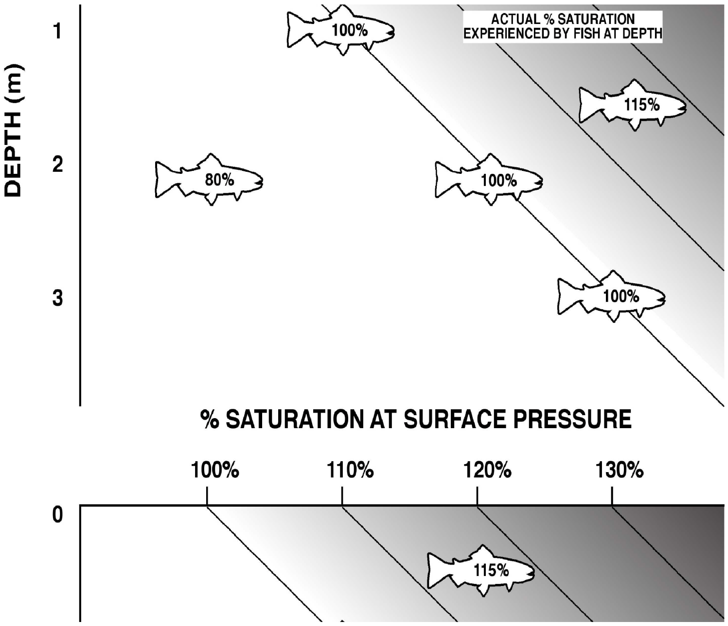
Weitkamp and Sullivan published results of two resident fish studies in 2003. Both investigations were conducted on resident fish species in the lower Clark Fork River in northern Idaho. The reports addressed the incidence and severity of gas bubble trauma and fish behavior in supersaturated waters. In the former study fish were electrofished in the four years from 1997 to 2000. As was stated above, 1997 was a year of high runoff. Resultant involuntary spill in the Clark Fork at Cabinet Gorge Dam resulted in gas levels approaching 150%. The spring runoff in 1999 was more moderate but did result in gas ranging from 120% to 130% in the river. A total of 16 species of resident fish were captured in the investigations. The bulk of the species list was similar to the Ryan et al studies discussed above and included large scale sucker, northern pike minnow, peamouth, and mountain whitefish. These species represented 84% of the fish captured. Resident salmonid species comprised the remainder of the list.

The Weitkamp and Sullivan study is a good indicator of resident fish GBT incidence and severity. In these studies the incidence and severity of GBT signs was less than might have been predicted based on laboratory bioassay results or TDG levels measured at the water surface. After four years of investigation the authors concluded that moderate levels of TDG did not have a substantial effect on resident fish in the lower Clark Fork River. Intermittent exposure to 120-130% TDG resulted in signs in a small number of resident species. The key factor explaining these results is that the fish were afforded deeper waters in the river habitat and benefited from depth compensation during periods of high dissolved gas.

In the second Weitkamp and Sullivan investigation pressure sensitive radio frequency tags were placed on examples of local resident species. These included brown trout, bull trout, west slope cutthroat, rainbow trout, mountain whitefish, large-scale sucker and northern pikeminnow. The tagged fish were tracked for periods up to 49 days during the spill season. Fish of each species tended to remain at depth of 2 m or deeper about half of the time. The conclusion is that the normal behavior of these species puts them at depths that mitigate exposure to the TDG supersaturation levels as measured at the water surface. The fish behavior results in depth compensation from elevated TDG.

With regard to TDG we have come to recognize a simple truth. Dissolved gas effects all aquatic biota similarly whether salmonids, resident fish and invertebrates. The biological effect is a function of dose response as moderated by hydrostatic pressure, that is, depth. Each meter of depth equates to 10 % of depth compensation. This means that the organisms' depth determines the biological effect of exposure to water supersaturated with atmospheric gas. If the FMS records a gas level of 120 % supersaturation, it is referring to a gas level relative to water surface pressure. This same gas content at 1 m is only 110% supersaturated. At 2 m it is in equilibrium. The same is true of fish tissue levels of gas. If the fish tissues are saturated with gas to the same degree as the water they occupy and the gas is 120% relative the surface, they cannot develop GBT if they are at 2 m or more of depth. In short GBT is the result of uncompensated hyperbaric pressure of TDG. See figure 5. It is the same for all fish, salmonid or resident species, as well as invertebrates.

Figure 5. Compensatory effects of depth (hyperbaric pressure) on fish exposed to supersaturated water.



In summary, the habitat between Bonneville Dam and the estuary is subject to the same basic laws of physics and gas solubilities as anywhere else. If the organism has access to or resides in waters deeper than 2 m the organism will not be afflicted with GBT. The habitat throughout the lower Columbia and Snake rivers has a large amount of such habitat. Consequently, it is unlikely that resident species are affected by TDG levels that exceed the 115% because of confounding environmental factors (temperature and biological processes).

Recommendations

The fisheries managers recommend a new point of compliance monitoring that is more responsive to spill changes, with retirement of the Camas/Washougal monitor. This is consistent with the spirit of the RPA 132, which was to improve the performance of the FMS through adaptive management. The original intent of the Camas/Washougal station was for it to act like a forebay monitor and limit the exposure of salmonids to higher TDG levels. However, we now know after several years of data collection and research that this model was incorrect. Fish move quickly through the lower River when not impeded by a hydroelectric project.

Recent Corps studies (2002) of Bonneville project tailrace TDG effects and 2003 data from the Bonneville tailrace monitor (BON TWP1) provides compelling support for use of the Bonneville tailrace monitor as the FMS station for management of voluntary spill at Bonneville. An evaluation of the spill at Bonneville and the TDG levels generated as measured at Camas/Washougal in recent Corps investigations has explained the significant variability in Camas/Washougal TDG data. It is now understood that the effects of environmental factors, including wind, temperature, solar input, barometric pressure and biological activity play a significant role in altering TDG as measured 25 miles downstream and 12-18 hours after the spill event. Therefore, applying Camas Washougal TDG data to spill management makes little sense. Analysis of the Corps 2002 and 2003 tailrace data demonstrate the new Bonneville tailrace station can provide timely, sound dissolved gas data for spill management.

The Appendix E of the 2000 BIOP reviewed all available data and found that the present voluntary spill program does not impose harm on migrating or resident fish in the hydrosystem. This document updates that appendix with the results of more recently conducted studies. Migrating fish spend very little time in the lower River below Bonneville Dam and resident fish are generally below compensation depths necessary to accommodate the levels of TDG.

Therefore, it appears prudent based on all the information reviewed to request that the Camas/Washougal site be removed from the Oregon Department of Environmental Quality waiver and be substituted with the Bonneville tailrace gage.

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