Transboundary Gas Group
Meeting at Revelstoke, BC

October 29, 2008

1. Welcome and Introductions

Today's meeting was chaired by Dan Millar of Environment Canada with representatives of B.C. Hydro, Teck Cominco Metals, U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, US Geological Survey, Washington Dept. of Ecology, Okanogan Public Utility District, the Confederated Tribes of Colville, Kalispell Tribe, Seattle City Light, Columbia Power Corporation attending.

Millar asked TGG members to review the membership list and notify him of any names that can be removed. He's paring the list to a manageable size.

Prior to today's meeting, B.C. Hydro took TGG members on a tour of Revelstoke Dam. A tour of Mica Dam took place the day after this meeting.

2. Ruskin Dam Spillway Gates and Spillway Project

Paul Higgins (B.C. Hydro) gave a presentation on a major project underway at Ruskin Dam, beginning in March 2007. The initial project included a seismic upgrade for the spillway as well as replacement of powerhouse equipment that is reaching the end of its lifespan. Because flow continuity and total dissolved gas supersaturation is a problem, B.C. Hydro is taking this opportunity to address adverse environmental effects in the design phase.

Ruskin Dam is located on the Stave River, which is a major salmon-producing tributary to the lower Fraser River, British Columbia. Elevated dissolved gasses are generated from spill at an upstream dam (Stave Falls) and are exacerbated by spills at Ruskin Dam. Backwater and tidal influences may also have a significant impact on fish habitat near Ruskin Dam because Fraser River dissolved gas concentration can exceed 110%. Although spill is the primary source of gas in the Ruskin tailrace, another source is the powerhouse itself when air is injected into draft tubes at partial loads. As a result, high TDG levels from the powerhouse have been recorded, as high as 135% in extreme cases. Another source is the Ruskin spillway design, where routing of flows through specific gates can result in generation of dissolved gas levels that exceed BC provincial guidelines for protection of aquatic life (110%).

Seasonal monitoring, empirical testing, and two-dimensional models have been used to study gas generation characteristics/dynamics at normal levels of spill through the Ruskin forebay and the falls that precede the dam. Key findings to date include a) elevated gas levels can be mitigated by the use of peripheral

gates that dissipate energy more effectively than the central gates that allow spill flows to plunge to depth, and b) TDG concentrations do not mix thoroughly as they move downstream. The biological consequences of elevated gas levels on aquatic ecosystems in Heyward Lake and the Lower Stave River will be assessed. Work to come includes identification of measures for improving water quality and establishment of TDG guidelines for the lake and river. Populations of 300,000 to 500,000 chum, approximately 10,000 coho, and 1,000 Chinook salmon stand to benefit from lower TDG levels.

Mitigation options range from operational changes to altering the Ruskin spillway gate design and geometry. Spillway deflectors are being considered. B.C. Hydro is investigating altering operation of the Ruskin spillway gates and powerhouse to minimize TDG production. Widening and reshaping of the Blind Slough waterfall, at an estimated cost of $12 million, is not a favored option. Baffle blocks have been considered but are also not a favored option.

A panel of specialists gave opinions on overall risks and desirable goals for the TDG mitigation project. Total dissolved gas exposure is typically short (1-2 days), and risk levels to fish are lower than in the U.S. portion of the Columbia River. Recommended goals are (1) maintaining TDG levels at or below 120% saturation during autumn, if river elevations provide at least 2 meters (6.6 feet) of water depth in the main Stave River channel, and (2) maintaining TDG levels of no higher than 110% during spring salmonid fry emergence. The specialists also offered comments on gas mitigation options in the Blind Slough spillway and Ruskin powerhouse and spillway. B.C. Hydro is in the process of quantifying potential benefits from possible mitigation actions, and guidelines are needed quickly. Key uncertainties include the effects of flow mixing, backwater effects, and ambient TDG levels in the Fraser River. A coho and chinook spawning channel on the left bank of the Ruskin Dam tailwater is an especially sensitive area.

Among the next steps are continued TDG monitoring for the next 2-3 years, confirming the feasibility of spill deflectors for the central bays of the spillway, experimental exposure of juvenile salmon to elevated dissolved gas levels to establish dose-response relationships, further monitoring during spill events to assess the capacity to dissipate gas through the peripheral gates and whether protracted spills result in gas bubble trauma, evaluating whether a “7Q10” exemption might be applicable, and developing a risk assessment model to use for evaluating mitigation benefits.

3. Columbia River Basin Water Management Program Update

Dan Haller (WDOE) gave an overview of this program the Washington legislature established in 2006 and discussed some of the projects the state has invested in over the past 2 years. The heart of the Columbia water supply development effort is retiming water for both instream and out-of-stream uses.

The goal is to invest in storage opportunities that can retime water uses from winter to summer and to invest in conservation to reduce demand year-round. The focus is on forecasting future Washington water demands on a rolling 5-year basis and developing supply commensurate with that demand. The Washington state legislature gave Ecology a broad mandate to develop new resources, including building reservoirs, funding reuse of existing structures, and paying for water leases – in short, any actions that provide access to new water supplies.

The most significant project to date is incremental releases at Lake Roosevelt behind Grand Coulee Dam, which stems from a 2004 Memorandum of Agreement between the Colville confederated tribes, the U.S. Bureau of Reclamation, and several irrigation districts in the Columbia river basin. A number of ideas are being studied, including releasing an extra foot of water beyond normal operations and using that 82,000 cubic acre feet to meet water needs. Of this, 27,500 acre feet would be reserved for instream flows and released when fishery managers say the flows are needed; 30,000 acre feet would be reserved for surface water supplies; and 25,000 acre feet would be reserved for cities downstream with pending water rights applications.

Another project is the Columbia River mainstem appraisal study, a search for an off-channel site that would store a million acre feet or more of water near the river. The focus was narrowed from 25 potential Washington sites to 4 in 2007: Crab Creek, Hawk Creek, Foster Creek, and Sand Hollow.

The first year of the Columbia River grant program was a whirlwind of spending on preservation efforts. Grant applications for the $200 million in available funding were vetted through a technical advisory group and narrowed down to 18 projects. Eighteen contracts are now in process of being awarded, two-thirds of which are feasibility studies and one-third construction. Their value to the Columbia River program is in helping to meet in-stream flow objectives while satisfying out-of-stream permitting requirements.

There is a special focus on the Odessa area, which has suffered declining groundwater levels over the past 30 years. In order to switch water users there from groundwater to surface water sources, development of storage capacity is needed for the summer irrigation season, as well as other means of storing 125-200 thousand acre feet of water. An Environmental Impact Statement will identify a preferred option for meeting those needs by 2011. Haller noted that the Columbia River treaty negotiations in 2013 will open a dialogue between the U.S. and Canada on Columbia River management.

The water being considered for storage is surplus to the river's biological objectives. In other words, the flows that would be captured in a proposed reservoir for storage are above and beyond the flows targeted in the NOAA Fisheries' 2008 Biological Opinion. Last year, the BiOp flow objectives for Libby were met in both spring and summer, but that was a rare occurrence, Jim Adams

(USACE) said. The frequency of refilling the reservoir will become part of the environmental review, Haller replied.

4. Mica Dam and Tailwater Gas Studies and Revelstoke Dam Monitoring

Gary Birch (B.C. Hydro) gave a presentation prepared by Bob Westcott (Golder Associates) on gas issues at Mica Dam which will be discussed during a site visit tomorrow. The water flow through Mica dam starts at the low level intake gates which feed hypolimnetic water into the penstock to the turbine units. From the units, water flows out of the draft tube and into a water collection manifold that leads to the tailrace. The discharge water from the Mica generating station can become supersaturated from a number of sources including ambient pressure upstream, synchronous condense uptake in the units, and spillway operation.

The normal synchronous condensed operation of the generator units at Mica is known to increase gas levels. Wicket gate leakage and surface agitation below the scroll case contribute to gas supersaturation during synchronous condense operations. Resulting gas levels in the draft tube were at times exceeding 200%. The uptake of gas is confounded by cooling water flows which circulate the synchronous condense-driven gas levels through the draft tubes and manifolds and into the tailrace. B.C. Hydro instituted a draft tube flushing procedure to minimize build-up of supersaturated water in the tailrace in1996 (15-30 minutes generation for every 12 hours of synchronous condense operation). The synchronous condensed operation can occur at any time when there is zero generation from Mica dam but is most prevalent during spring and fall, when water is being stored. Mica can run for weeks in synchronous condensed mode during periods of low electricity demand. There are socioeconomic and environmental constraints on the operation of Mica Dam that are driven by other parts of the hydro system. Fish kills, particularly of bull trout, might have been related to the synchronous condensed operation. However, no fish kills have been observed since the flushing process began.

Birch presented a graphic rendition of what happens below Mica Dam when blocks of supersaturated water from the synchronous condensed operation move downstream. These blocks, cooler and denser than the rest of the flow because of their high gas levels, tend not to dissipate and to travel along the river bottom. Typical TDG levels issuing from synchronous condensed operations are 150% but can go higher than 200%.

Synchronous condensed operations are needed less frequently at Revelstoke than Mica. Surprisingly, gas supersaturation levels at Revelstoke can reach 140% in the tailrace but are degassed to around 110% by the time the flow reaches the golf course a few miles downstream. In 2010, B.C. Hydro will initiate minimum flows at Revelstoke and monitor their benefits on aquatic habitat and fish populations for 12 years before performing a review of mitigation actions

taken. If no TDG benefits result from varying the unit operations in synchronous condensed mode, possible engineering solutions will need to be explored.

Spillway discharge is infrequent but produces heightened gas levels. Mica has spilled only six times since the reservoir first filled in 1976 until 1997. Potential spills in 2000 and 2007 were narrowly avoided. Limited information is available on the influence of spillway discharge on gas supersaturation. B.C. Hydro is preparing to monitor gas levels more rigorously if spill happens in future.

5. Enloe and Shanker's Bend Dam Projects

Nick Christoph (Okanogan PUD) gave a presentation on the FERC process of these two dams. Okanogan PUD has been working with the Colville confederated tribes and the WDOE on the relicensing of Enloe Dam, which is about 3 miles from Oroville, Washington, near Similkameen Falls, a culturally significant location. Anadromous fish do not cross the 33-foot falls that function as a natural barrier. The dam, which is 41 feet high and 276 feet long, now holds about 200,000 cubic yards of sediment behind it. The dam structure will be updated with new gates as part of the FERC relicensing process, which began with environmental studies in 2006-07. The Enloe reservoir behaves more like a river than a lake and has low TDG levels, which increase slightly when flows pass over the dam. The gas then dissipates, with TDG levels tending to remain below 108% until flows reach the falls. Water plunging over the falls shows a 12-14% increase in TDG levels, an effect that persists for about 3-4 miles downstream. Diverting water through the powerhouse and the tailrace, instead of allowing it to plunge over the falls, reduces gas levels in the tailrace.

The Shanker's Bend project so far has involved gathering existing data to determine environmental sensitivity. Shanker's Bend is a multi-use project used for water storage, flood control and hydropower generation. Okanogan PUD submitted a preliminary relicensing application to FERC. The PUD has received $300,000 in funding from WDoE's Columbia River water program for an appraisal-level study. Three dam locations, low (1,155 feet elevation), medium (1,175 feet), and high (1,289 feet) are being studied. Okanogan PUD has received a matching grant from the U.S. Army Corps of Engineers for a hydraulic water availability study that will be incorporated into the appraisal-level study process. Like the Enloe, the Shanker's Bend project is working collaboratively and consulting with the Tribes, U.S. agencies and Canadian entities.

6. Lower Snake and Lower Columbia Total Dissolved Gas Projects

Jim Adams (USACE) gave a presentation on the Corps of Engineers Gas Abatement Analyses that are being completed at the request of the states of Oregon and Washington for the eight dams on the lower Columbia River and lower Snake rivers. The COE is required by the FCRPS Biological Opinions to spill water past these dams for fish passage and must receive TDG waivers from

the states of Washington and Oregon to spill up to a daily average of 120% in the tailwaters of each project and up to a daily average of 115% in the forebays of each project, and up to 125% (on an hourly basis) anywhere in the rivers from April 3 through August 31. To obtain waivers, the COE must submit a gas abatement plan to the states to be issued this waiver of the state standard. Next year, the COE will need to apply for new multi-year waivers for the future spill seasons. All eight dams require waivers from Washington, and the four dams on the lower Columbia also require waivers from Oregon.

Using adaptive management, the COE is developing specific gas abatement plans for each of the lower Columbia and lower Snake dams as part of the water quality program. The plan for each dam is based on uniquely tailored operational and structural configurations. For example, John Day is required to spill 30% of its total flow in order to pass juvenile salmon. This increases gas production, so the COE has been investigating ways to modify the project so that it can spill enough to meet BiOp flow targets without causing TDG levels to exceed the 110% state standard. At John Day Dam, spillway deflectors were constructed on 18 of the dam's 40 bays, avoiding the end bays next to the adult salmon ladders. The deflectors have brought gas levels down. Before installation of the spillway deflectors, TDG levels at John Day were often 140%, mainly the result of involuntary spill. Now the project can spill to capacity without exceeding 110%. Flow in relation to the "7Q10" issue at John Day is 454 kcfs, while powerhouse capacity is 330 kcfs with all generator units running. John Day also has a temporary spillway weir which helps pass juvenile salmonids with lesser amounts of spill which is expected to reduce TDG levels in the tailrace.

The 2008 BiOp focuses on adaptive management to reach formal performance objectives, which are a percent survival for all juvenile salmon passing the project. Performance standards are tailored to each individual project. The gas abatement process at John Day will coincide with efforts to achieve the BiOp performance objective.

The basic strategy for each gas abatement plan is to devise a set of different alternatives which are then tested and evaluated. The gas abatement plans for each project will look for ways to simultaneously meet BiOp flow targets and performance objectives while keeping TDG production below 110%.

7. Boundary Dam Relicensing Update

Daniel Kirschbaum (Seattle City Light) gave a presentation on Seattle City Light's recent efforts to deal with the gas effects of Boundary Dam as part of the FERC relicensing process. Plans to abate TDG levels to 110% or less are part of that process. Two mechanisms have been found to increase TDG: (1) spill from the dam itself and from the sluice gates, and (2) air emissions during some turbine operations. There are air emission issues in 2 of the dam's 6 units. In spring 2008, a large spill of 108 kcfs was passed. This spill flow is similar to the

7Q10 flows that Boundary is required to pass per the water quality requirements of the State of Washington. Albeni Falls Dam on Lake Pend Oreille in Idaho and Box Canyon Dam start spilling before Boundary Dam does, so flows coming into Boundary already have high TDG levels. Albeni Falls hydraulic capacity is 33,000 cfs, Box Canyon hydraulic capacity is 27,400 cfs, and Boundary capacity is 55,000 cfs.

The study process for remediation includes spill tests as well as computational and physical models of Boundary Dam. Spill levels of 5 kcfs actually strip gas out of the river, resulting in a 5-10% TDG reduction. Spills of 5-10 kcfs (about 3 days per year) reduce gas levels by 2-3%. Spills of 10-15 kcfs (2 days per year) are neutral. Gas levels rise quickly, however, when spill volume increases above 15 kcfs.

For dam relicensing, Seattle City Light is required to identify "reasonable and feasible" improvements to meet the state of Washington's TDG standard of 110% year round. The standard is waived for conditions where (1) incoming TDG levels are higher than those leaving the project, and (2) flows exceed the 7-day, 10-year average flow ("7Q10"), which for Boundary Dam is 108,300 cfs.

Of the dam's two spill gates, gate 1 has more potential negative impact than gate 2. Seattle City Light has been monitoring gas levels since the mid-1990s and has observed numerous spikes above 110% due to turbine air admission. Operational changes have reduced the TDG impact of turbine operations.

Seattle City Light's strategy for Boundary Dam is to focus on operational and structural changes and ways to reduce gas levels incrementally using the two 50-foot spill gates and the 7 lower level outlet sluice gates. Efforts are underway to develop a tool that predicts TDG levels. The top three engineering alternatives currently under consideration are (1) throttling the sluice gates, (2) a deflector in combination with throttled sluice gates, and (3) altering the spill gates themselves. Criteria for prioritizing alternatives include low risk of fish injury, high likelihood of improving TDG conditions downstream, technical feasibility, and dam safety.

Seattle City Light has 9 TDG meters in the river to monitor TDG levels at Boundary, and efforts are underway to confirm previous data from the meters. This is the second year Seattle City Light has monitored gas with numerous meters under a variety of spill conditions. Engineering studies and physical modeling of the effects of spill are now in progress. The strategy for the spill gates is to increase turbulence, aerate the flow, and break up the jet that plunges about 200 feet into the plunge pool, sending gassed-up water into the tailrace. The strategy for the sluice gates is to be able to control the flow rate by throttling the gates and possibly installing deflectors to distribute the flows to precise locations within the plunge pool. Sealing plates are being added to a 21-foot

sluice gate, which will allow the gate to be raised and the seals to be re-sealed so the gate can be used in throttled operations. These changes will have the similar effect as with the spill gate, to increase turbulence, reduce plunging jets and reduce TDG.

High TDG levels in the tailrace due to turbine operations have been minimized by operating units 55 and 56 on a “last on, first off” basis above 125 MW except during startup and shutdown. These turbines have been found to admit air which is a cause of excessive gas levels when operated below 125 MW. These operational changes, in effect since 2004, have successfully reduced TDG caused by turbine operations.

A tour of the physical model is scheduled for January 20, 2009, in Redmond, Wash. The ultimate goal of this work is to use the physical model to develop computer modeling that can produce TDG levels under given conditions. Related goals are improved understanding of how gas is distributed in the river during spill events, and how spill gate operation affects TDG levels in the tailrace. The gas abatement plan will describe the process of developing alternatives to address TDG levels at Boundary Dam.

4. Next Meeting

The TGG agreed to reconvene at Grand Coulee Dam in October 2009. This meeting summary prepared by consultant and writer Pat Vivian.

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