Screening of Alternatives for Plan of Study Phase of the Chief Joseph Dam Dissolved Gas Abatement Study November 1998

1. **Purpose:** The purpose of this paper is to focus the scope of alternatives to be examined in the next phase of the Chief Joseph Dam Dissolved Gas Abatement Study, and therefore addressed in the Plan of Study for that phase. Our goal in narrowing the scope of alternatives is to reduce feasibility phase costs and potentially reduce the time to reach a decision on implementation of gas abatement measures. The intent is to evaluate the most promising and implementable alternatives to meet the study objectives.

2. **Background:** In the past few years, the combination of higher than average flow conditions requiring flood control spills and Endangered Species Act (ESA) efforts requiring spill for fish passage have magnified the dissolved gas supersaturation problem throughout the Columbia River system. Current state and federal water quality standards for total dissolved gas (TDG) concentrations are 110 percent saturation except when stream flow exceeds a 7-day average, 10-year flood event. The TDG levels downstream of Chief Joseph Dam frequently exceed this standard. In particular, very high levels of TDG supersaturation were observed below Chief Joseph and Grand Coulee Dams in 1996 and 1997. High levels of TDG produced at one dam tend to persist far downstream. Chief Joseph Dam is the upper boundary for the geographic range of the Upper Columbia River Evolutionary Significant Unit (ESU), within which steelhead have been listed as "endangered" under the ESA on August 18, 1997. Chinook salmon within this ESU have been proposed for listing as "endangered." ESA designations underscore the importance of minimizing the impact of TDG releases from Chief Joseph Dam. In an effort to improve water quality, the Corps of Engineers has undertaken on-going study efforts to identify appropriate cost-effective, long-term gas abatement alternatives at Chief Joseph Dam and dams on the Lower Columbia and Snake Rivers.

3. **Coordination of Dissolved Gas Abatement Studies for Chief Joseph.** The 1998 National Marine Fisheries Service (NMFS) Supplemental Biological Opinion (BiOp) specifically requests that the Corps and the Bureau of Reclamation (BOR) coordinate efforts in a joint study of dissolved gas abatement for Chief Joseph (CHJ) and Grand Coulee (GCL) Dams. Although each agency is pursuing an independent study, recent discussions within regional forums suggest a more coordinated effort is needed. The Corps and BOR are presently addressing means of coordinating the respective studies. The following information is provided in an effort to show the direction that the CHJ study is taking at this time and is intended to provide a context for any decisions on the scope of investigations specific to CHJ.

4. **Initial Appraisal Report of Dissolved Gas Abatement at Chief Joseph Dam.** The final draft of the initial appraisal report (IAR) of dissolved gas abatement at Chief Joseph Dam (CHJ) was released in May 1998. The objectives of the IAR were to:

- Reach a TDG level out of Chief Joseph Dam of 110 percent just below the spillway if feasible from an economic, engineering, and biological standpoint.
- Assess the causes and impacts of total dissolved gas at Chief Joseph Dam.
- Identify appropriate cost-effective, long-term gas abatement measures.
- Identify type and extent of role to be played by Chief Joseph Dam under a system-wide gas abatement scenario.

An overview of the report was presented at a combined meeting of the System Configuration Team (SCT) and the Dissolved Gas Abatement Team (DGT) on May 20, 1998. The IAR identified 9 alternatives for further consideration.

Structural Alternatives:

- Spillway Flow Deflectors
- Side Channel Canal
- Degas at Brewster Flats

Project Operational Alternatives:

- Operate Hydropower Units Outside Peak Efficiency Range

System Operational Alternatives:

- Spill During Maximum Power Generation
- Swap Power for Spill with Downstream Dams
- Raise control Flow at the Dalles
- Modify Operation of Grand Coulee Dam
- Combination of several of the above

5. **Comments on IAR.** The Corps received both verbal and written comments concerning the IAR. The following includes a summary of comments presented at the July meeting of the System Configuration Team (SCT).

The Columbia River Intertribal Fisheries Commission concurs with many other regional agencies in support of efforts to fast-track flow deflectors.

Comments were received jointly from the Confederated Tribes of the Colville Reservation and the Washington State Department of Ecology. The agencies want the project objective to be changed to "reduce total dissolved gas to 110 percent" rather than "reduce TDG to the extent economically, technically, and biologically feasible." The agencies also identified a need for the Corps to complete a gas abatement plan for approval by these agencies.

With respect to the alternatives identified in the IAR, the Colville Tribes and Department of Ecology requested further exploration of several alternatives that were eliminated after study in the IAR:

- Raised Tailrace
- Raised Stilling Basin

- Unplug Sluices in Spillway
- Side Channel Canal
- Enclosed Stilling Basin

However, these agencies are most interested in the alternative identified as "side channel canal."

Several comments identified a need for stronger justification for the 80,000 cfs design flow for dissolved gas abatement alternatives.

NMFS suggested that system operational changes be examined holistically before making structural changes, and that the study carry forward essentially the same alternatives as identified in the IAR. Specifically, NMFS' letter to the Corps contained the following.

> "While NMFS endorses site specific studies of TDG levels during spill operations, we would object to implementation of abatement options without first addressing integrated system-level review of existing sites where spill occurs, and determination of whether there is system operational flexibility to shift spill from one site to another……In that context, we believe the Chief Joseph appraisal report is an important first step. However, a decision to implement abatement measures at Chief Joseph should not be made until similar reports at all Mid-Columbia dams have been completed and system options have been integrated and prioritized. "

In reference to the Lower Columbia and Snake Rivers, NMFS stated at a recent SCT meeting that they consider flow deflectors to be a critical short-term modification that should be fast-tracked.

Several comments suggested that flow deflectors might not be necessary on all spillbays as a way to reduce costs.

The DGT suggested that a newer design of flow deflectors might be more effective than the 1979 design.

Several comments suggested that the performance of flow deflectors was overestimated in the IAR.

The study team received comments indirectly from the Bonneville Power Administration (BPA). In a letter to NMFS, BPA favored moving directly forward with installation of flow deflectors ("flip lips") at CHJ for the following reasons:

- It may substantially improve dissolved gas management on a system-wide basis and in a cost-effective manner;
- It is the only action justified for implementation in the near term; and
- It would save both time and expense of a long study.

In a report released on 29 September 1998, the Independent Scientific Advisory Board (ISAB) reviewed the Corps' Dissolved Gas Abatement Program. While this program specifically addresses the lower eight Snake and Columbia River dams, some of the ISAB comments pertain to dissolved gas abatement in the entire basin. For example,

- The objective of reducing TDG to the Clean Water Act standard of 110% during times when water is spilled at dams is unattainable even with major reconfiguration of the hydropower system. Attainment of the standard should be considered a policy issue and separated from technical considerations.
- A few critical studies would be useful to refine estimates of the biologically acceptable TDG level, now believed to be about 120%, as a goal for near-term abatement efforts. These studies are considered valuable, but not necessary for the program to proceed.
- Installation of proven technologies, such as flow deflectors, should proceed with all possible speed as an interim measure, regardless of decisions about future hydrosystem configuration.

6. **Focusing of alternatives.** Comments were helpful in focusing the next phase of study by reducing the number of alternatives to be examined. The following is the rationale for down-scoping the number of alternatives to be pursued.

a. **Operate Hydropower Units Outside Peak Efficiency Range.** By itself, this alternative has insignificant benefits for dissolved gas reduction. At best, an additional 4000 cfs could be run through the power units, resulting in a TDG decrease of about one percent. A major drawback to this alternative is increased unit maintenance.

b. **Spill During Maximum Power Generation.** This concept is valid for all projects. The more powerhouse flow, the greater the dilution and, hence, the lower the tailwater TDG (under most forebay TDG conditions). This approach is already partially used when implementing the spill priority list. The 1998 BiOp requires that flows in the Hanford Reach of the Columbia River be maintained at as constant levels as possible. This alternative would fluctuate flows even more dramatically than under current power-peaking operations, resulting in damage to the fisheries in the Hanford Reach.

c. **Swap Power for Spill with Downstream Dams.** Implementation of this alternative is already occurring through use of the Spill Priority List to maximize the effectiveness of existing dissolved gas abatement structures. This list includes both federal and non-federal dams in the basin.

The Bureau of Reclamation (BOR) has proposed an operational alternative similar to this in which flow deflectors would be installed at CHJ. Spill would be increased at CHJ while power generation would be increased at GCL. This joint alternative may be examined in a

study involving BOR, BPA, and the Corps. It should be noted that once CHJ is made more "gas-friendly" (saturates TDG less at high spill), this transfer would automatically occur under application of the spill priority list concept.

d. **Raise Control Flows at the Dalles.** This alternative is being examined by the Northwest Division office of the Corps and is not within the scope of this study. A roughly estimated cost of study has been identified as five million dollars due to the large number of elements in the study (system-wide flow modeling, flood damage assessment, estimating costs for dike strengthening/extension, etc.).

e. **Modify Operation of Grand Coulee Dam.** This alternative has been identified for examination under the joint operation alternative by BOR.

7. **Remaining Alternatives.** To compare the benefits of the three remaining alternatives, a numerical rating of the alternatives matrix in the Initial Appraisal Report was applied. "Flow deflectors" scored an *order of magnitude higher* than did "side channel canal" and "degas at Brewster Flats." The reasons for the fairly substantial difference in scores are summarized below.

a. **Flow Deflectors.** This alternative is a known solution with a high degree of degassing benefits. It increases flexibility for spill and power generation within the Federal Columbia River Power System (FCRPS). The cost for installation at CHJ is estimated to be $40M. A remaining question to resolve concerns negative stilling basin impacts at CHJ.

It has been suggested that the Corps examine flow deflector installation on fewer than all 19 bays. For example, flow deflectors on every other bay, every third bay, or on the center five or ten bays. There are both advantages and disadvantages to such a configuration. The major advantages are reduced construction time and cost. However, flow deflectors are inexpensive relative to other solutions. Coffer dam construction represents a significant part of the cost, so the savings realized with installation of fewer flow deflectors would depend on the coffer dam design.

The disadvantages would be evaluated prior to construction. The spillway would not be as effective at reducing TDG. Damage from high flows to the stilling basin would likely increase. Cost savings may be lost in subsequent repair costs of stilling basin damage.

Lower Monumental Dam on the Snake River provides an example of the damage that can occur when spillway bays with flow deflectors are operated next to bays without flow deflectors. Lower Monumental Dam has flow deflectors installed on only the center of the spillway. When adjacent bays are used, a non-uniform flow condition exists. Debris brought into the stilling basin by deflector bays is caught in the turbulence of non-deflector bays and erodes the stilling basin. At Lower Monumental Dam, a hole has been ground into the stilling basin that now requires a costly repair.

Currently, we plan to look at optimizing flow deflector length, configuration, and height variables in the physical model study.

b. **Side Channel Canal.** The side channel canal alternative would divert spill through a shallow, gently-sloped canal between the forebay and the river below the dam. Foster Creek is the obvious location for the canal to flow into the river.

The major drawback to this solution is the high cost. While costs for this alternative at CHJ have not been detailed, the estimated cost for similar structures at other dams can provide some insight to the cost at CHJ. For a smooth side channel to degas 96,000 cfs to 110% at Lower Granite Dam, the crest length would need to be 3000 feet at a cost of $302M for design and construction. At CHJ, the design flow would be less, but the channel would be twice as long to accommodate twice the head. If a baffled side channel is used, the unit flow can be reduced, for a cost of $230M at Lower Monumental. A baffled side channel at Bonneville Dam for 150,000 cfs is estimated to cost $706M. The corresponding channel at CHJ would have over twice the head.

Baffled side channels may be incompatible with fish passage. Fish get caught in the turbulence and slammed against the baffles. It is unknown if resident fish would be similarly affected at CHJ. Smooth-crested side channels are less damaging to fish.

In either case, the cost is at least ten times the cost for flow deflectors. The limited real estate opportunities would lead to a complicated and long pre-construction phase. This should be considered a long-term (greater than ten years) alternative.

c. **Degas at Brewster Flats.** The last structural alternative identified in the Corps' study of CHJ is a proposal to raise the riverbed in the Brewster Flats area about 10 miles downstream of CHJ. A shallow sill in this area would widen the river, decrease water pressure, and allow dissolved gases to dissipate. This alternative may impact the project with an associated loss of power generation due to an increased tailwater. It may be infeasible due to complicated real estate issues. It would require extensive flood control studies of the Brewster Flats area. It does not degas between the dam and Brewster Flats, a 10-mile stretch of the river that includes the mouth of the Okanogan River, an important stream for threatened steelhead. Under this alternative, adult and juvenile steelhead would need to navigate a short stretch of highly gassed river to enter or exit the Okanogan.

This alternative does not reduce gas production at CHJ, although it does reduce TDG levels in the forebay of Wells Dam (30 miles downstream of CHJ) and beyond. This alternative is highly unconventional and untested. Due to the expected high cost and study/design complications, it should be considered a long-term (greater than ten years) alternative.

In summary, flow deflectors have a much higher chance of reducing dissolved gas in the near-term for the least cost.

8. **Function of the Three Alternatives under Joint Operation of CHJ and GCL for Gas Abatement.** Thus far, the independent studies have identified structural and operational alternatives for dissolved gas abatement. The least costly would be the installation of flow deflectors at Chief Joseph Dam. A joint study between CHJ and GCL has varying implications for each structural alternative at CHJ. Any joint operation alternative would have to address the ramification on power revenue allocation, transmission issues, and potential for increased maintenance costs.

a. **Flow Deflectors.** The spillway at CHJ has three advantages that would positively contribute to the design and function of flow deflectors: 1) only one type of gated outlet, 2) an operating head that varies within only 6 feet, and 3) a tailwater elevation that varies relatively little. Installation of flow deflectors at Grand Coulee Dam (GCL) would cost much more and would be less effective. The head behind the dam is a critical feature in the design of flow deflectors. At GCL, flow deflectors would need to be effective for an operating head that can vary as much as 82 feet. Furthermore, GCL has outlets at three different elevations all on the same face of the spillway, a major complication in the design of deflectors. Because of the high unit flow through the outlet tubes at GCL, flow deflectors would not degas as well as at CHJ with its much lower unit flow.

Under a joint operation alternative, CHJ would spill more while GLC would generate more. This sort of pooling of resources at CHJ to achieve gas reduction at both projects would require a greater volume of spill at CHJ with less gas production, i.e. more flow deflectors.

b. **Side Channel Canal.** If joint operation with GCL is assumed, with more generation at GCL, then more spill at CHJ can be expected. The side channel canal would need to be larger to accommodate this additional spill. For example, if the flow through the two projects equals the 7-day, 10-year flow of 250,000 cfs, then CHJ would need to spill its own design flow of 80,000 cfs plus 50,000 cfs of GCL spill. To degas this additional flow would require a side channel canal 60 percent wider and more costly than in the examples given in section 7b above.

c. **Degas at Brewster Flats.** A shift in generation to GCL and spill to CHJ would result in less gas saturation below GCL and more gas saturation below CHJ. This would be a benefit to resident fish between GCL and CHJ in Rufus Woods Lake. The impact to steelhead migrating into and out of the Okanogan River would be greater, because TDG levels between CHJ and Brewster Flats would be higher than under current conditions. To reach the same gas level reduction with joint operation as under operation of CHJ alone would require a more extensive structure, resulting in a higher cost.

9. **Conclusion.** From the perspective of engineering feasibility/known technology, implementation timeliness, and cost-effectiveness, flow deflectors offer the best potential for

reducing TDG at Chief Joseph Dam. Flow deflectors should be the focus of further evaluation. Key points are:

a. **Solving the problem at CHJ in isolation.** Flow deflectors offer the best TDG reduction for the least cost.

b. **Basin-wide approach.** Flow deflectors at CHJ offer the opportunity to transfer a very large amount of spill to a relatively low-gassing dam, while allowing more power generation and therefore less gassing at other projects. Flow deflectors at CHJ would expand flexibility for spill and power generation in the entire Columbia River hydropower system.

c. **Joint operation with Grand Coulee Dam.** Flow deflectors at CHJ would be much less costly and more effective than at GCL. The much larger powerhouse capacity of GCL can pass 30,000 cfs more than the 7-day, 10-year flow, allowing greater power generation and less spill at GCL. Because CHJ and GCL utilize many of the same transmission lines, this would be a good fit within the hydropower generation system.

10. **Proposal.** The Corps proposes the next phase of evaluation of the Chief Joseph Dam Dissolved Gas Abatement Study proceed with modeling and design of flow deflectors, including an evaluation of installation on fewer than all 19 spillbays. Coincident with this fast-track approach, the Corps would continue to explore the viability of the side channel option as a long-term alternative to achieve 110% TDG. A parallel study should be initiated to address how to jointly operate GCL and CHJ to reduce dissolved gas supersaturation at both projects to the greatest extent possible. Also, the range of capabilities provided by CHJ should continue to be examined in the context of optimized system operation.

11. **Agency Concurrence.** The Corps is asking that the SCT provide feedback to this narrowing of the scope of the studies. Please respond by 4 December 1998 to:

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