2009 Total Dissolved Gas Management Plan

1.0 Introduction

High total dissolved gas (TDG) saturation levels are observed in various parts of the Columbia and Snake River systems where spill occurs; sometimes creating conditions that may impact fish survival. Therefore, a plan to control TDG is developed annually along with a water management plan based on the runoff and the resulting spill for that year. This document outlines the TDG management plan adopted by the Technical Management Team (TMT) for 2009. It includes a review of voluntary and involuntary spill, applicable management options, and a detailed TDG management plan with spill priority list and spill caps. This plan reflects relevant provisions of both the U.S. Fish and Wildlife Service and the National Marine Fisheries Service (NMFS) Federal Columbia River Power System (FCRPS) Biological Opinions (BiOps).

2.0 Voluntary and Involuntary Spill

2.1 Voluntary Spill

Voluntary spill is defined as the passing of water through the spillway gates of a dam to facilitate passage of juvenile salmon past the project or passage of water to aid fish downstream. Spill at projects that pass juvenile salmonids is done to decrease the residence time of juvenile salmon in the forebay of dams, which increases their passage and survival in the FCRPS. The amount of voluntary spill is adjusted so that the resulting TDG levels associated with spill are consistent with applicable State water quality criteria. These criteria specify that TDG levels are not to exceed 120% in the tailwaters and 115% in the forebays of downstream projects as measured as the average of the twelve highest hourly readings in any one day for the State of Oregon and as the average of the twelve highest consecutive hourly readings in any one day for the State of Washington. They also specify that TDG levels are not to exceed 125% on a one-hour basis (State of Washington) or on a two-hour basis (State of Oregon). These TDG levels are referred to as “gas caps”. The term “spill cap” is defined as the amount of spill necessary for TDG levels to reach the gas cap.

2.2 Involuntary Spill

Involuntary spill is caused primarily by project and/or system operational limitations. There are two primary causes for involuntary spill:

1. When hydrologic conditions result in flows which exceed the hydraulic capacity of power generation facilities, and/or

2. When potential power generation from water moving through the reservoir exceeds the available market, especially during light load hours at night and on weekends.

Other causes for involuntary spill include management of reservoirs for flood control, scheduled or unscheduled turbine unit outages of various durations, passing debris, or any other operational and/or maintenance activities required to manage project facilities for safety and multiple uses.

For example, in managing the project for flood control, the water supply forecast may underestimate the seasonal streamflows resulting in inadequate space available in the reservoirs to capture incoming water. In other instances, unusually high winter precipitation in January through March may force the operators to store water in the reservoirs above the flood control elevations during the month, causing involuntary spill to occur later in the month as the water is evacuated in an attempt to achieve end of the month reservoir flood control elevations.

The anticipated frequency and extent of involuntary spill due to hydrologic conditions cannot be predicted until the 2008 (April Final) January through July forecast for the Columbia River at The Dalles is completed. Isolated instances of involuntary spill, prompted by scheduled or unscheduled turbine unit outages of various durations and/or other operational and maintenance activities, are expected to occur in 2009.

3.0 Management Options

3.1 2008 Biological Opinion:

The 2008 BiOp provides for spill to improve juvenile fish passage while avoiding high TDG supersaturation levels or adult fallback problems. Specific voluntary spill levels will be provided for juvenile fish passage at each project, not to exceed established TDG levels (either 110 percent TDG standard, or as modified by State Water quality waivers, currently up to 115 percent TDG in the dam forebay and up to 120 percent TDG in the project tailwater, or if spill to these levels would compromise the likelihood of meeting performance standards (RM&E Strategy 2, RPA 29). The dates and levels for spill may be modified through the implementation planning process and adaptive management decisions. Details of the spill program will be specified in the 2009 Fish Passage Plan.

3.2 Spill Management:

Spill caps will be assigned to each project and will be adjusted in-season, based on actual TDG readings and a variety of other factors. TDG measurements will be reviewed on a daily basis and minor adjustments to the voluntary spill at each project will be made to the daily spill cap in order for TDG concentrations to be consistent with State water quality variances. The assignment of spill caps at each individual project is dependent upon an array of variables. Factors that are evaluated in the determination of spill caps are as follows,

1. Physical Design and Operation of Projects: TDG levels that are generated in the tailwaters of each project depend upon many factors including the amount of spill passing through the spillway, the pattern of spill through the spillway, the amount of flow through the powerhouse, structure of the stilling basin, the presence (or absence) of flow deflectors, the presence (or absence) of divider walls, the presence (or absence) of fish screens (which can influence decisions regarding distribution of spill at specific projects) , and river characteristics immediately below each project. These individual characteristics are taken into account when assigning spill caps.

2. Travel Time: The time it takes water to move from one project to the next depends upon the distance between projects and the flow rate in the river. Because of this, changes in spill at

an upstream project and the resulting change in TDG levels will not be seen in the forebays of the downstream project for several hours or days.

3. Water Temperature: Climatic conditions can cause increases in water temperatures, which in turn can cause increases in TDG levels. The rule of thumb for water temperature is that a $1^{o}C$ ($1.8^{o}F$) increase in water temperature can result in a 2 to 3% increase in TDG. Since the impact of changing climactic conditions on water temperature cannot be directly predicted, air temperature is used as a surrogate. If it is expected that significant increases air temperature are expected in a specific region, then it will be assumed that water temperatures would also be increasing and spill caps will be adjusted appropriately.

4. River Characteristics: Characteristics of the river channel can influence TDG levels. For example, the forebay of Lower Monumental Dam is shallow and therefore susceptible to heating by sunlight. Other projects have forebays that are deeper, and therefore less susceptible to heating effects.

5. Degassing: As waters flow from one project to another, degassing can occur. Experience has shown that winds above 10 mph enhance degassing. Therefore, wind conditions are used to predict levels of degassing. In addition, flows below 200 kcfs, significant degassing of TDG occurs in the river between the Bonneville dam and the Camas/Washougal FMS. However, when flows increase above 200 kcfs, little or no degassing has been observed.

6. Flow Variations: Spill decisions are often affected by forecasts of flows for the near future. For example, when high flows are anticipated, shifting of spill priorities at different projects may occur in order to develop an overall river-wide strategy to minimize TDG exceedances. Also, there are variations in flow on a weekly basis. On weekends, demand for power typically drops as compared to during the workweek. This results in decreases in flow through project powerhouses. As a result, the relative proportion of spilled water flow (which typically has higher TDG levels) to powerhouse flow (which typically has lower TDG levels) increases. If this condition is not taken into account, then tailwater TDG levels will be higher than what was predicted. The opposite occurs on Mondays where powerhouse flow generally increases over the flow on the weekends due to an increase in power demand as the workweek begins.

7. Maintenance and Repairs: Scheduled maintenance and repair activities can modify the amount of flow through a particular project. The type of maintenance and repair activity and how it will affect flows through the project need to be taken into account in order to assign appropriate spill caps.

8. Experimental Test Schedules: The scheduling of various investigative studies can result in alterations in the normal operation of a project. Examples of such alterations including modified spill pattern tests, Removable Spillway Weir tests, and modified spill operations (e.g. at Ice Harbor, 50% spill operations for 24 hours for two days and then BiOp spill operations for the next two days).

4.0 2009 TDG Management Plan

The 2009 TDG Management Plan is similar to previous years' plans. Flows will be regulated to maximize potential for voluntary spill. When project voluntary spill occurs, the projects will be operated to try to keep TDG consistent with variance criteria as long as possible without jeopardizing flood control objectives. When TDG cannot be managed within variance criteria, the river will be managed in the best interest of listed salmon stocks (see Section 4.1). It is recognized that measures designed to physically reduce TDG could have significant impact on migrating salmon. Therefore, input from Federal, State and Tribal salmon managers will be sought when attempting to use those TDG control measures.

The essence of the 2009 TDG Management Plan is as follows:

- The Corps and BPA will provide spill to improve juvenile fish passage while avoiding high TDG supersaturation levels or adult fallback problems. Specific spill levels will be provided for juvenile fish passage at each project that will be consistent with applicable State TDG criteria.

- Since the states of Oregon and Washington have specified different methodologies for calculating the daily average TDG level, projects on the lower Snake River will be managed differently than those on the lower Columbia River. Lower Snake River projects, since they are entirely within the boundaries of the State of Washington, will be managed to the 115%/120% TDG criteria based on the average of the twelve highest consecutive hourly readings in a given day and to 125% TDG as measured on an hourly basis. Lower Columbia River projects, since they are located along the border of the two states, will be managed to either the average of the 12 highest consecutive hourly readings in a given day or the average of the 12 highest hourly readings in a given day, whichever is higher, and to 125% TDG as measured on an hourly basis.

- The management of spill at each project is based on TDG levels measured at specific forebay and tailwater fixed monitoring stations. The current locations of these gauges are based on extensive studies that have been conducted since 1996. At the present time, there are regional discussions occurring regarding the use of these fixed monitoring stations for the management of TDG within the mainstem Columbia and Snake Rivers. The Corps will continue to participate in these discussions, coordinate with the States of Oregon and Washington on voluntary spill for fish passage, and provide technical information to inform the process. Future spill operations may be modified through the implementation planning process and adaptive management. The Corps' decision on the spill program will consider water quality effects along with the results of spill studies, biological evaluations, and the relationship to achieving BiOp performance standards.

- Adjust spill as needed, based on real-time TDG data, and fish movement and biological conditions in that order.

- Operate generators within 1% of peak efficiency.

- Accommodate special spill requirements/restrictions for research, adult passage, etc. that have the full endorsement of all concerned parties. Also, continue to implement fish transportation program as agreed to and using calculation method endorsed by NMFS (or an equivalent method agreed to at TMT).

- If systemwide TDG exceed 120%, update and implement the spill priority outlined in Attachment 1, with incremental system TDG control objectives. Unless and until a different reach priority is recommended by the TMT, spill will start as specified in the Spill Priority List.

- Discontinue or postpone field research and non-critical unit service and maintenance schedules that create (or have potential for creating) high localized TDG levels, especially when and where high numbers of listed fish are present.

- With regional coordination and recommendation from TMT, operate turbines outside their respective 1% peak efficiency flow range at projects where measurable reduction in TDG (at least 3%, given the accuracy range of the instrumentation) and no intolerable adverse fish impacts can be expected.

- With regional coordination and recommendation from TMT, store water at lower Snake reservoirs above MOP, if this would result in a measurable (3% or more, based on instrumentation accuracy) reduction in TDG levels.

- Experiment with promising new spill patterns.

- Implement other operations or measures recommended by the TMT or the IT. This may include appropriate changes in transportation targets when TDG exceeds levels that are universally recognized as lethal (130% more for 1 week or longer, per NOAA Fisheries) or when obvious in-river lethal conditions exist.

4.1 SPILL PRIORITY LIST and SPILL CAPS (April 3 - August 31)

This discussion provides project priority for spill and allowable spill levels to be used in an attempt to control total dissolved gas (TDG) to 120%, 125%, 130% and 135%. When systemwide TDG is at or below 120%, provide spill for fish passage on the Lower Columbia and Lower Snake rivers up to the 120% TDG tailwater and 115% TDG in the forebays of downstream projects. When systemwide TDG exceeds 120% TDG, then try to control systemwide TDG to 125%, then to 130%, and so on by spilling up to the spill caps indicated for those TDG levels at lower Columbia and Snake projects. The listing order of the projects on the Spill Priority List depends upon specific river conditions, locations of juvenile and adult salmonids, specific configurations of the projects, and any special operational conditions (e.g. research studies, maintenance outages, etc.). The listing order and the specific spill quantities to achieve the various TDG levels will be updated as necessary to account for changing conditions in the rivers.

Table 4-1.

Initial Spill Priority List for 2009

Project	Spill Cap to Generate Specific Percentage of Total Dissolved Gas (TDG)					
	110%	115%	120%	125%	130%	135%
LWG	20	30	41	90	125	200
LGS	10	15	32	80	110	250
LMN	10	15	31	55	110	250
BON	50	65	100	150	250	270
JDA	20	60	120	240	300	600
TDA	20	60	125	250	260	600
MCN	40	80	145	230	290	450
IHR	30	45	95	125	135	240
GCL	05	25	17	23	30	--
CHJ	05	10	22	35	45	--

5.0 2009 TDG Monitoring Plan of Action

In support of the spill management program, a TDG monitoring program has been established. Each year, this monitoring program is evaluated by the Regional Forum Water Quality Team (WQT). The draft plan for 2009 will be presented to the WQT at an October or November meeting and discussed at a meeting in December. Based on discussions at these meetings and submitted written comments, the final plan for 2009 will be completed in February 2009. A copy of the 2008 plan can be obtained at the TMT/Water Quality Programs webpage at:

http://www.nwd-wc.usace.army.mil/TMT/wqwebpage/mainpage.htm.

6.0 TDG Modeling

Total Dissolved Gas caused by large volumes of water spilled over dams can result in injury and mortality of juvenile salmonids. Development and continued refinement of a systemwide TDG model would assist with in-season management of involuntary spill.

In response to RPA 133 of the NMFS 2000 Biological Opinion, the Corps began developing a TDG model to be used as a river operations management tool. During the 2004 spill season, this model (SYSTDG) was utilized on a trial basis to evaluate TDG in the Columbia River Basin and to assist in the setting of spill caps at each of the projects where voluntary spill occurred. At the conclusion of the spill season, a review of the performance of SYSTDG was completed and included in the 2004 Dissolved Gas and Water Temperature Monitoring Report. The same was done for the 2005 through 2008 spill seasons. These reports are included in the annual "Total

Dissolved Gas and Temperature Annual Report" for each of those seasons and are available on the TMT/Water Quality Programs webpage at,

http://www.nwd-wc.usace.army.mil/TMT/wqwebpage/mainpage.htm .

As specified in the 2008 BiOp (RPA 15), SYSTDG will again be used as a TDG management tool in 2009. As the season progresses, modification of the model will occur as necessary due to modifications in project operations.

7.0 Temperature Management

The 2008 BiOp calls for cold-water releases from Dworshak reservoir (RPA 4). These releases serve the dual purpose of providing additional flows of water to assist passage of juvenile salmonids through the lower Snake River projects and to help moderate water temperatures of the lower Snake River. The management of the temperatures of these release waters is possible due to the presence of selector gates at Dworshak Dam which can move vertically and draw water from varying elevations in the reservoir. In addition, forebay waters of the lower Snake River projects are kept at "minimum operating pool" (MOP) in order to help reduce water temperatures (RPA 15).

The management of the flows and water temperatures from Dworshak reservoir is coordinated with TMT and the Nez Perce Tribe. The Water Quality Unit (WQU) of the Corps' Reservoir Control Center will provide TMT with water temperature stratification data from the Dworshak reservoir as well as temperatures of release water derived from the Dworshak tailwater fixed monitoring station (DWQI). The WQU will also provide TMT with data concerning the amount of storage of cool waters in the reservoir with the intent to ensure that sufficient quantities of these waters will be maintained through mid-September and what outflow water temperatures will be expected when the operation concludes and the projects returns to minimum flows.