Water Quality Plan
for Total Dissolved Gas and Water Temperature in the Mainstem Columbia and Snake Rivers

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With Input and Cooperation from:

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Environmental Protection Agency
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Idaho DEQ
Idaho Power
Nez Perce Tribe
NOAA – Fisheries (NMFS)
Oregon DEQ
Pacific Northwest National Laboratory
US Department of Justice
US Fish and Wildlife Service
Washington DOE

Version 2
December 2004

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0 Introduction

In Appendix B of the National Marine Fisheries Service 2000 Biological Opinion for Operation of the Federal Columbia River Power System (NMFS BiOp), EPA, NMFS, USFWS, and the Federal Action Agencies—the Corps, BPA, and BOR—committed to develop and implement a water quality plan to support TDG and temperature improvements to the Columbia River Basin, mainly in the portions of the Columbia, Snake, and Clearwater rivers where Federal dams exist. This Water Quality Plan (Plan) was prepared by the US Army Corps of Engineers (Corps) through coordination with and input from numerous other state and federal agencies (Table 0-1).

Table 0-1. Agencies coordinating and cooperating with the development of the water quality plan for Appendix B of the NMFS BiOp.

Federal	State	Tribal	Private
Bonneville Power Administration	Idaho DEQ	Nez Perce Tribe	Chelan County PUD
Bureau of Reclamation	Oregon DEQ		Douglas County PUD
Environmental Protection Agency	Washington DOE		Fish Passage Center
NOAA – Fisheries			Grant County PUD
US Department of Justice			Idaho Power
US Fish and Wildlife Service			Pacific Northwest National Laboratory

EPA, NMFS, USFWS, and the Action Agencies intend to integrate their fish and wildlife and water quality efforts in the form of actions to support the objectives and responsibilities of the ESA, CWA, and other fish and wildlife and water quality statutes such as the Northwest Electric Power Planning and Conservation Act. The plan is anticipated to be consistent with the Columbia and Snake River mainstem total maximum daily load (TMDL) limits that are currently being developed by EPA, the states, and the Tribes and focuses primarily on the physical and operational changes to both Federal and non-Federal dams that may benefit water quality in terms of temperature and dissolved gas while improving the survival rates of ESA-listed species. This plan was prepared to satisfy the commitments of the Federal Action Agencies as outlined in the NMFS BiOp.

This document was updated from the previous version, which was finalized in 2003.

0.1 Goals

The goals of the water quality plan are as follows:

• To assist in our understanding of system wide loading capacity and loading allocation by assessing the existing effects at Federal and non-Federal dams and tributaries.

• To provide an organized, coordinated approach to improving water quality, with the long-term goal of meeting water quality standards that the states and Tribes can integrate into their water quality management programs.

• To provide a framework for identifying, evaluating, and implementing reasonable actions for dam operators to use as they work toward reducing temperature and dissolved gas levels.

• To provide a record of the actions that are and are not feasible for structural and operational improvements aimed at improving water quality conditions and meeting water quality standards. This information may provide a basis for future beneficial use and water quality criteria revisions.

• To bring basin wide information into the decision processes regarding dissolved gas and temperature, and to provide technical assessment of a project's relative value in terms of water quality.

• To integrate dissolved gas and temperature work into one process for both Federal and non-Federal dams on the mainstem Columbia River and Snake River system.

Over the long term, with a focus on water quality, Plan implementation anticipates that EPA, NMFS, and the Federal Action Agencies will properly integrate implementation of the Plan to ongoing TMDL development activities on the mainstem and in the sub-basins.

Total Dissolved Gas (TDG)

1 Introduction

The problem of supersaturation of Total Dissolved Gas (TDG) occurs in many rivers throughout the world, but has been noted to be a particular problem in the Columbia River Basin. This excess gas can be a serious threat to the health of aquatic life subjected to it. The exposure of fish to excess dissolved gas can produce a class of physiological problems known as Gas Bubble Trauma (GBT). This condition causes the growth of internal or external gas bubbles, which can be fatal. As a result, the Transboundary Gas Group is facilitating the co-operative efforts of the United States and Canada to undertake various measures that will reduce the amount of dissolved gas in the Basin (Goldschmid 2001).

TDG has been the primary water quality parameter monitored by the Corps to meet the recognized or designated beneficial uses of the states of Idaho, Oregon and Washington. The designated uses include aquatic life, water supply, recreation, wildlife habitats, and aesthetics. High saturation level TDG can cause physiological damage to fish. Water temperature is also measured because it affects TDG saturation levels, and because it influences the health of fish and other aquatic organisms. Both TDG and water temperature are closely linked to water management operations (e.g. water released over the dam spillways, releases through the powerhouses and other facilities, and forebay and tailwater water surface elevations) at Corps projects.

The National Marine Fisheries Service (NMFS) 2000 Biological Opinion (BiOp) on the operation of the Federal Columbia River Power System (FCRPS) established a conservation measure for the development of a Water Quality Plan for the mainstem waters of the Clearwater, Snake and Columbia rivers that are directly impacted by federal dams. The goal of the plan, as outlined in Appendix B of the BiOp, is to outline the physical and operational changes that could be used to improve the overall water quality in these rivers, and to conserve threatened and endangered species, thus meeting the requirements of both the Clean Water Act (CWA) and the Endangered Species Act (ESA).

This Total Dissolved Gas (TDG) document presents the background of TDG issues in the Columbia River Basin, the rationale for preparing the document, what can be and has been done to address and resolve TDG issues, and what the Corps' planned schedule is for addressing these issues. This document is also being prepared in partial fulfillment of the request for gas waivers from the states of Oregon and Washington (Section 1.4) This document is composed of five major categories including:

1) The background of TDG in the Columbia and Snake rivers, the goal of the NMFS 2000 FCRPS BiOp and Total Maximum Daily Loads of TDG.
2) The monitoring of TDG in the area covered by the plan, a description of operational and physical changes that can be made at the hydroprojects

that have potential to lower TDG levels, a description of the numerical models that can be used to look at dissolved gas in the system, and studies and programs of how these goals are examined and accomplished.

3) Discussion of the current configurations of the primary FCRPS hydroprojects, how they are operated and a schedule of past and proposed future TDG related improvement measures.

4) A brief discussion addressing the Reasonable and Prudent Alternatives in the BiOp that are being addressed by this work and the long-term non-BiOp strategy to get TDG levels to 110%.

5) A final summary and appendices.

1.1 <u>Background</u>

When water is spilled over a spillway at a dam, it entrains bubbles of air. As the water plunges into the deep pool (stilling basin) at the base of the dam, the air bubbles carried to depth are subjected to hydrostatic pressure that forces them to dissolve into the water. The air bubbles consist mainly of oxygen and nitrogen, with traces of argon and carbon dioxide, each of which exerts pressure. When the sum of the partial pressures of the gases in the water exceeds their partial pressures in the atmosphere, the condition is called dissolved gas supersaturation. The amount of TDG created, increases with water temperature, spill volumes, and spillway plunge depth.

Spilling water at dams may be done voluntarily or involuntarily. Voluntary spill occurs primarily to assist juvenile salmon migration. This operation is done to decrease residence time of juvenile salmon in the forebay of the dam and to provide a passage route that typically has a higher survival rate than most other routes of passage at the dam. Involuntary spill occurs either due to the physical limitations of the system, because the flow exceeds the hydraulic capacity of the powerplant (can be either limited by generators or by turbines), or because the flow exceeds the available market for the power that can be generated by the plant.

Gas can also be entrained into water that passes through dam turbines or through low-level ports in the dam. Air can become entrained in vortices near the ports or turbine intakes and can be forced into solution due to the very high level of hydrostatic pressure that exists near the ports and turbines but typically, more dissolved gas is created when water is spilled than when it is routed through turbines. Dissolved gas can persist in the river for significant distances downstream; however, each dam has its own unique and strongly localized gassing effect. Kaplan turbines on Snake and Columbia river dams generally do not entrain air and do not generate TDG, rather they simply pass downstream the TDG levels which are present in the forebay waters. Dworshak Dam, however, has Francis turbine units and air is introduced to those units (aspiration) to control cavitation that can physically damage the machines and adjacent supporting structures. TDG is generated during the time when the units are being aspirated normally during low turbine discharges.

In the years just after the completion of the four lower Snake River dams, with both the absence of flow deflectors in most locations and high river discharge levels, smolt survival through the hydrosystem was quite low. For example, in some years during the late 1970's, inriver survival estimates for juvenile Snake River Chinook salmon and steelhead from Lower Granite to Bonneville Dam was under 5% (Corps 2002b - Lower Snake River Feasibility Study) some of which was attributed to high TDG in the lower Snake River. Current estimates of survival in normal flow years, however, are from 40-60% inriver survival. Coupling this with the 98% direct survival of juvenile salmon that are transported form the lower Snake River Dams, has yielded substantially better survival rates for fish than when the dams were first completed. The improvements in fish passage and implementation of the strategy to pass migrating juvenile fish over the spillway despite causing TDG levels in excess of the states water quality standard of 110% probably helped to improve juvenile survival.

1.2 TDG and The Corps of Engineers

The general policies of the Corps related to water quality are summarized in the **Corps Digest of Water Resources Policies and Authorities**, Engineering Pamphlet 1165-2-1, dated February 1996 (Corps 1996). The Corps policy is to comply with water quality standards to the extent practicable regarding nationwide operation of water resources projects. "Although water quality legislation does not require permits for discharges from reservoirs, downstream water quality standards should be met whenever possible. When releases are found to be incompatible with state standards they should be studied to establish an appropriate course of action for upgrading release quality, for the opportunity to improve water quality in support of ecosystem restoration, or for otherwise meeting their potential to best serve downstream needs. Any physical or operational modification to a project (for purposes other than water quality) shall not degrade water quality in the reservoir or project discharges" (Section 18-3.b, page 18-5). The data from the Corps Dissolved Gas Monitoring Program before 1984 was used to voluntarily monitor for compliance with water quality standards. In 1984, the Corps Dissolved Gas Monitoring Program was enhanced to serve the multiple purposes stated in the Corps policies and authorities.

With the listing of certain Snake River salmonids under the 1991 ESA, the Corps implemented a variety of operational and structural measures to improve the survival of listed stocks. The National Marine Fisheries Service (NMFS) 1992 BiOp called for providing summer releases of available water for flow augmentation for migrating juvenile salmon. Spill for fish at the lower Snake River projects was limited to Lower Monumental and Ice Harbor dams. In 1994, the program was further expanded in response to the NMFS request to release water over the spillways at the lower eight Columbia and Snake rivers mainstem dams to a level of 120% TDG where State rule modifications, variances or waivers had been provided. This spill level has become an annual operation for the benefit of ESA listed juvenile fish.

The Corps addressed TDG and water temperature during the ESA consultation in 1994. In a letter from the Corps to the NMFS, dated November 9, 1994, the Corps stated that "Spill for fish passage at Corps projects will be provided in 1995 according to the Fish Passage Plan (FPP) criteria, including any modifications agreed upon in consultation under the [ESA]…Also, any necessary waivers of water quality standards must be obtained beforehand from appropriate State or Federal authorities..."

The Corps' 1995 Record of Decision (ROD) and the 1998 Record of Consultation and Summary of Decision (ROCASOD) adopted the recommendations of the NMFS 1995 BiOp, and the 1998 Supplemental BiOp, respectively. Relevant sections of the 1995 and 1998 BiOps regarding operations that impact TDG levels and water temperature include:

Reasonable and Prudent Alternative (RPA) #2 in the 1995 BiOp identified additional voluntary spill at the lower Snake River projects to achieve 80% Fish Passage Efficiency (FPE) and survival of migrating juvenile salmonids (1995 BiOp, pages 104 - 110). At certain projects, voluntary spill up to 110% TDG would not achieve 80% FPE. Therefore, in recommending the spill levels above the State water quality standard of 110%, NMFS considered the risk of the elevated levels of TDG on migrating salmon and decided the risk was acceptable.

In the 1998 Action Agency Biological Assessment, it was proposed that voluntary spill be minimized at lower Snake River projects due to concerns of high TDG and to maximize fish transportation by barges. During consultation with NMFS this proposal was amended and the 1998 Supplemental BiOp increased the voluntary spill levels partially based on observations made after 1995. "NMFS also believes that moving past the per-project FPE goals (stated in the 1995 RPA) to further increase juvenile survival would not violate the intent of the requests to the State water quality agencies for dissolved gas waivers." (98BiOp, page c-4) NMFS recommended maximum spill up to the higher TDG levels rather than curtailing spill when 80% FPE was achieved, which the Corps agreed to implement. (98ROCASOD) The NMFS 1998 BiOp also asked the Corps to test increasing voluntary spill at John Day Dam from 12 hours to 24 hours. The Corps initiated those studies during the 1999 spring migration.

1.2.1 Mainstem Water Quality Plan Workgroup

The 2000 Biological Opinion observed the complementary features of the ESA and the CWA. It was recognized that an assertive implementation of the dissolved gas and water temperature actions of the Reasonable and Prudent Alternatives (RPA) and Appendix B would promote attainment of water quality standards as well as the recovery of endangered stocks. The NOAA Fisheries, EPA, USFWS and the Action Agencies called for the integration the Biological Opinion water quality actions with the relevant objectives of the CWA and other fish and wildlife and water quality statutes. The mechanism by which this integration could occur was through the development of a mainstem water quality plan.

The Biological Opinion Section 9.6.1.7 and Appendix B charted a course for the development of a comprehensive Columbia and Snake River water quality plan. From the outset of the planning effort it was clear that the scope of the mainstem plan would be broader than the RPAs and would include additional actions to improve mainstem water quality by reducing total dissolved gas and water temperature. Appendix B of the Biological Opinion tabulated actions required to avoid jeopardy as well as those actions that are beyond the scope of the RPAs. However, although Appendix B is not itself a water quality plan it does suggest the procedure for the development of a plan toward attainment of water quality standards in the Federal Columbia River Power System. Furthermore, it was anticipated that a mainstem water quality plan would include Columbia and Snake River TMDL limits currently under development by the states, tribes and EPA.

To this end a Mainstem Water Quality Plan Workgroup (Workgroup) was formed in 2001 and has been meeting regularly since. The Workgroup has produced a detailed outline of a comprehensive Mainstem Water Quality Plan and agreed to the following purpose statement to guide the group's efforts:

- The Mainstem Water Quality Plan Workgroup will work to identify short-term actions for funding and implementation while working towards a long-term water quality plan for the mainstem that coordinates the Federal Columbia River Power System, Northwest Power Planning council sub-basin plans and the Clean Water Act to benefit fish.

In pursuit of this purpose the Workgroup also discussed and agreed to the following goals:

- Provide an implementation plan for water quality actions as called for in Appendix B of the NOAA Fisheries 2000 FCRPS Biological Opinion.
- Serve as an implementation framework for the Columbia and Snake rivers mainstem TMDLs.
- Serve as the implementation framework for total dissolved gas waivers for the Corps of Engineers implementation of the Biological Opinion spill program.
- Full engagement of the Columbia River action agencies.
- Commitment to ongoing Federal Executives dialogue.
- Commitment to use unified and best available science, and
- Commitment to fund the plan development.

Simultaneous to the early meetings of the Workgroup and the drafting of the above statements, the Northwest Power Planning Council conducted a solicitation for projects implementing the Mainstem Provincial Review. The Workgroup reviewed the water quality projects responding to the solicitation and offered policy guidance regarding the proposals to the Power Council and the Columbia Basin Fish and Wildlife Authority. Recently, the Workgroup has focused attention on the drafting of the Mainstem Water Quality Plan.

1.2.2 Water Quality Team

The Mainstem Water Quality Plan Workgroup may have specific technical issues arise as they pursue regional water quality planning and policies. Examples of technical issues could include but would not be limited to total dissolved gas or water temperature improvement topics, research needs or designs, monitoring strategies, or TMDL compliance concerns. In these instances the existing NOAA Fisheries technical Water Quality Team operating in support of the Biological Implementation may be called on for assistance. The Workgroup could also communicate with the other technical teams serving the NOAA Fisheries and the regional

Implementation Team. These teams include the System Configuration Team and the Technical Management Team regarding issues of Federal Columbia River Power System modification and operation, respectively.

1.2.3 Transboundary Gas Group

The Transboundary Gas Group (TGG) was formed in April 1998 during an international conference attended by scientists, planners, and policy-makers from federal, state and provincial agencies, tribes and first nations, private industry, utility owners/operators, and public interest groups from Canada and the United States. The TGG was formed to help coordinate dissolved gas planning activities between Canada, the United States, tribes, first nations, and other organizations. The overall, long-term goal of the TGG is to:

> "Reduce systemwide total dissolved gas to levels safe for all aquatic life in the most cost-effective manner possible"

Initially, a steering committee was developed to help guide the efforts of the group and to monitor its fulfillment of the group's goals. Four technically focused workgroups were also formed to assist in the development of a framework plan. The four groups were:

- Biological Effects and Research
- Monitoring and Information Sharing
- Modeling (Computer Simulations)
- Operational and Structural Gas Abatement

The TGG continues to meet twice each year, usually in the early Spring and again in the Fall. The latest developments in dissolved gas monitoring, abatement methods, modeling, and biological effects are discussed at the meetings. The group has also offered opinions and guidance regarding dissolved gas questions that have arisen in the Pacific Northwest.

To date the TGG has developed a "Framework Plan for Coordinating Activities of the Columbia river Transboundary Gas Group" and offered Canadian energy entities, specifically Columbia Power Corporation and Tech-Cominco, letters endorsing structural and operational gas abatement initiatives. Through contractual support by the British Columbia Ministry of Environment, Lands, and Parks the TGG also produced a paper addressing the international treaties affecting potential water quality actions and remediation, Treaty Implications of Dissolved Gas Management in the Columbia River Basin

1.3 2000 FCRPS Biological Opinions

The Final 2000 NMFS and FWS 2000 Biological Opinions for operations of the Federal Columbia River Power System (FCRPS) state: "The two agencies intend the recommendations and requirements of these opinions to be mutually consistent. They represent the Federal biological resource agencies' recommendations of measures that are most likely to ensure the survival and recovery of all listed species and that are within the current authorities of the Action agencies."

According to the UFWS 2000 BiOp, operational and structural changes are to be made to reduce uncontrolled spill and the effects of high levels of TDG at lower Columbia River dams if it is determined that bull trout are affected by the FCRPS.

The NMFS 2000 BiOp identified metrics that are indicative of juvenile fish survival to meet system-wide performance objectives consistent with actions likely to avoid jeopardizing the continued existence of 12 listed fish species in the Columbia River Basin. To achieve the objectives of the BiOp, NMFS developed the jeopardy analysis framework. It was recognized that, in many instances, actions taken for the conservation of ESA-listed species also move toward attainment of State TDG and water temperature standards.

There are 14 RPAs (namely, RPAs 130 to 143) identified as part of a water quality strategy in the NMFS 2000 BiOp. Specifically, RPA's 131 and 132 deal with water quality monitoring. RPA 131 indicates that the physical and biological monitoring programs are to be developed in consultation with the NMFS Forum regional Water Quality Team and the Mid-Columbia Public Utility Districts (PUDs). RPA 132 specifies that a plan must be developed to perform a systematic review and evaluation of the TDG fixed monitoring stations (FMSs) in the forebays of all the mainstem Columbia and Snake River dams.

Appendix B of the 2000 NMFS BiOp, is meant to address conservation measure actions in the mainstem Columbia River that go beyond the ESA guidelines. The Appendix B geographic scope ranges from the International Border to the Bonneville Dam tailrace, in the mainstem Snake River from Brownlee Dam to the mouth and in the Clearwater River from Dworshak Dam to the mouth. In Appendix B, NMFS indicates that their goal is to get TDG levels to no more than 110% for river discharges up to the 7-day, 10 year flow in all critical habitat of the basin.

In developing the BiOp, however, the goal of NMFS was also to consider the respective ecological objectives of both the CWA and ESA. In many instances, the goals of the two acts are mutually inclusive in that many of the benefits of appropriate levels of dissolved gas and temperature can be realized by the endangered species within the system. However, despite the overlap, there may be actions that help to meet the CWA that have detrimental, little, or no effects on endangered fish species.

1.4 Variances to the TDG Standards

One of the components of the NMFS 2000 BiOp water quality strategy was for the Corps to take the actions necessary to implement the spill program at the dams called for in the BiOp, including obtaining variances from appropriate State water quality agencies of Idaho, Oregon, and Washington. The Corps took the actions necessary for the 2001 and 2002 spill seasons.

The Corps also addressed variances from the TDG water quality standard with the States and tribes impacted by the program implemented in the FCRPS for which the Corps has responsibility. As a long-term strategy, the Corps opened discussions about the process of pursuing long-term variances from the entities involved, hoping to eventually replace the year-to-year processes. A regional water quality plan group worked in 2002 to develop a regional water quality plan that this document represents. The Corps is developing its component portion of the regional water quality plan and the water quality agencies of Oregon and Washington are working to consider longer-term numeric criteria changes. The State of Oregon is considering a three-year TDG variance and the state of Washington is considering a 5-year rule modification.

Meetings will be held to continue to pursue long-term variance and rule modification. Also discussed will be the relationship for the regional water quality plan to implementation plans of TDG and water temperature Total Maximum Daily Loads (TMDLs).

1.5.1 Idaho

The State of Idaho was approached in 2001 concerning a variance to water quality standards. The State, in conjunction with the tribes, provided a set of conditions that must be met as part of the variance process. Due to the conditions provided by the State and tribes, the forecasted drought conditions and the foreseen use of Dworshak water releases, there was no further pursuit of a water quality variance by the Corps after the 2001 water year. State water quality standards were generally met.

1.5.2 Oregon

The Corps took appropriate actions for attaining a water quality variance from the State of Oregon for the 2002 spill season. A report of the 2001 TDG monitoring program was provided to the Oregon Department of Environmental Quality on December 28, 2001 that also included a request for a variance during the 2002 spill season. The Oregon Environmental Quality Commission met on March 8, 2002 and approved a variance for the 2002 spill season, subject to specific conditions, as signed by Stephanie Hallock on March 8, 2001. A variance of the TDG standard for the Columbia River was provided from midnight on April 1, 2002 to midnight August 31, 2002. The Commission approved a TDG standard for the Columbia River of a daily (12 highest hours) average of 115% as measured in the forebays of McNary, John Day, The Dalles, and Bonneville dams, and at the Camas/Washougal monitoring stations. They approved a cap on TDG for the Columbia River during the spill program of 120% measured at the McNary, John Day, The Dalles, and Bonneville dams tailwater monitoring stations, based on the average of the 12 highest hourly measurements per calendar day. The Commission also approved a cap on TDG for the Columbia River during the spill program of 125%, based on the highest two hours per calendar day. The Commission also required that if 15% of the juvenile fish examined showed signs of gas bubble disease in their non-paired fins, where more than 25% of the surface area of the fin was occluded by gas bubbles, the variance would be terminated.

The following conditions were incorporated into the Commission's variance. The Corps was to provide written notice within 24 hours to the Oregon Department of Environmental Quality on any exceedances of the conditions in the variance as it relates to voluntary spill. The Corps was to provide a written report of the 2002 spill program by December 31, 2002 and supply information on the levels of TDG, fish monitoring, and incidence and severity of GBT. Additionally, any proposal for a modification to the TDG standard in 2003 was to be received by the Oregon Department of Environmental Quality no later than December 31, 2002.

1.5.3 Washington

The State of Washington modified its rule on TDG standards for multi-year to accommodate fish passage spill as called for in the NMFS Biological Opinions. The rule was in effect until 2003. Additional actions with the State were not required for the 2002 water year.

1.6 Total Maximum Daily Loads (TMDLs)

A TMDL is a CWA tool for meeting water quality standards and is based on the relationship between pollution sources and in-stream water quality conditions. A TMDL establishes the allowable loadings or other quantifiable parameters for a water body and thereby provides the basis to establish water quality-based controls. These controls should provide the pollution reduction necessary for a water body to meet water quality standards.

TMDL Implementation Plans are developed by States to achieve the load allocations identified in the TMDL. Implementation actions include the NPDES Permit Program, State Water Quality Certification Programs, State Non-point Source Management Programs and other mechanisms.

For Columbia/Snake Mainstem TDG TMDLs, implementation plan development and implementation are the responsibility of the states of Oregon and Washington in coordination with Columbia Basin Tribes. However, these states will rely heavily on the Federal Agencies that administer and operate the Federal Columbia River Power System. Further progress in TDG reductions in the Columbia and Snake rivers will require a system-wide evaluation of the Columbia and Snake River system. This will require regional, national and international forums for problem identification and problem solving. It is hoped that this Water Quality Plan will form the fundamental foundation for the TMDL implementation plans for the Columbia and Snake River.

1.7 Existing TDG TMDLs

In September 2002, a TMDL was released for TDG in the lower Columbia River, from the mouth of the Snake River near the Tri-Cities Washington to the mouth of the Columbia at the Pacific Ocean (http://www.deq.state.or.us/wq/TMDLs/TMDLs.htm). Elevated TDG levels are caused by spill events at the four hydroelectric projects on the lower Columbia River and this entire reach is considered impaired for TDG. The states of Oregon and Washington have both listed multiple reaches of the lower Columbia River on their federal CWA 303(d) lists due to TDG levels exceeding state water quality standards.

The water quality standards for both Oregon and Washington have an identical TDG criterion: *110 percent of saturation not to be exceeded at any point of measurement.* This criterion does not apply to flows above the seven-day, ten-year frequency flow (7Q10) flood flow. In addition, special "waiver" limits for TDG have been established as a temporary special condition in Washington rules, to allow higher criteria with specific averaging periods during periods of spill for fish passage. Oregon rules specify a process for establishing waiver limits as variance on an annual basis. Because the waiver limits are either temporary or annually renewed, this TMDL addresses only the 110 percent criterion. However, the implementation plan allows compliance with waiver limits through 2010 as an interim allowance for compliance with the TMDL in the short-term.

1.8 Anticipated TDG TMDLs

Four additional TMDLs for TDG are anticipated within the near future. A plan for the lower Snake River is currently in progress and is being compiled by the Washington Department of Ecology (WDOE). A plan for Hells Canyon was released as a draft in December of 2001 (http://www.deq.state.or.us/wq/TMDLs/Snake/srhctmdl.pdf) and additional plans for Lake Roosevelt and the Mid-Columbia River will be compiled by the Environmental Protection Agency and WDOE.

2 Monitoring/Modeling/Operations/Structures

2.1 Physical Monitoring

The Corps plan of action for TDG monitoring for 2003 can be found in Appendix D. This plan is produced annually in coordination with the Fish Passage Plan and provides greater detail for those who are interested. Additionally, a similar TDG monitoring plan is prepared for the Technical Management Team Water Management Plan. The details of the 2003 water-quality monitoring plan are in Appendix 4 of the annual Water Management Plan.

2.2 Purpose of TDG Monitors

In general the water quality fixed monitoring stations are designed for the following purposes.

a. To provide river operations and fisheries managers with synthesized and relevant information needed to control dissolved gas supersaturation in the river system on a real time basis.
b. To determine how project releases affect downstream water quality and aquatic habitat relative to ESA Biological Opinion measures and CWA related state and tribal dissolved gas standards.

c. To identify long-term changes in basin wide dissolved gas saturation levels resulting from water management decisions (structural and operational) and/or natural processes, i.e., trend monitoring.
d. To provide data of known quality to enhance analytical and predictive capability of existing models/tools used to evaluate management objectives.

2.3 TDG Fixed Stations - Function and Location

Since 1994, two different types of fixed water quality monitoring stations have been used to achieve the purposes outlined in 2.1.1. Forebay and tailrace monitors are maintained by the Corps of Engineers at each Corps hydroproject and record temperature, and total gas pressure. This information is coupled with operational data and reported in near real time at http://www.nwd-wc.usace.army.mil/tmt/wcd/tdg/months.html. In general, the stations located downstream of the project within the tailwater channel are intended to monitor spillway releases and those in the forebay are intended to be sample conditions representative of the total river.

The tailwater instruments are located near the project and are generally positioned in the spillway releases, downstream of aerated flow and prior to complete mixing with powerhouse releases. The tailwater location often captures spill water average to peak TDG concentration. The forebay instruments are located in the forebay of the receiving pool project. The project forebay TDG monitors are intended to represent a mixed cross section in the river just upstream of the dam and can be a fair approximation of aquatic habitat conditions as defined by TDG and water temperature in that area of the pool. This information is often applied to spill management practices for the upstream project and is applied to water quality compliance monitoring as well. Because TDG concentrations measured and recorded at fixed monitoring locations downstream and within the forebay of each project are used to manage voluntary spill releases, verification of these measurements has become part of the data collection effort.

2.4 Results of Annual Physical Monitoring

A TDG report containing the physical gas monitoring is prepared by the Corps Reservoir Control Center annually and distributed to regional stakeholders. The States of Oregon and Washington have made the annual reporting of the biological and physical monitoring a component of the state variance and rule modification processes. The Corps 2002 TDG report is included in Appendix A.

2.5 BiOp TDG Physical Monitoring Requirements - RPA Action Item 132

The 2000 Biological Opinion Reasonable and Prudent Alternative (RPA) Action Item 132 required the Action Agencies to develop a plan to conduct a systematic review and evaluation of the total dissolved gas (TDG) fixed monitoring system (FMS) in the forebays of all the mainstem Columbia and Snake river dams. The evaluation plan was to be developed by February 2001 and included as part of the first annual water quality improvement plan. The Action Agencies, NOAA Fisheries and the Washington Department of Ecology formed a special subgroup of the Water Quality Team to aid the implementation of Action Item 132. The FMS subgroup has been conducting a systematic evaluation of forebay and tailrace fixed monitor locations in the mainstem Columbia and Snake rivers.

The management of the Biological Opinion Spill Program relies on the(FMS). The locations of the FMS stations can have a significant effect on the measurements of dissolved gas and can mislead the river managers in their efforts to control spill to benefit fish while remaining attentive to water quality standards.

The TDG monitoring in tailraces has produced variable results associated with differences in dam operations. Operational differences cause the proportion of spill and powerhouse discharges to change in space and time. Also, the tailrace monitors are located at various distances downstream from the hydro projects. The degree to which the spillway and powerhouse flows are mixed reflects the distance from the project and the hydrodynamics of that section of the river.

Forebay monitors typically are located on the pier noses and other portions of hydroprojects near turbine intakes or spillways. Recent Corps investigations have demonstrated the influence of certain environmental factors on the measurements of TDG. The environmental factors include water temperature, wind, barometric pressure, solar input, and biological activity (photosynthesis). The forebay waters are subjected to these influences throughout the transit from the tailrace of the previous upriver dam. Several of these environmental factors can cause dissolved gas readings to increase although the mass of gas dissolved has not changed. Sustained winds can result in off-gassing and lowering the amount of TDG in river waters as it passes through the reservoirs. The challenge for the WQT subgroup has been interpreting the TDG record and suggesting FMS locations that minimize the influence of these environmental factors and improve the representativeness of the stations.

The FMS subgroup has reviewed the data from the FMS for the past two years and made recommendations to the Corps for adjustments to the system. The Camas/Washougal monitor was one of the initial concerns. This station is an obvious deviation from the normal forebay monitoring location. In February 2002 the subgroup recommended the installation of a new monitor in the Corbett region of the river to serve as a point of comparison for the Camas/Washougal station. Other recommendations made in 2002 included the addition of a new FMS station on the west end of The Dalles powerhouse and the testing of new monitor locations for the forebay monitors at John Day, McNary, Ice Harbor Lower Monumental, Little Goose and Lower Granite dams. All of these powerhouse monitors are influenced by localized warming of the surface waters and vertical density gradients. Relocation of the monitoring probe to a position free from the surface warming due to solar input and summer air temperatures could eliminate or drastically minimize the influence of the major environmental factor, i.e., water temperature spikes.

At the recommendation of the Fixed Monitoring System (FMS) subgroup of the Water Quality Team (WQT) the Walla Walla District, Army Corps of Engineers conducted a review and evaluation of forebay fixed monitoring stations within its purview. This study was conducted during the 2003 fish spill season at McNary Dam and the four Lower Snake River projects, Ice Harbor Dam, Lower Monumental Dam, Little Goose Dam, and Lower Granite Dam. The basic approach was to evaluate the general representativeness of the six forebay TDG fixed monitors, two at McNary and one at each of the other four projects. In addition, alternative monitor locations were evaluated and compared to the existing FMS station. The study included alternative stations near to the existing FMS station but deeper, 10-meters versus 5-meters for existing. Additional alternative sites were included in the releases on the draft tube deck, on the upstream navigation lock guide wall, and suspended from buoys upstream of the projects.

All of the existing project forebay FMS stations were problematic in that each experienced thermally induced TDG pressure spikes during the test period. Some experienced spikes exceeding 5 % saturation fluctuation on a daily basis. This phenomenon is due to near field hydrodynamics coupled with vertical thermal gradients in the water column. Those monitors that are located on or near the upstream face of the powerhouse can be impacted by the down welling of the warm surface waters which result in the ambiguous and non-representative spiking of the TDG. The more significant occurrences were identified for McNary and Lower Granite dams. These sites also resulted is a relatively high number of exceedances of the water quality standard for TDG for the study period. The data suggests the fixed monitor instruments can often report TDG values that are not representative of the forebay waters and may not meet the requirements or purpose of the FMS station.

The primary recommendations for improving the forebay FMS operation and representativeness are twofold. The first is to relocate each instrument to an area just upstream of the project not affected by down welling surface waters. This first choice is the upstream tip of the navigation lock guide wall or any other floating structure that does not impact flows near the instrument. Note that the Lower Granite FMS station is already positioned upstream. The second recommendation is to position each instrument at a depth of 12-15 meters. This would be adequate to avoid thermal responses in the TDG pressure readings brought about a general deepening of the warm surface layer.

At the FMS subgroup meeting in December of 2003, the subgroup recommended that the 2004 spill year be used as a transition year for Walla Walla District's FMS forebay monitors. To that end they recommended that the existing FMS forebay monitors at these projects continue to be used to manage spill for 2004. Monitors will also be deployed for the 2004 spill season at the following alternate locations in order to further evaluate and support permanent relocation to these sites in FY 2005.

- McNary Dam – two stations at 15 m depth, one on the tip of the navigation lock guide wall and one on a buoy located upstream of the powerhouse near the MCNFBBRZP1 station
- Ice Harbor Dam – station near the upstream tip of the navigation lock guide wall at 15 m
- Lower Monumental Dam – station near the upstream tip of the navigation lock guide wall at 15 m

- Little Goose Dam – station near the upstream tip of the navigation lock guide wall at 15 m
- Lower Granite Dam – station at existing location on the navigation lock guide wall at a depth of 15 m

3 Biological Monitoring

3.1 Results of the 2002 TDG Biological Monitoring

Biological monitoring of juvenile salmonids in 2002 for GBT was conducted at Bonneville and McNary dams on the lower Columbia River, and at Rock Island Dam on the mid-Columbia River. The Snake River monitoring sites were Lower Monumental , Little Goose, and Lower Granite dams. Sampling of fish began the first full week of April at all sites and continued through mid-June at the Snake River sites, when the numbers of steelhead and yearling chinook were too few to sample effectively. Subyearling chinook were not sampled in the lower Snake River due to their endangered status and because the Biological Opinion does not call for the implementation of summer spill at the Snake River collector projects. Sampling of subyearling chinook did occur at Columbia River sites until the end of August.

In 2002, a total of 13,477 juvenile salmonids were examined for GBT between April and August. A total of 155 or 1.2% showed some signs of GBT in fins or eyes. (For a more detailed description of GBT monitoring in 2002, please see Appendix A).

The prevalence and severity of fin signs in juvenile salmonids sampled in the lower Snake and lower Columbia rivers from 1995 to 2002 reflected changes in TDG conditions in the river from year to year. In 1995 no fish had severe fin GBT and 1995 had the lowest number of days with high TDG. Also the occurrence of severe signs in 1996 and 1997, and the increase in exceedances of the NMFS action criteria, reflected a significant increase in the number of days when TDGS rose above 125% in the forebays of these dams. While in 1998 only 4 fish were found with severe fin GBT and 1 fish in 1999, reflecting the more moderate conditions found in the river. (Corps 2002a)

3.2 Biological Monitoring Plan for 2003

Biological monitoring in 2003 for GBT will be the same as that which occurred in 2002 and previous years. Sampling would occur at Bonneville, McNary, Rock Island, Lower Granite Little Goose and Lower Monumental Dams as mentioned in section 2.2.1.

3.3 Modeling

Modeling of the river system is typically done to aid in decision making for fish and water quality issues. Modeling can be categorized into two main groupings. Physical models, or precision scale mock-ups of the dams, and computer based computational models designed to model inriver conditions over longer reaches than the physical models can accommodate.

3.3.1 Physical Hydraulic Models – Engineering Research and Development Center

Physical hydraulic model studies of the tailrace conditions at various dams have been constructed at the Engineering Research and Development Center (ERDC) in Vicksburg, MS. Currently, general models, or physical models of the entire dam (including forebay and tailrace geomorphology), exist for Chief Joseph Dam and every mainstem Snake and Columbia River federal fish-passing dam. In addition, sectional models, or partial cross sectional models of sections of the dams, exist for many of the spillways of these dams. Among other various objectives, these models can be used to develop spill patterns to achieve acceptable tailrace hydraulic conditions for adult fish passage, juvenile fish egress from the tailrace areas, and optimum conditions for TDG abatement. Other concerns that have been tested using the physical models include but are not limited to RSWs and spillway/powerhouse divider walls.

3.3.2 Mathematical Models

Two mathematical models (MASS1 AND MASS2) were developed by Battelle Pacific Northwest Laboratories and utilized during the Dissolved Gas Abatement Study (DGAS, See section 2.4). These models were primarily developed to provide information for the study and were not intended for use with real-time operational decisions. The models are in an expert user status and could be used for real-time decision-making but would need further work to provide user manuals and interface. A simpler spreadsheet model (SYSTDG) was also developed as a result of the DGAS study. This model was intended to be used as an operational decision making tool. Development is ongoing.

3.3.3 MASS 1

Mass 1 is a one dimensional, unsteady hydrodynamic and water quality model for river systems. It was developed to be used on branched (tree-like) channel systems and has been extensively applied by Battelle Pacific Northwest Division to the Columbia and Snake rivers. The model simulates cross-sectional average values and only single values of water surface elevation, discharge, velocity, concentration, and temperatures are computed at each point in the model, at each time interval.

3.3.4 MASS 2

MASS 2 is a two- dimensional, depth-averaged hydrodynamic and transport model for river systems. It simulates time varying distributions of the depth averaged velocities, water temperature, and dissolved gas. The model is capable of simulating mixed sub-critical and super-critical flow regimes. The model is an unsteady finite-volume code that is formulated using general principles described in Patankar (1980). It uses a structured multi-block scheme on a curvilinear grid system and is formulated using orthogonal, curvilinear coordination system in a conservation form using a full-transformation in the curvilinear system by Richmond (1986).

3.4 SYSTDG

The Corps of Engineers and the Bureau of Reclamation, with assistance from BPA, initiated a joint study to determine the most efficient and effective dissolved gas abatement measures at Chief Joseph and Grand Coulee dam. A System TDG model was developed (SYSTDG) in response to this study with the purpose of assessing how the Columbia River system would best benefit from proposed gas abatement measures and operational schedules. The concepts and application of the SYSTDG decision support tool were presented first to the action agencies and regional representatives in February of 2000 and to the Implementation Team in July of 2000. The need for a system model of TDG was outlined in the 2000 Draft BiOp to assist spill and TDG management planning throughout the Columbia River Basin.

The SYSTDG model predicts the TDG loading at each project in the system subject to project operations and routing of TDG pressures generated by upstream projects. The TDG pressures of spillway releases are determined from a set of empirical equations based upon observations of TDG exchange associated with highly aerated flow. The passage of water through the powerhouse does not change the TDG content and thereby retains the TDG pressures present in the forebay of a project. However, the powerhouse releases can either be entrained into the highly aerated flow below the spillway and acquire elevated TDG pressures or mix with spillway releases downstream of the highly aerated flow. The SYSTDG model predicts the average TDG levels in the forebay of a dam and TDG pressures associated with both spillway and powerhouse releases. The system is represented as a simple linked node network where TDG pressures are estimated from project operations and routed downstream to the next project. The average TDG pressures associated with project operations are routed through each pool subject to dispersion and exchange at the water surface. The influences of tributary inflows are also accommodated in this formulation. The variation in water temperature on TDG pressures can also be accounted by the model provided the net change in water temperature is provided.

3.5 Dissolved Gas Abatement Study (DGAS)

The Dissolved Gas Abatement Study (DGAS) is an element of the Columbia River Fish Mitigation Program (CRFMP) and was initiated in 1994. It was established to examine potential methods for reducing TDG supersaturation produced by spillway operations on the eight Corps' dams on the lower Snake and Columbia rivers. The DGAS was conducted in two phases. Phase I consisted of a general investigation of alternative concepts and Phase II was a continuation of analysis and evaluations based on recommendations and study plans identified in the Phase I report.

The Phase I report was published in April 1996 and a Phase II 30% report was released in 1997. It identified a shift from the 110% goal to a new goal designed to reduce TDG to the extent economically, technically, and biologically feasible. A 60% report on Phase II of the DGAS was released in 1999. A draft final Phase II report was distributed for review and comment in April 2001 and the study was completed in May 2002.

Near the conclusion of the DGAS Phase I, several alternatives were identified for immediate implementation. These alternatives consisted of spillway flow deflectors at Ice Harbor and John Day dams and spill pattern changes at Little Goose and Lower Monumental dams. The completion of 10 spillway flow deflectors at Ice Harbor in 1998 lowered peak TDG production levels of near 170% TDG to less than 125 % TDG for similar spill levels. The completion of 18 spillway flow deflectors at John Day in 1999 resulted in similar reductions. The new spill patterns at Little Goose and Lower Monumental resulted in TDG reductions of 5 to 10%.

For the lower Columbia and Snake River dams, the study recommended moving forward with the deflector optimization program which includes possible operational changes (spill pattern adjustment) and optimizing performance of spillway deflectors through addition of deflectors or modification of existing deflectors if necessary. Additional modifications that would further reduce the production of TDG included construction of powerhouse/spillway divider walls and additional spillway bays.

3.6 Dissolved Gas Fast Track Program

Because of the success of the gas abatement improvements at John Day and Ice Harbor dams, decisions were made to move forward with the implementation of additional flow deflectors at all projects where possible, concurrently with the Phase II DGAS. The Dissolved Gas Abatement Fast-Track (Deflector Optimization) Program was established and funded to accomplish this and is currently ongoing.

The history and anticipated FCRPS project modifications that may result from the Fast-Track Deflector Optimization Program are summarized in Table 2-2. A more detailed discussion of modifications being considered at individual projects follows the table.

3.7 Operations at Hydroprojects

The water quality standard and criterion developed by the states and EPA is 110% of saturation at ambient temperature and pressure. The Corps' policy is to operate each mainstem project to meet state standards insofar as physically possible unless other overriding reasons cause temporary deviations. The Corps also recognizes that the NMFS 2000 BiOp calls for fish spill to be provided at levels that create TDG levels exceeding 110%. The Corps operates its lower Snake and lower Columbia dams to meet the NMFS 2000 Biological Opinion spill of 115% TDG in the project forebays and 120% in the project tailwaters. Spring freshet river flows above the generation capacity of the FCRPS projects has occurred in the past, causing TDG levels to exceed the 115% and 120% levels for fish passage. Also, implementation of fish spill requests from fisheries agencies and tribes has resulted in TDG levels of 120% or greater. Therefore, fish

Table 3-1 Summary of the Current Status of the Corps' Gas Abatement Fast-Track Deflector Optimization Program.

Project	Pre-1995 Number of Spillbays with Deflectors	Post-2003 Number of Deflectors	Total Number of Spillbays
Bonneville	13	18	18
The Dalles	SIS[1]	SIS[1]	22
John Day	0	18	20
McNary	18	22	22
Ice Harbor	0	10	10
Lower Monumental	6	8	8
Little Goose	6	6	8
Lower Granite	8	8	8

[1]SIS – Spillway Improvement Study is underway and will analyze various spillway modifications designed to improve juvenile fish survival through The Dalles spillway passage route. Improvements currently being considered include modifications to the baffle blocks and endsill, construction of spillway deflectors and training walls and spill pattern modification.

spill implementation will be subject to further coordination with appropriate entities if excessive TDG levels occur or if evidence of gas bubble disease is observed in fish. The Corps will take those actions necessary to coordinate with the region and provide spill to protect ESA-listed fish in 2003. TDG levels are provided to the TMT and summarized for the year in the Corps' annual TDG Monitoring report.

Presently, the Corps is planning to provide spill for juvenile fish passage at its mainstem projects to protect ESA-listed salmon species as specified by the NMFS BiOp. Target spill levels are developed through consultation with NMFS and may be adjusted during the fish migration season as recommended by the Technical Management Team (TMT).

Continuous spill is provided at Bonneville, The Dalles, and Ice Harbor dams, and nightly spill is provided at John Day Dam for spring and summer outmigrants to meet BiOp measures. Also, continuous spill at Lower Monumental Dam will resume in spring 2003 after stilling basin repairs have been completed. Nightly spill is provided at McNary, Little Goose, and Lower Granite dams for spring outmigrants. Spill may also be provided under special circumstances for non-listed fish species if recommended by the fisheries agencies and tribes and if the recommendations are consistent with regional operational agreements (i.e., Spring Creek

National Fish Hatchery release in March) Please see BiOp pages 9-88 to 9-92 for more detailed information.

3.7.1 Changes in Hydroproject Operations

Changing the way a hydroproject is operated (in addition to modifying total volume of spill) can also have impacts to the amount of TDG that can be produced below a dam or a series of dams. Three examples of operational changes that can be instituted include the changing of spill patterns at individual hydroprojects, shifting of power production between dams, and spill prioritization at projects.

3.7.2 Spill Priority and Operational Changes

The Corps has developed tools to estimate the amount of gas produced at incremental spill levels. At the start of each spill season (April 1 to August 31), a spill priority list is developed. When the hydraulic capacity of the hydropower system is exceeded, a spill priority system would be used to spread excess spill over the entire system to minimize high TDG levels. Spill cap volumes are estimated on a daily basis so that forebays spill near to, but don't exceed, 115% and tailwaters don't exceed 120%.

Spill priority is a tool that is used in an effort to control TDG to 120%, 125%, 130% and 135% when necessary. When system wide TDG exceeds 120% TDG, then an attempt will be made to control system wide TDG to 125%, then to 130% and so on by spilling up to the spill caps indicated for those TDG levels, at lower Columbia, Snake, mid-Columbia, HGH, and Willamette Projects in that order.

When system wide TDG is at or below 120%, spill for fish passage would be conducted up to the 120% TDG spill caps in the following order: McNary, John Day, The Dalles, Bonneville, Lower Monumental, Little Goose, and Lower Granite dams. In addition, spill could occur up to the 110% TDG spill caps at projects outside the lower Columbia River fish migration corridor: Priest Rapids, Rocky Reach, Wells, Rock Island, Wanapum, Chief Joseph, Grand Coulee, and Dworshak dams in that order.

Spill caps for various applicable TDG levels are provided in Table 3-2. They are updated, as needed based on real-time TDG information.

3.8 TDG Exceedances

Due to involuntary spill, exceedances in the TDG standards can occur throughout the year. As described in Section 1.1, involuntary spill occurs either; due to the physical limitations of the

Table 3-2 Spill caps (in kcfs) corresponding to 110-135 % TDG Levels

PROJECT	TDG%	TDG%	TDG%	TDG%	TDG%	TDG%	REMARKS
	110	115	120	125	130	135	
MCN	20	80	170	250	340	410	(NEW DATA)
JDA	40	90	160	300	400	450	(NEW DATA)
TDA	50	100	200				(NEW DATA)
BON	70	120	170	250	300	370	(NEW DATA)
IHR	20	45	85	120	145	160	(NEW DATA)
LMN	35	40	45	70	170	250	(NEW DATA)
LGS	30	35	50	80	200	250	(NEW DATA)
CHJ	05	27	30	33	50	70	(NEW DATA)
LWG	20	40	60	90	130	190	(NEW DATA)
DWR	03	07	12	15	15	15	(NEW DATE)
WAN	10	15	20	50	100	200	
PRD	25	30	40	100	210	350	
RIS	05	10	20	30	150(1)	300	(LIMITED DATA)
RRH	05	10	20	30	150(1)	300	(LIMITED DATA)
WEL	10	15	25	45	130(1)	250	(LIMITED DATA)
GCL(2)	0 20	5 25	10 30	20 75	35 120	55 170	
HGH	03	3	3	3	3	3	
HCR	04	4	6	6	6	6	
LOP/DEX	05	5	5	5	5	5	
GPR	02	2	2	2	2	2	
DET/BCL	07	7	7	7	7	7	
PROJECT	TDG%	TDG%	TDG%	TDG%	TDG%	TDG%	REMARKS

1. 1. Limit daytime spill to 100 kcfs -
2. 2. Assume forebay TDG at 120% (1st row=outlet El<1260'), 2nd row=spillway (El>1260')
3. 3. HGH spill to 3 kcfs (110% TDG) until further notice

system, because the flow exceeds the hydraulic capacity of the power plant (can be either limited by generators or by turbines), or because the flow exceeds the available market for the power that can be generated by the plant. As the term suggests, the Corps has no other alternative but to spill and has little to no control over when this might occur.

When TDG exceedances do occur, spill caps are changed to reduce spill in order to be in compliance with the 115% or the 120% TDG levels. Each exceedance is then evaluated to see if any of 12 factors contributed to the occurrence of the exceedance. Changes in spill are then made, daily if necessary, to correct spill to eliminate exceedances.

The 12 criteria used to evaluate the spill level at each project during each day of the spill season are as follows:

1. BiOp Guidance, Table 9.6-3 (on Page 9-89) Estimated spill levels and gas caps for FCRPS projects during spring (all) and summer (non-transport) projects.

    a. Limiting Factors: gas cap, % of river flow (JDA-60% at night, TDA 40% of instantaneous flow), and minimum spill at BON of 75 kcfs.

2. Oregon Variance and Washington Rule Change (115% forebay, 120% tailwater)

    a. Corps Check Spill Program (graphic) reviewed daily; calculate high 12-hour daily average. TMT Webpage www.nwd-wc.usace.army.mil/tmt/
        1. Operations
        2. Spill Charts

    b. Daily TDG Spill Decisions, numeric data of project forebay and tailwater reviewed daily and put in a Spill Log.
        1. TMT Webpage at www.nwd-wc.usace.army.mil/tmt/
        2. Related Links
        3. RCC-WQT
        4. 2002 Spill Log

    c. Daily High-12 hour TDG level reported to TMT every two weeks.
        1. TMT Webpage at www.nwd-wc.usace.army.mil/tmt/
        2. Operations
        3. Spill Charts (example: May 24)
        4. Annual summary

3. Firm Generation Commitments

    a. LWG, LGS, LMN, IHR 11.5 kcfs
    b. MCN, JDA, TDA 50 kcfs
    c. BON 30 kcfs

4. Project-by-Project Guidance, DGAS Report. Project TDG Performance Graphs

5. Travel Time Guidance

6. Basic Adjustment Guidance:

    a. Snake projects – 5 kcfs change results in about 2% change in TDG.

b. Columbia projects – 10 kcfs change results in about 2% change in TDG
c. SYSTDG guidance for BON (with new deflectors on bays 1-3 and 16-18) Graphics based on variable spill levels based on variable inflowing TDG.

7. Weekend Guidance: Total River Flow can significantly decrease on weekends, causing a resulting increase in TDG if the Friday spill level is not changed.

    a. SSARR guidance for forecasted total river flow

8. Monday Guidance: Beginning-of-the-Week Total River Flows on Monday increase, causing the TDG level to decrease

    a. SSARR guidance for forecasted total river flow

9. Holiday Guidance: same as weekend guidance.

10. Degassing Guidance:

    a. Winds above 10 mph enhance degassing in Columbia Gorge. http://www.wunderground.com/US/OR/Hood_River/KDLS.html Go to Personal Weather Station: Hood River (near bottom of the webpage)
    b. At flows above 200 kcfs at BON, little degassing occurs between BON and Camas.
    c. At flows below 200 kcfs at BON, significant degassing occurs between BON and Camas.

11. Water Temperature Guidance: Increasing air temperatures cause TDG levels to increase about 1%. Decreasing air temperatures cause TDG levels to decrease about 1%.

12. Spill passage test schedules cause the mass of TDG in the river to fluctuate.

3.9 Spill Patterns

As a general rule, optimal spill patterns for TDG typically tend to be a flat pattern, or equal amounts of spill from each spillbay, across the spillway. Al though these conditions, may be good for TDG, they may not necessarily be good for ESA listed fish in the affected area. The travel time, or egress, from the stilling basin of downstream migrating juvenile salmonids may be greatly increased if a spill pattern is not appropriate for a given stilling basin. In addition, adult salmonid migrations could be delayed at up to 9 hydroprojects within the system if spillway patterns are not optimized, resulting in an unknown impact to successful spawning. Physical models are often used to determine appropriate spill patterns to minimize both TDG and the impacts to juvenile and adult salmon in the spillway area.

3.10 **Power Load Redistribution**

Because power generation and spill have different TDG production potential at various dams, using operational changes at a combination of dams may also help to decrease TDG system wide. For example, at Chief Joseph and Grand Coulee Dams, studies have indicated that because passing water through turbines at Grand Coulee adds little to no gas to the water, full turbine operation at Coulee combined with spill at Chief Joseph could have more TDG benefits system wide rather than both spilling water and generating power at each dam.

3.11 **Physical Changes to Hydroprojects**

Making physical changes to the hydroprojects typically means constructing more physical structures in the river at the dams. Examples of structural changes to the dams that have either been made or proposed in recent years include spillway flow deflectors, additional spillbays at existing dams, removable spillway weirs, and powerhouse/spillway divider walls.

3.11.1 **Flow Deflectors**

Spillway flow deflectors have been installed at many dams in the FCRPS (Table 2-2). These devices are built into existing spillbays and prevent flow from plunging deep into the spillway stilling basin, tending to force higher energy flow out into the tailrace channel, and reducing the initial uptake in TDG. These structures also promote a rapid decrease in TDG by extending the boundaries of a more turbulent aerated plume. Near-field tests have shown that a significant and rapid decrease in TDG occurs within the aerated plume exiting the spillway's stilling basin due to flow deflectors.

Currently, flow deflectors do not exist at all spillbays on FCRPS dams. Installation of flow deflectors on spillbays where they do not currently exist and where it is thought to be beneficial, is being considered as a viable method for reducing TDG. In addition, modifications to existing flow deflectors may also help to lower TDG. These modifications may include changing the height, length or the transition of the structure.

3.11.2 **Additional Spillway Bays**

Building additional spillway bays at existing dams to allow voluntary and involuntary spill releases to be more spread out, with less energy dissipation requirements and associated gas uptake, was determined to be a feasible alternative from the DGAS study. By creating more spillbays, the spill release per spillbay could be effectively reduced, directly correlating to reduced TDG production. Although this option has been considered viable for TDG reduction, it is a very expensive alternative (See section 2.9).

3.11.3 Fish Passage Improvement

The BiOp requires that certain performance objectives be met. Currently many agencies prefer the spillway as a non-turbine passage route for fish, despite the generation of higher than preferred levels of TDG. Any improvements to fish passage systems, including more fish diverted from turbines by more effective traveling or bar screens, would help to reduce the reliance on spill as a non-turbine passage route. This in turn could reduce the amount of TDG in the system.

A Removable Spillway Weir (RSW) is an overflow weir that can be installed in a regular spillbay at dams in the FCRPS. The weir is elevated from the typical spillway ogee, thereby creating a surface draw from the forebay rather than the deep draw conditions of most existing spill operations. This device is meant to pass a high percentage of surface-oriented fish in a relatively small amount of water and is currently being tested at Lower Granite Dam to determine if it will enhance juvenile salmonid passage at this location and potentially at other dams. During high flow conditions, approaching standard project flood levels, the weir can be lowered out of position down to the river bottom whereby the dam can pass unimpeded the standard project flood flow. RSWs are a means to provide or maintain levels of fish passage while possibly reducing the volume of voluntary spills. It is conceivable that if voluntary spill can be reduced, a corresponding reduction in the production of TDG could also be realized.

Additional measures designed to pass juvenile fish via improved screened bypass or alternatively surface bypass systems at powerhouses may also provide a reduction in TDG. If fish can be successfully passed via a non-turbine route other than spill (e.g. Bonneville 2 Corner Collector), then it may provide an opportunity to reduce the reliance on voluntary spill as a means of juvenile salmon passage and in turn could have a beneficial effect on TDG.

3.11.4 Powerhouse/Spillway Divider Walls

Additional improvements in TDG can be gained by construction of powerhouse/spillway divider walls. Depending on spill and powerhouse discharge flow dynamics, a portion of the powerhouse water may be entrained in the spillway flow. This situation is thought to be exacerbated by flow deflectors. The powerhouse waters are then subject to additions of dissolved gas. A divider wall could prevent powerhouse water from being entrained in the spillway stilling basin and gassed up to the same levels as the water being spilled over the spillway. Additional investigation is required to increase understanding of this issue prior to pursuit of corrective actions. If the entrainment flows are reduced or prevented, then this water would be available for dilution of the gassed up spillway releases beyond the spillway flow zone.

Technical reports summarizing physical hydraulic modeling, water quality benefits, and estimated construction costs of divider walls are being prepared as part of the deflector optimization program for McNary, Lower Granite, Little Goose and Lower Monumental.

This project addresses RPA Action 135, which states: "The Corps shall include evaluations of divider walls at each FCRPS project in the spillway deflector optimization program. Design development and construction of the divider walls would begin only after coordination within the annual planning process, and only if warranted."

3.12 Long Term Implementation Plan

Appendix Table B-3 of the BiOp lists actions that were determined to possibly further CWA objectives but that are not specifically called for in the BiOp RPAs. At the time of publication of the BiOp, these actions were to be considered for implementation in the future. These include development of TMDLs, long-term Gas abatement alternative selection studies including side channel spillways, baffled spillways and/or raised stilling basins.

The states and EPA have completed and are currently working on TMDLs, and the Corps is anticipating funding for Chief Joseph Flow deflectors to couple with alternative power loading at Grand Coulee to reduce TDG. However, Phase II of the DGAS study, completed in May 2002, evaluated the remaining alternatives and determined:

"*Based on the level of design detail, all alternatives* (see below) *appear feasible to construct and operate. The baffled chute spillway, side channel spillway, and submerged conduits alternatives have the greatest potential to achieve State and Federal water quality standards. However, the only alternatives expected to achieve safe or acceptable fish passage conditions while providing for significant gas reduction benefits include the additional/modified deflectors, powerhouse/spillway separation wall, submerged spillway gates, and additional spillway bays. These four alternatives, with operational changes to the spillway flow patterns, were recommended for evaluation in a system-wide analysis. Because of the high risk to juvenile and adult salmonids, none of the other alternatives were recommended for further consideration or development*." (Page 11-5)

As indicated on page 69 in the TMDL, "*Clearly, if spilled water is the cause of elevated TDG levels but is required for fish passage, care needs to be taken not to implement gas abatement measures that may benefit water quality, while damaging the beneficial uses, such as juvenile migration, that the federal Clean Water Act was designed to protect*."

Because of these findings, further investigations into these alternatives have not been scheduled.

4 Hydrosystem TDG management History, Status and Schedules

The historic, current status and plans for TDG management in the hydrosystem are discussed in detail in this section. Although these plans are detailed in each section, they can also be found compiled in Appendix B.

An implementation strategy for reduction of TDG can be found in the TMDL for lower Columbia River TDG. This strategy outlines a two-phased approach for reducing gas levels. The first phase is meant to identify the activities that are planned for completion in the short-term, roughly through 2010, that will help to reduce TDG levels as well as ensure the fish passage requirements as set out in the BiOp. Phase II identifies action items that are planned for the longer term, to potentially take place in 2011-2020 if warranted. In addition, the monitoring strategy for improving the reliability and accuracy of water quality monitors was outlined. In the following sections, tables 3-1 through 3-6 demonstrate the current status of the 28 items listed as Phase I and Phase II items in the TMDL.

4.1 Overall Hydrosystem TDG Issues

Although TDG issues throughout the basin can be considered inter-related, certain planned and historic activities and actions can be considered as overall hydrosystem TDG issues. These issues include the DGAS studies (2.4), the BIOP (1.1), water quality monitoring (2.1), and investigating the relationship between TDG and adult salmonid lesions known as headburn.

4.2 Adult Salmonid Headburn

Adult salmonid head burn has not yet been addressed in this document. However, recent investigations have indicated that lesions on the heads of adult salmonids, that are thought to cause a decrease in survival to spawning, may be attributable to high levels of TDG due to spill. This research item is currently being funded by the Portland District Corps of Engineers and is expected to occur through 2005.

4.3 Overall Hydrosystem - Recent TDG History and Schedule

Action Item #	Type Of Measure	Project Location	TDG Measures	Status/ Year(s)	TMDL IP Phase	NMFS 2000 BiOp RPA
Systemwide 1	Study	FCRPS	DGAS	1994-2002		
Systemwide 2	Plans	FCRPS	NMFS FCRPS Biological Opinion	2000		
Systemwide 3	Activity	FCRPS	Predator Removal/Abatement	Ongoing	II	
Systemwide 4	Operations	FCRPS	Improved O&M	Ongoing	II	
Systemwide 5	Studies	FCRPS	Turbine Survival Program	Phase I - 2003 Phase II - 2004	II	
Systemwide 6	Model	FCRPS	SYSTDG	2000		
Systemwide 7	Bio Study	FCRPS	Investigate if Adult Head Burn is Caused by High TDG	2001-2004		

Table 4-1 Overall Hydrosystem - Recent TDG History and Schedule

5 Federal Mid-Columbia River

5.1 Grand Coulee Dam

Dissolved gas supersaturation is generated at Grand Coulee Dam when a portion of the total discharge is spilled through the outlet tubes or drum gates. Involuntary spill occurs an average of one in every six years at this dam. Because power plant releases transfer forebay gas levels downstream to the tailrace without introduction of additional dissolved gas, the 280,000 cfs (cubic feet/second) hydraulic capacity of power generation facilities provides an opportunity to resolve at least a portion of the TDG problem at Grand Coulee operationally, if adequate load can be developed or transferred there, for example, from Chief Joseph Dam.

The BOR completed the “Structural Alternatives for TDG Abatement at Grand Coulee Dam” in October 2000. The study of gas abatement options at Grand Coulee Dam was conducted on a parallel track with Corps studies of Chief Joseph Dam spillway deflectors. The study evaluated gas abatement effects in the Grand Coulee tailrace with and without transfer of power loads from Chief Joseph to Grand Coulee. Results of the BOR study indicated that the ability to reach 110% TDG in the river below Grand Coulee is more dependent on the TDG levels present in the reservoir above than on any of the structural or operational changes studied. However, a potential structural gas abatement option at Grand Coulee could include extending and covering the existing outlet tubes to provide for submerged discharge of spill.

Following completion of the structural gas abatement study, the BOR requested formation of a System Configuration Team/Water Quality Team subcommittee to further evaluate the Chief Joseph and Grand Coulee joint operations alternative for transferring power loads to Grand Coulee, evaluate load growth between 1997 and 2005, and project the estimated proportion of the seven day, ten year (7Q10) flow which could be used for power generation at Grand Coulee during future flood control operations. Based on the results of this study, the subcommittee concluded that for flow up to the 7Q10 value, the risk of spill at Grand Coulee could be effectively eliminated by joint operations between the two projects, involving shifting of power generation to Grand Coulee. The resulting flow increase from Grand Coulee would require spill at Chief Joseph Dam after construction of spillway flow deflectors.

5.2 Chief Joseph Dam

Chief Joseph Dam does not have a means of preventing gas supersaturation under spill conditions. Involuntary spill occurs when total river flow is greater than powerhouse capacity due to high runoff or from spring drawdown of Lake Roosevelt (Grand Coulee reservoir) for flood control, and no voluntary spill occurs at Chief Joseph Dam because there is no anadromous fish migration past this project.

The BiOp required the Corps and BOR to individually and jointly examine gas abatement opportunities at Chief Joseph and Grand Coulee dams. The Corps initiated a planning study for Chief Joseph Dam in several phases and produced several documents that can be found on the Web: http://www.nwd-wc.usace.army.mil/nws/hh/gas/index.html. Similarly, the BOR began an evaluation of alternatives for Grand Coulee. The Corps and BOR also began a study of joint operation to reduce TDG loading into the Columbia.

The SYSTDG model was initially a product of the joint study alternative that was addressed in the General Reevaluation Report, a feasibility level document. The Initial Appraisal Report examined 19 alternatives and recommended nine for further study. The System Configuration Team (SCT) participated in a screening process to reduce the nine alternatives down to three. The preferred alternative was to install flow deflectors at Chief Joseph Dam and to operate it jointly with Grand Coulee. Joint operation would entail a shifting of spill from Grand Coulee to Chief Joseph and a shifting of generation in the opposite direction.

5.3 RPA Action Item 136

The 2000 Biological Opinion RPA Action Item 136 requires the Corps to develop and construct spillway deflectors at Chief Joseph Dam by 2004 to minimize total dissolved gas (TDG) levels associated with system spill. Additionally, RPA 136 instructed the Corps, Bureau of Reclamation and the Bonneville Power Administration, to the extent feasible, to operate Grand Coulee and Chief Joseph dams jointly to reduce the incidence of spill and TDG supersaturation below Grand Coulee by spilling proportionately at Chief Joseph and shifting electrical load to Grand Coulee Dam.

5.3.1 Chief Joseph Dam Spillway Deflectors

In April 2000 the Seattle District of the Corps completed a General Reevaluation Report on the Chief Joseph Dam Gas Abatement Study. This study considered eighteen alternatives to reducing TDG contributions from Chief Joseph dam. The preferred alternative was to design and construct spillway deflectors at the project and to operate Chief Joseph jointly with Grand Coulee. Congressional funds requested in FY 2001 were not provided.

The Corps received $500,000 of congressional funds in FY03 to initiate design of the flow deflectors selected during the General Reevaluation Report process as well as complete the design of some pre-construction projects necessary for dam preparation prior to the construction of the flow deflectors. The Corps received an additional $2,000,000 of congressional funds for FY04 to complete design and modeling work associated with the flow deflectors and to initiate a contract for the construction of deflectors in FY05. Flow deflectors are scheduled for construction during FY05 and FY06, with some of the deflectors being completed by the end of FY05. The Corps will continue to seek the necessary appropriations to complete the construction of the spillway deflectors at Chief Joseph Dam.

5.3.2 Joint Operations of Chief Joseph Dam and Grand Coulee Dam

In late fall 2002 at a joint meeting of the Action Agencies, NOAA Fisheries, Washington Department of Ecology and the Colville Tribe a question was posed regarding the potential benefit to upper Columbia River water quality through joint operations of Grand Coulee and Chief Joseph dams in the absence of spillway deflectors at the latter project. The question was assigned to the regional Water Quality Team (WQT). The team's final evaluation and recommendations were provided to the Technical Management Team (TMT) in March 2003 for consideration in the TMT Water Management Plan and Spill Priority List. The Implementation Team was also briefed on the WQT. A summary of the WQT evaluation of joint operations of Chief Joseph Dam and Grand Coulee Dam is presented below.

5.3.2.1 Introduction

A study conducted by the National Marine Fisheries (NMFS) Water Quality Team (WQT) subgroup concluded that reductions to total dissolved gas (TDG) saturations could be achieved in the Mid-Columbia River through joint operations of Grand Coulee Dam and Chief Joseph Dam (Schneider 2003). The study investigated the consequences of TDG saturation in the Mid-Columbia River from spilling via the outlet works at Grand Coulee Dam versus spilling via the existing spillway (no flow deflectors) at Chief Joseph Dam. The evaluation of water quality benefits were based on reducing TDG saturation above and below Chief Joseph Dam while maintaining a constant joint power output from both projects. Empirical equations were used to estimate the TDG exchange and power production from both projects subject to various background TDG levels, river flows, and power scenarios.

5.3.2.2 Background

Grand Coulee Dam has the greatest generation flow capacity (280 kcfs) in the Mid-Columbia with Chief Joseph having the second largest capacity at 220 kcfs. Spill has occurred at Chief Joseph Dam and Grand Coulee Dam during spring snowmelt season in almost half of all years, with almost all spill at both projects occurring due to lack of load (surplus generating capacity) rather than due to river flow exceeding the generating capacity. In general, Grand Coulee spills via the outlet works from March through early June when forebay pool elevations are below 1260 feet and spills via the drum gates at all other times when Lake Roosevelt is at or above 1260 feet elevation. Total dissolved gas exchange studies by Frizell (1997) and historic data measured in 1997 suggest that average TDG saturations below Grand Coulee are substantially greater for outlet works spills compared to drum gate spills.

Differences in TDG loadings to the Columbia River using the outlet works at Grand Coulee and the existing spillway at Chief Joseph are substantial. For example, during an April 7, 1996 outlet works spill of about 35 kcfs, less than one-third the total project flows from Grand Coulee, the average cross-sectional TDG saturation in the river as measured at the tailwater fixed monitoring station (FMS) increased from about 110% to 132%. A comparable spill of 35 kcfs at Chief Joseph, during powerhouse releases of 140 kcfs on June 9, 1999, resulted in an average cross-sectional TDG saturation increase in the river as measured at the tailwater FMS from 109% to 113%. These historic events illustrate the potential water quality benefits of joint operations of these projects.

5.3.2.3 Approach

Joint operations of Chief Joseph and Grand Coulee were only considered when spill was required from the outlet works as a result of excess power generation capacity. Water quality benefits were based on maintaining a constant joint power output from both projects while reducing TDG above and below Chief Joseph Dam. To maintain constant joint power output the differences in head and power output between the two projects necessitated that a 1 kcfs reduction in spill at Grand Coulee be accompanied by a 1.8 kcfs increase in spill at Chief Joseph.

Total dissolved gas exchange equations for Grand Coulee were derived from limited studies conducted by the Bureau of Reclamation in March 1997 as well as historic TDG data collected at the FMS (Frizell 1997, Schneider 1999). For the joint operations study, TDG loading associated with outlet works releases were assumed to be a linear function of spill discharge. Entrainment of powerhouse discharge into the aerated outlet works discharge was necessary to attain an acceptable TDG exchange equation for Grand Coulee. The TDG exchange characteristics for Chief Joseph Dam were derived from a comprehensive study of TDG in June 1999 (Schneider and Carroll 1999). Results show the TDG exchange during spillway operations at Chief Joseph are an exponential function of spillway discharge, weakly related to tailwater depth of flow, and with little powerhouse entrainment.

An optimization program was written to minimize the average TDG saturation below Chief Joseph Dam while maintaining the joint power production capacity. This program determined the optimal distribution of both spill and power generation at Grand Coulee and Chief Joseph for a wide range of river flow, river TDG saturation, and power demand conditions. Baseline conditions were determined from average conditions observed during outlet works spills in 1997, where spill at Chief Joseph was twice the rate of outlet works spill at Grand Coulee.

5.3.2.4 Results and Discussion

Joint operations of Chief Joseph and Grand Coulee can be devised to meet power generation demands while minimizing the average TDG saturation below Chief Joseph when spill operations via the outlet works are required at Grand Coulee Dam. The optimum joint operations policy avoids using outlet work releases at Grand Coulee Dam by shifting all spill to Chief Joseph Dam for spill discharges up to 70 kcfs. If river conditions require spillway releases above 70 kcfs, the additional spill should be distributed between Chief Joseph and Grand Coulee Dams in a 2.5 to 1 ratio.

The change in TDG saturation levels throughout the study area afforded by the optimal spill policy was compared to base conditions. TDG saturation in Lake Rufus Woods will experienced the greatest improvement with reduction in the average cross-sectional TDG saturations up to 12%. These improvements will be indirectly related to Lake Roosevelt forebay TDG saturations and the amount of spill shifted from Grand Coulee to Chief Joseph. The reduction in the average cross-sectional TDG saturation in the Columbia River below Chief Joseph will be minor (1 to 3 %) when compared to typical historic operations. However, because Chief Joseph will be spilling greater amounts of water, the TDG saturation in undiluted spillway releases from Chief Joseph will experience an increase of up to 7 % saturation as measured at the FMS below Chief Joseph. Consequently, the shift of spill to Chief Joseph will increase the frequency and degree of TDG excursions above the State of Washington waiver standards of 120% and 125% at the tailwater FMS below Chief Joseph, even though the average cross sectional TDG in the Columbia River below Chief Joseph will be reduced.

5.3.2.4 Conclusions and Recommendations

The study produced the following conclusions and recommendations:

- Joint operations of Grand Coulee and Chief Joseph is recommended to reduce the average cross-sectional TDG saturations in the Columbia River above and below Chief Joseph by taking advantage of the larger generation flow capacity of Grand Coulee and the lower average TDG loading below the Chief Joseph spillways (absent deflectors).

- When Lake Roosevelt is below 1260’ elevation, it is recommended that spill from the outlet tubes be avoided by shifting all spill to Chief Joseph for spill discharges up to 70 kcfs. If river conditions require spill releases above 70 kcfs at Chief Joseph, the additional spill should be distributed between Chief Joseph and Grand Coulee in a 2.5 to 1 ratio.

- When Lake Roosevelt TDG is elevated and at or above 1260’ elevation, spill over the drum gates at Grand Coulee may be beneficial to the system due to potential degassing. The continuation of monitoring practices and additional investigations of these operational measures on TDG exchange are recommended to further establish efficient and effective joint operations at Grand Coulee and Chief Joseph.

- Study results predict that joint operations will decrease the average TDG saturation in the Columbia River below Chief Joseph and Grand Coulee dams, but increase the localized TDG saturation in an area below the Chief Joseph spillway

5.4 Non-Federal Mid-Columbia Projects

The Corps is not prepared to address the current status, history or schedules of gas abatement measures for the 5 mid-Columbia non-federal projects. These projects consist of Wells Dam – Douglas County PUD, near Brewster, WA, Rocky Reach and Rock Island dams – Chelan County PUD, near Wenatchee, WA, and Wanapum and Priest Rapids Dams – Grant County PUD, near Mattawa, WA.

5.4.1 Federal Mid-Columbia History and Schedule

Table 5-1 Federal Mid-Columbia History and Schedule

Action Item #	Type Of Measure	Project Location	TDG Measures	Status/ Year(s)	TMDL IP Phase	NMFS 2000 BiOp RPA
Fed Mid-C - 1	Operational	Grand Coulee	Shift spill to Chief Joseph Dam	2004?		
Fed Mid-C - 2	Physical	Grand Coulee	Submerge spill by extending outlet tubes	?		
Fed Mid-C - 3	Studies	Chief Joseph	Physical Model Built	1999		
Fed Mid-C - 4	Studies	Chief Joseph	Flow Deflector Models Tested	2000		
Fed Mid-C - 5	Operational	Chief Joseph	Shift power generation to Grand Coulee Dam	2004?		
Fed Mid-C - 6	Physical	Chief Joseph	Flow Deflectors	2005-2006	I	

5.5 Snake River – Hells Canyon

The Hells Canyon Complex includes Brownlee, Oxbow and Hells Canyon dams. Of these three, Brownlee Dam is the only one that has any significant amount of active storage. There is minimal stratification and cool water in Oxbow and Hells Canyon Reservoirs and water temperatures inflowing into Brownlee, the most upstream reservoir, in the summer have been measured at upwards of 25 to 28°C. The following information was taken entirely from the December 2001 draft Snake River Hells Canyon - Total Maximum Daily Load.

5.5.1 <u>Brownlee Dam</u>

The maximum reservoir depth behind Brownlee Dam is 270 feet and has a total capacity of 1.4 million acre-feet of water, 975,000 of which is active storage. Spill generally occurs during about 50 percent of the years and is most common in March, April, or May. During drawdown of Brownlee Dam, late summer water can contain low levels of dissolved oxygen. When this water leaves the Hells Canyon Complex, the water generally has dissolved oxygen concentrations of 4 - 5 mg/L but is quickly aerated in the Snake River downstream of Hells Canyon Dam.

Spill tests were conducted at Brownlee Dam on June 4, 1998 at a spill level of 39,000 cfs. The tests were conducted to determine if spilling through the upper or lower gates resulted in a measurable difference in TDG in the downstream waters. The TDG levels observed from spilling through the upper gates averaged 114% of saturation while spill through the lower gates averaged 127.7% of saturation. This difference was considered to represent reduced impacts to aquatic species in the Oxbow and Hells Canyon reservoirs. (Snake River Hells Canyon Draft TMDL 2001)

5.5.2 <u>Oxbow Dam</u>

Oxbow Dam creates a reservoir containing 58,000 acre-feet of storage, 11,000 acre-feet of which is active storage. To dampen the effects of power peaking from Brownlee, Oxbow Dam is often used in conjunction with Hells Canyon Dam to moderate discharges to the lower Snake River. Spill from this dam is not thought to have an impact on the TDG levels downstream from Hells Canyon Dam.

5.5.3 Hells Canyon Dam

Hells Canyon Dam has a maximum reservoir depth of 220 feet with 118,000 acre-feet of storage, 23,000 acre-feet of that is active storage associated with a stage change of 5 feet.

Spill tests were conducted at Hells Canyon Dam on June 3, 1998 at a spill level of 28,000 cfs. The TDG levels observed from spilling through the upper gates averaged 139% of saturation while spill through the lower gates averaged 135% of saturation. This difference was considered to represent sufficient benefit to aquatic species in the downstream Snake River segment, and that the lower gates were recommended to be used for spill whenever possible. Spill episodes at Hells Canyon Dam over 19,000 cfs caused exceedences of the 110% standard throughout the downstream Snake River segment of the SR-HC TMDL. TDG levels did not drop below 110% upstream of RM 188 at this level of discharge. Standard exceedances from spill volumes between 9,000 cfs and 13,400 cfs were not observed below RM 200, and spill volumes of 2,400 cfs showed standard exceedances to RM 230 only. The total distance downstream of the dam where water was observed to exceed the 110% standard was directly related to the volume of the spill. During the period of no spill, the state standard of 110 % within the Snake River below Hells Canyon Dam was always met.

Hourly monitoring of TDG concentrations below Hells Canyon Dam in 1999 (IPCo, 1999b) showed a defined relationship between spill and TDG below the dam. TDG in the tailwater area of Hells Canyon Dam ranged from 108% to 136% while spill was occurring from Hells Canyon Dam. Nearly all levels of spill monitored resulted in TDG levels above the 100% of saturation target. The data collected indicate that TDG levels in the downstream Snake River segment of the SR-HC TMDL are largely dependent on the occurrence of spill at Hells Canyon Dam and that upstream spill has little effect (IPCo, 1999b). Turbine operations seem to have little affect on TDG levels relative to the effects of spill. (IPCo, 1999b ER 2000). (2001 Draft TMDL for Snake River - Hells Canyon) Some research has been completed showing that flip lips would likely help lower TDG concentrations at Hells Canyon Dam.

5.5.4 Partial History of Hells Canyon TDG Events

Table 5-2 Partial History of Hells Canyon TDG Events

Action Item #	Type Of Measure	Project Location	TDG Measures	Status/ Year(s)	TMDL IP Phase	NMFS 2000 BiOp RPA
Hells-C - 1	Study	Brownlee	Spill Gate Preference	1998		
Hells-C - 2	Study	Hells Canyon	Spill Gate Preference	1998		
Hells-C - 3	Study	Hells Canyon	TDG Monitoring	1999		
Hells-C - 4	Study	Hells Canyon	Flow Deflectors	?		

5.6 Lower Snake River

The Walla Walla District of the Corps of Engineers has begun an Action Planning Process focused on future fish, water quality, and planning activities. The final plan was planned for release in August 2003.

5.6.1 Lower Granite Dam

Flow deflectors exist on all eight-spillway bays at Lower Granite dam. These deflectors were part of the original construction of the dam and are 12.5 feet long with radiused transitions. The deflector optimization program calls for a systematic review of the existing deflector performance. One of the tasks includes conducting a physical near field gas test of the existing spillway to assess the current structural TDG performance. To date, near field TDG testing has been delayed to avoid interferences with ongoing fish passage research on the RSW and surface collection prototypes at Lower Granite.

Another TDG task includes constructing and testing a physical hydraulic sectional model of the Lower Granite Spillway to assess potential improvements that might be made to the deflectors to improve their performance. Possible future modifications may include the addition of pier nose extensions, spillway/powerhouse divider wall and relocating the deflectors at an elevation optimized for current operation.

Operational changes (spill patterns) will also be examined for potential TDG reduction benefits. This study of deflector performance and possible modifications was deferred because of a lack of funding. This project is a part of the Columbia River Fish Mitigation Program (construction general funding), and the regional System Configuration Team (SCT) did not rank this as a high priority for FY04.

5.6.2 Little Goose Dam

Deflectors have been constructed on six of the eight spillway bays at Little Goose Dam. These deflectors are 8 feet long and have a non-radiused transition.

During FY02, testing of a spillway sectional model was completed along with construction of a general physical hydraulic model of Little Goose dam. Testing of the general model began in FY02 and was planned to continue into FY03. Because of the lack of funds and SCT priority ranking, this project was suspended and is not currently funded in FY04. The model testing was to include the examination of a spillway/powerhouse divider wall as well as tailrace hydraulic conditions to allow development of spill patterns to achieve acceptable tailrace hydraulic conditions for both adult fish passage and juvenile fish egress from the tailrace area. Little Goose tailrace can present poor conditions for juvenile egress and adult fish passage. In addition to consideration of altered spill patterns to reduce TDG, the Walla Walla District Action Plan mentioned above would consider a Removable Spillway Weir (RSW) option as an alternative for the current 12 hour spill to gas cap option during spring passage season. If the RSW option is selected and funded construction would be anticipated in the 2006 – 2007 time frame. In addition, a powerhouse/spillway divider wall would provide reductions in TDG loading to downstream water bodies during spillway operations.

Once testing is complete, design of deflectors will be initiated along with required NEPA documents. Possible modifications include the addition of deflectors in end bays 1 and 8. Consideration may also be given to relocating the deflectors at an elevation optimized for current operation. Deflector improvements would provide benefits in reduced TDG during involuntary spill events. A contract for installation of end-bay deflectors is anticipated to occur in FY2006. Additionally, divider walls may be constructed to further improve TDG by reducing powerhouse flow entrainment into the spill waters. Following the installation of the deflectors, a post construction TDG near field test will be completed in April or May 2007.

5.6.3 Lower Monumental Dam

Engineering work began on Lower Monumental Dam in FY1999 with construction of a 1:55 scale general physical hydraulic model and a 1:40 scale spillway sectional model. A contract was prepared and awarded in FY2002 for installation of two end-bay deflectors, repair of an existing deflector in Bay 2 of the spillway and repair of erosion in the existing stilling basin. This contract was completed in February 2003. Lower Monumental dam now has a complete compliment of deflectors on all eight spillway bays. New spill patterns for juvenile fish egress and adult fish passage have been developed

A post construction near-field TDG test was planned for spring 2003 to assess the performance of the newly added deflectors and revised spill pattern. However, due to funding limitations, the testing has been delayed until FY04. Additional work will be undertaken in FY04 to evaluate benefits and costs of adding a spillway/powerhouse divider wall and RSW. A technical report addressing divider wall and juvenile fish outfall relocation will be completed under the Lower Monumental outfall relocation project.

5.6.4 Ice Harbor Dam

The Ice Harbor spillway consists of 10 spillway bays, all of which now have flow deflectors. Installation of four of the ten spillway flow deflectors was completed in December 1996 and an additional four deflectors were completed in November 1997. The remaining two end-bay deflectors along with mitigative structures to correct a navigation and adult fishway impact were completed by March 1999. These flow deflectors helped to decrease the TDG. Currently, the Ice Harbor deflectors allow the largest spill flow, 105 kcfs, on the Snake River without exceeding the 120% TDG gas cap. This is a dramatic improvement in gas abatement due to the installation of the deflectors in 2001.

Improved spill patterns for adult fish passage, juvenile fish egress and TDG reductions were implemented in the Spring of 1999. Additional work, which remains to be completed on Ice Harbor, includes model study work and associated reporting on the costs and benefits of installing a powerhouse/spillway divider wall. This additional work is not currently scheduled. Continuing work will include biological studies to determine fish survival over the spillway as well as investigations into a removable spillway weir coupled with training flow in the appropriate spill pattern to aid in fish egress.

5.6.5 Lower Snake River History and Schedule

(Table for this section is on the following page)

5.7 Clearwater River

5.7.1 Dworshak Dam

Spillway, low level regulating outlets and some turbine operations at Dworshak Dam can produce increased levels of TDG in the tailwater area of the project. TDG production at Dworshak dam may contribute to elevated gas levels observed in the mainstem Clearwater River, at Lower Granite dam and can be problematic for a US Fish and Wildlife fish hatchery (Dworshak Hatchery) located immediately downstream from the dam on the North Fork Clearwater River. To examine current project TDG performance and identify and implement operational or structural methods to decrease the production of TDG to acceptable levels, the following studies and/or activities would be conducted.

Table 5-3 Lower Snake River History and Schedule

Action Item #	Type Of Measure	Project Location	TDG Measures	Status/ Year(s)	TMDL IP Phase	NMFS 2000 BiOp RPA
Lower Snake 1	Bio Study Physical – Operational	Lower Granite	Surface Bypass Collection	1995 – 2000		
Lower Snake 2	Study – Physical – Operational	Lower Granite	Gas Fast Track	Not funded FY04 Funds requested for FY05 start. SCT Ranked low		
Lower Snake 3	Study	Lower Granite	- Sectional Hydraulic Model	TBD		
Lower Snake 4	Physical	Lower Granite	- Optimize Deflectors	TBD		
Lower Snake 5	Study	Lower Granite	- New Spill Patterns	TBD		
Lower Snake 6	Physical	Lower Granite	- Pier Nose Extensions	TBD		
Lower Snake 7	Physical	Lower Granite	- Divider Walls	TBD		
Lower Snake 8	Physical – Bio Study	Lower Granite	- RSW	2002 – 2007	I	
Lower Snake 9	Bio Study	Lower Granite	- Spillway Passage Survival Study	2003 – 2006	I - II	
Lower Snake 10	Gas Study	Lower Granite	- Near Field Testing	2003?		
Lower Snake 11	Study – Physical - Operational	Little Goose	- Gas Fast Track	2002 - TBD Funds requested for FY05 start. SCT Ranked low		
Lower Snake 12	Study	Little Goose	- General Model Tests	TBD		
Lower Snake 13	Operational	Little Goose	- New Spill Patterns	TBD		
Lower Snake 14	Study – Physical - Operational	Little Goose	- End Bay Deflectors	TBD	I	
Lower Snake 15	Study – Physical - Operational	Little Goose	- Optimize Deflectors	TBD		
Lower Snake 16	Study – Physical - Operational	Little Goose	- Spillway Divider Wall	TBD		
Lower Snake 17	Study – Physical - Operational	Little Goose	- Spillway Sectional Model Test	200?- Low SCT priority lead to no funding FY03/04		
Lower Snake 18	Bio Study	Little Goose	- Spill Passage Survival Studies	2004 – 2006	I - II	
Lower Snake 19	Gas Test	Little Goose	- Near Field Test	2005		
Lower Snake 20	Physical – Bio Study	Little Goose	- RSW	2006 – 2010	II	
Lower Snake 21	Study	Lower Monumental	- Physical Model Development	1999		
Lower Snake 22	Physical	Lower Monumental	- Gas Fast track			
Lower Snake 23	Physical	Lower Monumental	- End Bay deflectors	2001 – 2003	I	
Lower Snake 24	Operational	Lower Monumental	- Spill patterns	2002 - 2004		
Lower Snake 25	Physical	Lower Monumental	- Divider Wall Report	2004		

Table 5-3 Lower Snake River History and Schedule (Continued)

Action Item #	Type Of Measure	Project Location	TDG Measures	Status/ Year(s)	TMDL IP Phase	NMFS 2000 BiOp RPA
Lower Snake 26	Physical	Lower Monumental	- Report on Juvenile Bypass Outfall Reloc.	2004	I	
Lower Snake 27	Physical	Lower Monumental	- Stilling Basin Repair	2001 – 2003		
Lower Snake 28	Gas Study	Lower Monumental	Near Field Test	2004		
Lower Snake 29	Bio Study	Lower Monumental	Passage/Survival	2003-2006	I - II	
Lower Snake 30	Study	Lower Monumental	Extended Fish Screens	?	II	
Lower Snake 31	Physical – Bio Study	Lower Monumental	RSW	2005 – 2009	II	
Lower Snake 32	Physical	Ice Harbor	Flow Deflectors (4)	1996	I	
Lower Snake 33	Physical	Ice Harbor	Flow Deflectors (4)	1997	I	
Lower Snake 34	Physical	Ice Harbor	Flow Deflectors (2)	1999	I	
Lower Snake 35	Gas Study	Ice Harbor	Near Field Test	Not Scheduled		
Lower Snake 36	Operational	Ice Harbor	Spill Patterns	1999		
Lower Snake 37	Bio Study	Ice Harbor	Passage/Survival	1999 – 2005	I - II	
Lower Snake 38	Physical – Bio Study – Operat.	Ice Harbor	RSW	2003 – 2008	II	
Lower Snake 39	Phys. – Study	Ice Harbor	Divider Wall	Not Scheduled for installation		

Field investigations would be conducted to define performance of individual project features including the low-level outlets, turbines, and the spillway. Additional field monitoring of the mainstem Clearwater and Snake rivers above Lower Granite dam may be needed to assess Dworshak effects. In combination with this, a hydrological analysis to define 7Q10 and probability of certain operations and discharges would need to be conducted.

The potential operational or structural changes that may alleviate or reduce production of TDG e.g. additional turbine installation, modifications to spillway etc. would need to be evaluated and identified. Using this information, a physical sectional spillway hydraulic model would be constructed to evaluate potential structural changes to alleviate production of TDG. A technical report documenting investigations, potential solutions and associated costs would make recommendations concerning the next steps.

5.7.2 Clearwater River History and Schedule

Table 5-4 Clearwater River History and Schedule

Action Item #	Type Of Measure	Project Location	TDG Measures	Status/ Year(s)	TMDL IP Phase	NMFS 2000 BiOp RPA
Clearwater 1	Study	Dworshak	Identify potential methods of reducing production of TDG.	TBD – Not Currently Funded		139
Clearwater 2	Physical	Dworshak	Modifications as recommended by TDG study. Modifications may include spillway modifications, Turbine Installation etc.	TBD Based on Clearwater 1		139
Clearwater 3	Physical	Dworshak	Spillway Modifications	TBD		139
Clearwater 4	Physical	Dworshak	Turbine Installation	TBD		139
Clearwater 5	Study	Dworshak	Hydrologic Analysis	TBD		139
Clearwater 6	Study	Dworshak	Model Construction	TBD		139

5.8 Lower Columbia River

5.8.1 McNary Dam

The McNary spillway consists of 22 spillway bays, all of which have flow deflectors. All bays were outfitted with hoists in 2002 that allow for previously impossible, relatively instantaneous modifications to spill patterns. Physical hydraulic model studies of the tailrace conditions at McNary were conducted allowing development of new spill patterns to achieve acceptable tailrace hydraulic conditions for both adult fish passage and juvenile fish egress from the tailrace area. Deflector improvements combined with changes in spill patterns will provide benefits in reduced TDG during involuntary spill events.

Modifications to McNary Dam could include lengthening an existing training wall to protect an adjacent fish ladder entrance on the North Shore from adverse hydraulic conditions possibly impeding fish entry. New spill schedules to be implemented in 2003 are expected to resolve this pattern through operational modifications. The effect of a powerhouse/spillway divider wall could also be investigated as a possible future measure to reduce TDG beyond that achievable by deflectors. A post-deflector construction TDG near field study is not scheduled at this time.

Currently, McNary Dam is being studied for turbine replacement. The preferred replacement turbine design would pass more water through the turbine than is currently possible. Because McNary is a bottleneck for flow through the powerhouse and spill is often required due to a lack of powerhouse capacity, it is thought that with the possibility of increased turbine discharge, that decreased spill could be a long term action for helping to reduce TDG. However, spill reduction must be reconciled with the reduced juvenile fish passage and associated reduction in survival that could also be realized.

Four new hoists were installed at the McNary Spillway, however, during commissioning overload switches on these tripped out. Further review found that older hoists installed in 1974 were also operating in overload condition. Additionally, it was determined that the gantry crane (used to operate two spillway gates) was also operating in an overload condition. End result was that only 16 spillway bays could be operated in 2003. Modeling work to develop a 22-bay operational spill pattern was completed but the spill pattern could not be employed because of the hoist and gantry crane problems. The spill cap at McNary was limited to 130 kcfs as a result.

For the FY 2004 spill season, the four new hoists are being repositioned over the four spillway gates with the least loading. The two gantry crane lifting beams are being modified to increase their capacity to 250-tons. While not providing ideal conditions, these two actions will allow for a full 22-bay spill pattern this coming spill season with operational constraints applied. Additionally, CRFM has funded a contract for gate rehabilitation that will provide for the complete rehabilitation of up to four existing gates this FY. The contract is written with an option to complete rehabilitation of up to four additional gates depending on the availability of O&M funds. Gates to be rehabilitated will be prioritized based on the results from load testing with the gate that is responsible for the heaviest loading being rehabilitated first, the next highest loading second, and so forth.

The gate hoists for the remaining sixteen gates also need to be evaluated to determine if past operation in overload conditions has stressed any components to generate concerns which require modifications be performed. The evaluation will also consider the loads from the rehabilitated gates and will determine if re-rating the hoists is possible to meet the actual load conditions or determine what modifications are necessary to allow the re-rating of the hoist. Evaluation of these hoists is dependent on the availability of O&M funding.

As funding is made available the goal is to rehabilitate 24 spillway gates (includes 2-spares) and re-rate the hoists and gantry cranes to allow the full 22-bay spill pattern to be used within safe operating conditions. Until such time as these actions are complete, our ability to ensure a 22-bay spill pattern is at risk as the probability of a failure of one or more of numerous hoists operating in overload conditions is high.

5.8.2 John Day Dam

Eighteen of the 20 spillway bays at John Day Dam were modified with flow deflectors in February 1998. New spill patterns were established at that time. Endbays (bays 1 and 20) were not modified primarily due to concerns with adverse juvenile salmon egress with deflectors on these bays. The additional increment of improvement in gas entrainment during involuntary spill conditions prompted reconsideration of deflector installation on the end bays. Also under consideration is an extended flow deflector on Bay 20, which would potentially be installed in association with an RSW prototype for testing at that bay. The RSW prototype program at John Day is presently deferred to address potential adverse effects of its operation on juvenile fish egress from the stilling basin. Until that issue is resolved, end-bay flow deflector installation is on hold. (Mark Schneider) A decision document on John Day Dam will be developed with a draft expected in 2005. This decision document is expected to have construction alternatives and/or operations improvements at the facility with potential impacts on TDG levels.

5.8.3 <u>The Dalles Dam</u>

The Dalles Dam was not identified as a project for immediate implementation of spillway flow deflectors at the conclusion of the DGAS Phase I, primarily due to its relatively shallow stilling basin. Deflectors may still significantly reduce TDG at The Dalles, however, and are being considered as one component of a Spillway Improvement Study (SIS) that is currently underway. This study will analyze various spillway improvements at The Dalles Dam designed to improve juvenile survival through the spillway passage route and was initiated due to the relatively high spillway juvenile mortality measured at The Dalles during high spill volumes in recent years.

The SIS will rely heavily on numeric and hydraulic modeling efforts, which are anticipated to provide hydrodynamic data to help define the optimum deflector design elevation for TDG abatement. Due to the complexity of the stilling basin hydrodynamics and downstream topography, deflector benefits of reduced TDG may be offset by increased juvenile predation, direct impact or other factors that may be influenced by the deflected flow pattern. These factors require full analysis and understanding prior to implementation. A decision document on The Dalles Dam will be developed with a draft expected in 2004. This decision document is expected to have construction alternatives and/or operations improvements at the facility with potential impacts on TDG levels.

5.8.4 <u>Bonneville Dam</u>

Deflectors were constructed on 13 of the 18 spillbays in the early 1970s at Bonneville Dam. These deflectors were designed for involuntary spillway releases, however, because of the shift from involuntary to voluntary spill for fish passage, TDG supersaturation during spillway operation has again become a regional concern.

Deflector construction in bays 1, 2, 3, 16, 17, and 18 was completed in 2002. A second post-construction evaluation (biological) test planned for the spring and late summer of 2003 was deferred due to funding priorities. These deflectors were installed about seven feet lower than where the existing deflectors are located. Revised spill patterns were established for the new configuration and near field TDG testing to determine effectiveness of the new flow deflectors was conducted. The additional testing is currently planned for 2004 and a decision will follow as to whether replacement of the existing deflectors is warranted. If replacement is deemed appropriate, construction contract preparation could be initiated in 2005 with the 2nd phase of construction completed by 2006. A final decision document on Bonneville Dam will be developed by 2005. This decision document is expected to have construction alternatives and/or operations improvements at the facility with potential impacts on TDG levels.

5.9 <u>Lower Columbia River History and Schedule</u>

Table 5-5 Lower Columbia River History and Schedule

Action Item #	Type Of Measure	Project Location	TDG Measures	Status/ Year(s)	TMDL IP Phase	NMFS 2000 BiOp RPA
L Columbia 1	Document	System	Final TMDL-TDG	2002		
L Columbia 2	Physical – Operational – Study	McNary	Gas Fast Track	2002 – TBD Not funded FY04 Funds requested for FY05 start. SCT Ranked low		
L Columbia 3	Physical – Operational – Study	McNary	Gate Hoists	2002 - Unresolved		
L Columbia 4	Physical – Operational – Study	McNary	Deflector Optimization	2002		
L Columbia 5	Physical – Operational – Study	McNary	Spill Patterns	2002		
L Columbia 6	Physical – Operational – Study	McNary	Divider Walls	TBD		
L Columbia 7	Physical – Operational – Study	McNary	Training Walls	TBD		
L Columbia 8	Physical – Operational – Study	McNary	Modeling	TBD		
L Columbia 9	Physical – Operational – Study	McNary	Outfall relocation	TBD	II	
L Columbia 10	Physical – Bio Study	McNary	RSW	2005 - 2010		

Table 5-5 Lower Columbia River History and Schedule (Continued)

Action Item #	Type Of Measure	Project Location	TDG Measures	Status/ Year(s)	TMDL IP Phase	NMFS 2000 BiOp RPA
L Columbia 11	Physical	McNary	Turbine Replacement	2008-2015		
L Columbia 12	Bio Study	McNary	Spillway Passage Survival	2003 - 2006	I - II	
L Columbia 13	Study	McNary	Near Field Test	Not Scheduled		
L Columbia 14	Physical	McNary	Endbay Deflectors	2002	I	
L Columbia 15	Physical	John Day	Flow Deflectors (18/20)	1998 – 1999	I	
L Columbia 16	Study - Physical	John Day	RSW (Surface Bypass)	On hold	II	

L Columbia 17	Bio Study	John Day	Passage/Survival Studies	2000-2004	I - II	
L Columbia 18	Physical	John Day	Extended Screens	2004 Decision	II	
L Columbia 19	Physical	John Day	End Bay Deflectors	TBD	I	
L Columbia 20	Physical	John Day	End Bay Deflector – Bay 1	TBD	I	
L Columbia 21	Study – Physical	The Dalles	Spillway Improvement Study	2003 – 2006	I	
L Columbia 22	Study – Physical	The Dalles	Spill Wall	2004?		
L Columbia 23	Study – Physical	The Dalles	Model Studies	Ongoing		
L Columbia 24	Study – Physical	The Dalles	Spillbay Modifications	TBD		
L Columbia 25	Study - Physical –	The Dalles	Surface Bypass	2003 – 2007		
L Columbia 26	Study – Physical	The Dalles	Turbine Intake Blocks	2000-2002 Suspended	I	
L Columbia 27	Study – Physical	The Dalles	Sluiceway Outfall relocation	2000-? On Hold	I	
L Columbia 28	Bio Study	The Dalles	Spillway and Sluiceway Survival Study	2000 – 2007	I - II	
L Columbia 29	Physical	Bonneville	Spillway Deflectors (13/18)	1970's		
L Columbia 30	Physical	Bonneville	Spillway Deflectors (18/18)	2002	I	
L Columbia 31	Study - Physical	Bonneville	PH1 improvements	2003 – 2005	I	
L Columbia 32	Study – Physical	Bonneville	PH1 Surface Bypass	On hold until 2004	I	
L Columbia 33	Physical	Bonneville	PH2 Corner Collector	2003-2004	I	
L Columbia 34	Physical Study	Bonneville	Turbine Improvements (MGRs)	Ongoing	II	
L Columbia 35	Physical	Bonneville	PH2 FGE Improvement	2005 Decision	I	
L Columbia 36	Bio Study	Bonneville	Passage/Survival Studies	2000 – 2005	I - II	

Table 5-5 Lower Columbia River History and Schedule (Continued)

Action Item #	Type Of Measure	Project Location	TDG Measures	Status/ Year(s)	TMDL IP Phase	NMFS 2000 BiOp RPA
L Columbia 37	Study – Physical – Operational	Bonneville	Gas Fast Track	2003 – 2007		
L Columbia 38	Study	Bonneville	Near Field Testing	2002		
L Columbia 39	Physical	Bonneville	Improve Existing Deflectors if needed	TBD		
L Columbia 40	Operational	Bonneville	Spill Patterns	2002		

L Columbia 41	Study	Bonneville	Bonneville Dam Decision Document	Final in 2005		
L Columbia 42	Study	The Dalles	The Dalles Dam Decision Document	Draft in 2004		
L Columbia 43	Study	John Day	John Day Dam Decision Document	Draft in 2005		

6 Long Term Plan

Section 3 presents in detail what is described in the lower Columbia River TMDL as the short-term and long-term plans for TDG abatement, indicated as the Phase I and Phase II in the TMDL IP, all of which need to be addressed by 2020. However the Corps recognizes that the combination of all of these items, while making substantial progress towards attainment of the goals, may not get TDG to the desired attainment levels in all flow years. Other items that were discussed in the DGAS study that may need to be revisited after the Phase I and Phase II implementation actions have been completed.

Implementation of operational alternatives, additional or modified spillway flow deflectors, and powerhouse/ spillway flow separation walls has the potential to significantly reduce production of TDG and can be implemented in the near term.

Other alternatives are considered more long term since they will require regional consensus, possible prototype studies, lengthy engineering studies, lengthy construction periods, very high implementation costs, and will have high uncertainty as a safe bypass route for fish. These may include:

- Raised tailrace channel
- Additional spillway bays
- Submerged conduits
- Baffled chute spillways
- Side channel spillways
- Pool and weir spillways
- Submerged spillway gates

7 RPAs Addressed

The BiOp contains 199 Reasonable and Prudent Alternatives that the Action Agencies are attempting to meet in an effort to avoid jeopardy to ESA listed anadromous salmonids. These include items ranging from habitat work in headwater streams to fish passage improvement devices at the Federal hydroelectric projects. The following table represents a partial list of the reasonable and prudent alternatives related to TDG that were identified in the BiOp. Those RPAs that are directly related to TDG are in the table, however, those with less direct ties (e.g. extended fish screens, etc…) are only partially covered.

As of December 3, 2002, the Corps believes that all of the BiOp RPAs noted in this table are either in the process of being addressed, or have been addressed in an attempt to fulfill the requirements of the BiOp. (Please Refer to the BiOp Implementation Plan). Appendix C has a more detailed list of the RPAs addressed in table 7-1.

Table 7-1 TDG Reasonable and Prudent Alternatives

Actions		Reasonable and Prudent Alternative						
Planning/Tools		5	54	99	130	133	198	
Gas Monitoring		131	132	141	142	143		
Gas Abatement Structures		134	135	136	139*	140		
Gas Abatement Operations		76*	139*					
Fish Passage Operations		71						
Fish Passage Evaluations		60	68	82	83	86	113	
Fish Passage Structures	- RSW	72	75	77	80	138		
	- Standard Bypass	62	97	98				
	- Other	61	66	69	70	76*	84	108

* Indicates an RPA included in two Action categories

8 Conclusions

This document is meant to address part of the plans requested through Appendix B of the 2000 NMFS FCRPS Biological Opinion. In this document, the Corps has presented the background of TDG issues in the Columbia River Basin, the rationale for preparing the document, what can be and has been done to address TDG issues, and what the Corps' planned schedule is for addressing these issues. Much of the background information was taken from documents found in the citations, from assisting government agencies, or gathered from personnel in the Northwest Division or Portland, Seattle or Walla Walla District, Corps of Engineers. This document was not meant to be all-inclusive, in that the complete history of TDG issues in the Columbia Basin could make for an unwieldy document and could overwhelm the reader, rather, it was meant to provide a background of TDG Issues and how the Corps has dealt and is attempting to deal with them.

Mainstem Snake and Columbia River Water Temperature

9 Introduction

The National Marine Fisheries Service (NMFS) issued a Biological Opinion (BiOp) on the operation of the Federal Columbia River Power System (FCRPS) in December of 2002. Appendix B of this BiOp called for a plan to outline the structural and operational changes to the current river system that could be used to improve the overall water quality in these rivers. The long-term goal of the plan was to improve water quality but also to conserve threatened and endangered species, thus meeting the requirements of both the Clean Water Act (CWA) and the Endangered Species Act (ESA). The BiOp also established a conservation recommendation for the development of a Water Quality Plan as a conceptual strategy for the mainstem TMDL implementation plan for the Clearwater, Snake and Columbia rivers that are directly impacted by federal dams.

Although TDG has been the primary water quality parameter monitored by the Corps, water temperature is also measured because it affects TDG saturation levels, and because it influences the health of fish and other aquatic organisms. Both TDG and water temperature are closely linked to water management operations (e.g. water released over the dam spillways, releases through the powerhouses and other facilities, and forebay and tailwater water surface elevations) at Corps projects.

This water temperature document presents the background of water temperature issues in the Columbia River Basin, the rationale for preparing the document, what is being done and what has been proposed to address and resolve water temperature issues. This document is composed of five major categories including:

1) The background of water temperature issues in the Columbia and Snake rivers, the goal of the NMFS 2000 FCRPS BiOp and the Total Maximum Daily Load process,
2) The monitoring of water temperature in the area covered by the plan,
3) A brief discussion addressing the Reasonable and Prudent Alternative actions in the BiOp that address water temperature and the long-term non-BiOp (Clean Water Act) strategy to get temperature levels below 20°C.
4) A description of operational, structural and other changes that have been proposed that may have potential to lower water temperature levels or provide a better understanding of water temperature impacts to aquatic species.
5) A final summary and appendix.

9.1 Background

Water temperature conditions have a complex array of effects on salmonids. Water temperatures affect the rate of embryonic development, post-emergence growth rates, and smolt survival. Water temperature also indirectly affects salmon survival by its effects on foraging rates of predatory fish and the rates of infertility and mortality rates of several diseases in adult salmon. In addition, an emerging issue is potential water temperature effects on juvenile outmigration timing (NMFS 2000). The hypothesis being that Snake River juvenile fall chinook outmigration timing is delayed by cooler-than-historical water temperatures during incubation and early rearing life stages due to the modified releases from Dworshak Dam.

The geographic scope of this water quality plan, as outlined in the BiOp, will include the Columbia River from the international boundary, the Clearwater River from Dworshak Dam downstream to the Snake River, and Brownlee Dam on the Snake River, to the tailrace of Bonneville Dam. This plan will also briefly address issues above the international boundary as items to be considered for the Clean Water Act, that were not necessarily called for in the BiOp. There are three primary storage reservoirs in the United States, Grand Coulee Dam, Brownlee Dam and Dworshak Dam. Two major storage projects also exist in Canada including Mica and Keenleyside dams. Six run of the river dams exist on the middle and Lower Snake river, four on the Lower Columbia and six on the middle Columbia.

9.2 2000 FCRPS Biological Opinions

The NMFS and FWS 2000 Biological Opinions (BiOp) for operations of the FCRPS state: "The two agencies intend the recommendations and requirements of these opinions to be mutually consistent. They represent the Federal biological resource agencies' recommendations of measures that are most likely to ensure the survival and recovery of all listed species that are within the current authorities of the Action agencies."

In developing the NMFS BiOp, however, the goal was also to consider the respective ecological objectives of both the CWA and ESA. In many instances, the goals of the two acts are mutually inclusive in that many of the benefits of appropriate levels of dissolved gas and temperature can be realized by the endangered species within the system. However, despite the overlap, there may be actions that help to meet the CWA that have detrimental, little, or no effect on endangered fish species.

There are 11 RPA actions directly addressing water temperature in the NMFS 2000 BiOp. Specifically, RPA's 19, 20, 33, 34, 35, 114, 115, 141, 142, 143 include direct language regarding either biological studies, the collection of temperature data, or the reduction of water temperatures within the FCRPS.

Appendix B of the 2000 NMFS BiOp, is meant to address conservation measure actions in the mainstem Columbia River that go beyond the ESA RPA recommendations. The Appendix B geographic scope for temperature ranges in the Columbia River from the Canadian Border to the Pacific Ocean and the Snake River from its confluence with the Salmon River to its confluence with the Columbia River. In Appendix B, NMFS indicates that their long-term goal for water temperature is standard attainment in all critical habitats in the Columbia and Snake River basins (For detailed information on individual states mainstem water temperature standards, please see BiOp Appendix B).

9.3 <u>Water Quality Team</u>

Being that it is important for EPA, NMFS, USFWS, and the Federal Action Agencies to understand the relationship between the Water Quality Plan and ongoing TMDL planning processes, particularly their relationship with each other and evaluation and implementation of the system improvements and studies. Therefore, final development and implementation of the plan could be accomplished through reformulation of the Water Quality Team, consisting of senior policy analysts and supported by technical staff from Federal agencies (EPA, NMFS, USFWS, Corps, BPA, and BOR); the states of Oregon, Washington, and Idaho; Columbia River Tribal governments; and non-Federal entities such as municipalities and PUDs.

The team would also have specific TDG and temperature technical subcommittees included under the overall umbrella of team actions. The new Water Quality Team could also be a cross-connecting link between the NMFS Regional Implementation Forum and the Columbia River Basin Forum, as appropriate, through input and updates on water quality plan implementation. The new Water Quality Team would review the water quality plan developed by the Action Agencies to help identify key TDG and temperature studies and implementation of structural and operational changes to the FCRPS system, including PUDs. The plan's timeline would provide specific milestones to conclude discussions on technical issues related to structural and operational changes to the FCRPS, consultation with the other basin forums discussed above, and implementation of actions so that they may be considered in conjunction with the 2005 mid-point evaluation under the RPA.

The BiOp goes on to state;

"To ensure progress toward the long-term goal, the Corps, BOR, and BPA will also work with NMFS, USFWS, EPA, the Columbia River Tribes, and the states of Washington, Oregon, Idaho, and Montana through an adaptive management process as a part of the water quality plan to achieve the following:

- Make operational and capital investment decisions at the FCRPS projects to move toward attainment of thermal water quality standards.
- Seek consensus on offsite mitigation measures that would contribute to attainment of water temperature standards.
- Fund, implement, and report on adequate physical and biological temperature monitoring to assess compliance with state and Tribal water quality standards and other special conditions that may apply.
- Cooperate with others to fund implementation and modeling to better assess and act on thermal water quality problems and opportunities.
- Develop emergency measures that may be needed to address immediate and acute water temperature problems affecting listed salmon.

The feasibility of meeting the long-term goal will be revisited annually during the water quality improvement planning process.”

9.4 Mainstem Water Quality Plan Workgroup

The 2000 Biological Opinion observed the complementary features of the ESA and the CWA. It was recognized that an assertive implementation of the dissolved gas and water temperature actions of the Reasonable and Prudent Alternatives (RPA) and Appendix B would promote attainment of water quality standards as well as the recovery of endangered stocks. The NOAA Fisheries, EPA, USFWS and the Action Agencies called for the integration the Biological Opinion water quality actions with the relevant objectives of the CWA and other fish and wildlife and water quality statutes. The mechanism by which this integration could occur was through the development of a mainstem water quality plan.

The Biological Opinion Section 9.6.1.7 and Appendix B charted a course for the development of a comprehensive Columbia and Snake River water quality plan. From the outset of the planning effort it was clear that the scope of the mainstem plan would be broader than the RPAs and would include additional actions to improve mainstem water quality by reducing total dissolved gas and water temperature. Appendix B of the Biological Opinion tabulated actions required to avoid jeopardy as well as those actions that are beyond the scope of the RPAs. However, although Appendix B is not itself a water quality plan it does suggest the procedure for the development of a plan toward attainment of water quality standards in the Federal Columbia River Power System. Furthermore, it was anticipated that a mainstem water quality plan would include Columbia and Snake river TMDL limits currently under development by the states, tribes and EPA.

To this end a Mainstem Water Quality Plan Workgroup (Workgroup) was formed in 2001 and has been meeting regularly since. The Workgroup has produced a detailed outline of a comprehensive Mainstem Water Quality Plan and agreed to the following purpose statement to guide the group’s efforts:

- The Mainstem Water Quality Plan Workgroup will work to identify short-term actions for funding and implementation while working towards a long-term water quality plan for the mainstem that coordinates the Federal Columbia River Power System, Northwest Power Planning council sub-basin plans and the Clean Water Act to benefit fish.

In pursuit of this purpose the Workgroup also discussed and agreed to the following goals:

- Provide an implementation plan for water quality actions as called for in Appendix B of the NOAA Fisheries 2000 FCRPS Biological Opinion.
- Serve as an implementation framework for the Columbia and Snake rivers mainstem TMDLs.
- Serve as the implementation framework for total dissolved gas waivers for the Corps of Engineers implementation of the Biological Opinion spill program.

- Full engagement of the Columbia River action agencies.
- Commitment to ongoing Federal Executives dialogue.
- Commitment to use unified and best available science, and
- Commitment to fund the plan development.

Simultaneous to the early meetings of the Workgroup and the drafting of the above statements, the Northwest Power Planning Council conducted a solicitation for projects implementing the Mainstem Provincial Review. The Workgroup reviewed the water quality projects responding to the solicitation and offered policy guidance regarding the proposals to the Power Council and the Columbia Basin Fish and Wildlife Authority. Recently, the Workgroup has focused attention on the drafting of the Mainstem Water Quality Plan.

9.5 Water Quality Team

The Mainstem Water Quality Plan Workgroup may have specific technical issues arise as they pursue regional water quality planning and policies. Examples of technical issues could include but would not be limited to total dissolved gas or water temperature improvement topics, research needs or designs, monitoring strategies, or TMDL compliance concerns. In these instances the existing NOAA Fisheries technical Water Quality Team operating in support of the Biological Implementation may be called on for assistance. The Workgroup could also communicate with the other technical teams serving the NOAA Fisheries and the regional Implementation Team. These teams include the System Configuration Team and the Technical Management Team regarding issues of Federal Columbia River Power System modification and operation, respectively.

The Water Quality Plan Workgroup was formed to work towards identifying short-term actions for funding and implementation while working towards a comprehensive, long-term Water Quality Plan for the mainstem. This plan is meant to coordinate water quality improvement actions of the 2000 FCRPS Biological Opinion, the Northwest Power Planning Council's (NWPPC's) sub-basin plans, the Clean Water Act, and Tribal treaty and trust resources to benefit fish.

The principle goals for this plan include:

1) Provide an Implementation Plan for water quality actions as called for in Appendix B of the NMFS 2000 FCRPS BiOp.
2) Serve as an implementation framework for the Columbia/Snake mainstem TMDL
3) Serve as the implementation framework for TDG waivers for the Corps
4) Full engagement of the Columbia River Action Agencies
5) Commitment to ongoing Federal Executives Dialogue
6) Commitment to use unified and best available science, and
7) Commitment to Fund the Plan development

9.6 Total Maximum Daily Loads (TMDLs)

A Total Maximum Daily Load (TMDL) is a CWA tool for meeting water quality standards and is based on the relationship between pollution sources and in-stream water quality conditions. A TMDL establishes the allowable loadings or other quantifiable parameters for a water body and thereby provides the basis to establish water quality-based controls. A TMDL is required by the Clean Water Act for any stream reaches included by States or Tribes on their lists of impaired waters required under Section 303(d) of the Clean Water Act. Impaired waters are those that do not attain State or Tribal Water Quality Standards. These controls should provide the pollution reduction necessary for a water body to meet water quality standards. TMDLs are typically developed by States or tribes and approved through the EPA.

TMDL Implementation Plans are developed by States to achieve the load allocations identified in the TMDL. Implementation actions include the NPDES Permit Program, State Water Quality Certification Programs, State Non-point Source Management Programs and other mechanisms. The implementation plan development and implementation are the responsibility of the states of Idaho, Oregon and Washington in coordination with Columbia Basin Tribes. However, these states will rely heavily on the Federal Agencies that administer and operate the FCRPS. Further progress in water temperature reductions in the Columbia and Snake rivers will require a system-wide evaluation of the Columbia and Snake River system. This will require regional, national and international forums for problem identification and problem solving. It is hoped that this Water Quality Plan will form the fundamental foundation for the TMDL implementation plans for the Columbia and Snake rivers.

The Snake River from its confluence with the Salmon River at RM 188 to its confluence with the Columbia River has been included on the 303(d) list of impaired waters for temperature and TDG by Idaho, Oregon or Washington as appropriate. Oregon and Washington also included most of the Columbia River on their 303(d) lists for temperature. The Columbia River exceeds the WQS of the Colville Confederated Tribes and the Spokane Tribe of Indians also (WQS have been adopted by the Tribe but not yet approved by EPA).

9.7 Existing Temperature TMDLs

There are currently no approved temperature TMDLs for the mainstem Snake and Columbia rivers.

9.7.1 Anticipated Temperature TMDLs

EPA released a preliminary draft TMDL for water temperature in portions of the Columbia and Snake rivers in September of 2002. The Preliminary Draft TMDL addresses water temperature in the mainstem segments of the Columbia River from the Canadian Border to the Pacific Ocean and the Snake River from its confluence with the Salmon River to its confluence with the Columbia River. A series of public meetings have been held since July 2001, in part to discuss the methodology for allocations and potential solutions.

A workgroup has been formed to develop the Temperature and TDG TMDLs. This workgroup consists of staff from the Idaho Department of Environmental Quality, the Oregon Department of Environmental Quality, the Washington Department of Ecology and the EPA. A number of Columbia Basin Tribes, PUDs, Bonneville Power Administration, Corps of Engineers, Bureau of Reclamation, pulp and paper industries, NOAA Fisheries and US Fish and Wildlife Service also participate on the committee. EPA will issue the TMDLs for the parts of the rivers that are in Tribal Reservations.

The Snake River – Hells Canyon (SR-HC) draft TMDL document was released in 2001. This document addressed the water bodies in the SR-HC Subbasin that have been placed on the "303(d) list." This TMDL is expansive in that it covers toxics, temperature and TDG. This subbasin assessment and SR-HC TMDL analysis is a joint effort between the Idaho Department of Environmental Quality (IDEQ) and Oregon Department of Environmental Quality (ODEQ), with participation by the US Environmental Protection Agency (US EPA) and local stakeholders. (IDEQ & ODEQ 2001)

9.8 <u>Water Temperature and The Corps of Engineers</u>

The general policies of the Corps related to water quality are summarized in the **Corps Digest of Water Resources Policies and Authorities**, Engineering Pamphlet 1165-2-1, dated February 1996 (Corps 1996). The Corps policy is to comply with water quality standards to the extent practicable regarding nationwide operation of water resources projects. "Although water quality legislation does not require permits for discharges from reservoirs, downstream water quality standards should be met whenever possible. When releases are found to be incompatible with state standards they should be studied to establish an appropriate course of action for upgrading release quality, for the opportunity to improve water quality in support of ecosystem restoration, or for otherwise meeting their potential to best serve downstream needs. Any physical or operational modification to a project (for purposes other than water quality) shall not degrade water quality in the reservoir or project discharges," (Section 18-3.b, page 18-5). The data from the Corps Dissolved Gas Monitoring Program before 1984 was used to voluntarily monitor for compliance with water quality standards. In 1984, the Corps Dissolved Gas Monitoring Program was enhanced to serve the multiple purposes stated in the Corps policies and authorities.

9.9 <u>Water Temperature and The Columbia River Basin States and Tribes</u>

In addition to parts of British Columbia, the Columbia River Basin encompasses parts of Idaho, Oregon, Washington, Montana, Nevada, Utah and Wyoming, each of which has its own water quality standards. In addition, various Columbia basin tribes have water quality standards. Of primary interest of this Water Quality Plan are the States of Idaho, Oregon and Washington, as well as the regional tribes. Although some of these entities have water quality standards, currently EPA has promulgated only the plans the states of Idaho, Oregon and Washington and the Colville Tribe.

9.9.1 Idaho Water Quality Standards

The Idaho Water Quality Standard for water temperature is segregated by beneficial use of the water. The uses of interest in this document are the following two subcatagories of aquatic life:

1) Cold water (COLD): water quality appropriate for the protection and maintenance of a viable aquatic life community for cold water species.

Waters designated for cold water aquatic life are not to vary from the following characteristics due to human activities: Water temperatures of 22 degrees C (71.7 degrees, F) or less, with a maximum average daily average of no greater than 19 degrees C (66.2 degrees, F).

2) Salmonid spawning (SS): waters that provide or could provide a habitat for active self-propagating populations of salmonid fishes.

Waters designated for salmonid spawning are to exhibit the following characteristics during the spawning period and incubation for the particular species inhabiting those waters: Water temperatures of 13 degrees C (55.4 degrees, F) or less, with a maximum daily average of no greater than 9 degrees C (48.2 degrees, F).

Note that SS appears in Idaho's rules as a subsection under cold-water aquatic life. Thus the qualification for human caused deviation from the criteria also applies. These rules also state that when natural background conditions exceed any applicable criteria, pollutant levels shall not exceed the natural background condition, except that point sources may increase temperature levels up to 0.3°C above natural background. The provision that numeric criteria are not to be exceeded due to human activities is recent and has not yet been approved by EPA, but it is the law in Idaho.

9.9.2 Oregon Water Quality Standards

For the State of Oregon Water Quality Standard for water temperature, numeric temperature criteria are measured as the seven-day moving average of the daily maximum temperatures. If there is insufficient data to establish a seven-day average of maximum, the numeric criteria shall be applied as an instantaneous maximum. The measurements shall be made using sampling protocol appropriate to indicate impact to the beneficial uses. A measurable temperature increase means an increase in stream temperature of more than 0.25ºF.

Oregon standards also indicate that no measurable surface water temperature increases are allowed resulting from anthropogenic activities, including:

1) In the Columbia River or its associated sloughs and channels from the mouth to river mile 309 when surface water temperatures exceed 68.0ºF (20.0º).

2) In waters and periods of the year determined by the Department to support native salmonid spawning, egg incubation, and fry emergence from the egg and from the gravels in the basin which exceed 55.0ºF (12.8ºC).

3) In waters determined by the Department to support or to be necessary to maintain the viability of native Oregon bull trout, when surface water temperatures exceed 50.0ºF (10.0ºC).

4) In water determined by the Department to be ecologically significant cold-water refugia.

5) In stream segments containing federally listed Threatened and Endangered species if the increase would impair the biological integrity of the Threatened and Endangered population.

6) In Oregon waters when the dissolved oxygen (DO) levels are within 0.5 mg/l or 10 percent saturation of the water column or intergravel DO criterion for a given stream reach or subbasin.

7) In natural lakes.

9.9.3 Washington Water Quality Standards

For the Washington water quality standards, the designation of Class A (excellent) waters is as follows. "Temperature shall not exceed 18.0º C (64.4ºF) (freshwater) or 16.0º C (marine water) due to human activity. When natural conditions exceed 18.0º C (64.4ºF) (freshwater) and 16.0º (marine water), no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3º C.

Incremental temperature increases resulting from point source activities shall not, at any time, exceed t=28/(T+7) (freshwater) or t=12/(T-2) (marine water). Incremental temperature increases resulting from non-point source activities shall not exceed 2.8ºC. For purposes hereof, "t" represents the maximum permissible temperature increase measured at a mixing zone boundary; and the "T" represents the background temperature as measured at the point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge."

The Columbia River from the mouth to the Washington-Oregon border (river mile 309.3) is designated as Class A with a special condition. The temperature shall not exceed 20.0º C (68.0ºF) due to human activities. When natural conditions exceed 20.0ºC (68.0ºF), no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3ºC (0.5ºF); nor shall such temperature increases, at any time, exceed 0.3ºC (0.5ºF) due to any single source or 1.1ºC (1.9ºF) due to all such activities combined.

The Columbia River from the Washington-Oregon border (river mile 309.3) to Grand Coulee Dam (river mile 596.6) has a special condition from Washington-Oregon border (river mile 309.3) to Priest Rapids Dam (river mile 397.1). The temperature shall not exceed 20.0º C (68.0ºF) due to human activities. When natural conditions exceed 20.0ºC (68.0ºF), no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3ºC (0.5ºF); nor shall such temperature increases, at any time, exceed t=34/(T+9)[between 1.13º and 0.9 ºF].

The Snake River from the mouth (confluence with the Columbia River) to the Washington-Idaho-Oregon border (river mile 176.1) is designated Class A with a special condition.

(a) Below the Clearwater River (river mile 139.3): The temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t=34/(T+9).

(b) Above the Clearwater River (river mile 139.3): The temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed 0.3°C due to any single source or 1.1°C due to all such activities combined.

9.9.4 Colville Tribal Water Quality Standards

The use designations and corresponding temperature criteria for the Colville Tribe are as follows:

Class I (Extraordinary)—Fish and shellfish: Salmonid migration, rearing, spawning, and harvesting: Temperature shall not exceed 61°F (16°C) due to human activities. Temperature increases shall not, at any time, exceed t = 23/(T + 5). When natural conditions exceed 61°F (16°C), no temperature increase will be allowed that will raise the receiving water by greater than 32.5°F (0.3°C). For purposes hereof, “t” represents the permissive temperature change across the dilution zone; and “T” represents the highest existing temperature in this water classification outside of any dilution zone. Temperature increase resulting from nonpoint source activities shall not exceed 37°F (2.8°C) and the maximum water temperature shall not exceed 50.5°F (10.3°C).

Class II (Excellent)—Fish and shellfish: Salmonid migration, rearing, spawning, and harvesting: Temperature shall not exceed 64°F (18°C) due to human activities. Temperature increases shall not, at any time, exceed t = 28/(T + 7). For purposes hereof, “t” represents the permissive temperature change across the dilution zone; and “T” represents the highest existing temperature in this water classification outside of any dilution zone. Temperature increase resulting from nonpoint source activities shall not exceed 37°F (2.8°C) and the maximum water temperature shall not exceed 65°(18.3°C).

Class III (Good)—Fish and shellfish: Salmonid migration, rearing, spawning, and harvesting: Temperature shall not exceed 70°F (21°C) due to human activities. Temperature increases shall not, at any time, exceed t = 34/(T + 9). For purposes hereof, "t" represents the permissive temperature change across the dilution zone; and "T" represents the highest existing temperature in this water classification outside of any dilution zone. Temperature increase resulting from nonpoint source activities shall not exceed 37°F (2.8°C) and the maximum water temperature shall not exceed 70.3°F (21.3°C).

Class IV (Fair)—Salmonid migration. Temperature shall not exceed 72°F (22°C) due to human activities; T increases shall not exceed t = 20/(t + 2).

9.10 Snake and Columbia Water Temperatures – A Corps of Engineers Perspective

The Corps believes that water temperatures in the Snake and Columbia mainstem rivers regularly exceeded 20°C prior to impoundment, but also believes that temperatures are warmer today than they were historically. However, the Corps also believes that to characterize hydropower development as the only reason current temperatures are warmer than historic is incorrect. The Corps believes that water temperatures are warmer because of three major factors including:

1) Construction and Operation of the Federal and Private Columbia/Snake Mainstem Dams
2) Climate Changes
3) Upstream Influences

A brief discussion of the Corps perspective is presented in Appendix F.

10 Monitoring/Modeling/Operations/Structures

10.1 Physical Monitoring

The Corps plan of action for TDG monitoring for 2003 (including temperature) can be found on the TMT website http://www.nwd-wc.usace.army.mil/tmt/documents/wmp/ . This plan is produced annually in coordination with the Fish Passage Plan and provides greater detail for those who are interested. The details of the 2003 water-quality monitoring plan are in Appendix 4 of the annual Water Management Plan.

10.2 Purpose of Water Quality Monitors

In general the water quality fixed monitoring stations are designed to provide information needed to control dissolved gas supersaturation in the river system on a real time basis, to determine how project releases affect downstream water quality, trend monitoring, and to provide data of known quality to enhance analytical and predictive capability of existing models/tools. The data collected also measures temperature, as that is an integral part of analysis for total dissolved gas.

10.3 TDG Fixed Stations - Function and Location

Since 1994, two different types of fixed water quality monitoring stations have been used to achieve the purposes outlined in 2.1.1. Forebay and tailrace monitors are maintained at each Corps hydroproject and record temperature, and total gas pressure. This information is coupled with operational data and reported in near real time at http://www.nwd-wc.usace.army.mil/tmt/wcd/tdg/months.html. In general, the stations located downstream of the project within the tailwater channel are intended to monitor spillway releases and those in the forebay are intended to be conditions representative of the total river.

The forebay instruments are located in the forebay of the receiving pool project. The project forebay monitors are intended to represent a mixed cross section in the river just upstream of the dam and can be a fair approximation of aquatic habitat conditions as defined by TDG and water temperature in that area of the pool. The tailwater instruments are located near the project and are generally positioned in the spillway releases, downstream of aerated flow and prior to complete mixing with powerhouse releases. This information is often applied to spill management practices for the upstream project and is applied to water quality compliance monitoring as well.

11 RPAs Addressed

The BiOp contains 199 Reasonable and Prudent Alternatives that the Action Agencies are attempting to meet in an effort to avoid jeopardy to ESA listed anadromous salmonids. These include items ranging from habitat work in headwater streams to fish passage improvement devices at the Federal hydroelectric projects. Table 11-1 represents a partial list of the reasonable and prudent alternatives related to water temperatures that were identified in the BiOp.

Table 11-1 RPA actions being addressed by this Water Quality Plan

Type of Measures	Reasonable and Prudent Alternative				
Operational	19*	20	34*	35	
Construction	33				
Research/Monitoring/Modeling	114	115*	141*	142	143

* Indicates that the proposed temperature measures would yield only partial fulfillment of the RPA

As of January 10, 2003, the Corps believes that all of the BiOp RPAs noted in this table are either in the process of being addressed, or have been addressed in an attempt to fulfill the requirements of the BiOp. (Please Refer to the BiOp Implementation Plan). Appendix C has a more detailed list of the RPAs addressed in this table.

11.1 RPA Measure 141

This RPA evaluates the link between high water temperatures and associated disease on juvenile migration patterns during critical periods in the Lower Snake and Lower Columbia Rivers. Under this RPA several agencies collected hydrodynamic and water quality data during 2001 and 2002 for the Lower Snake. The USACE assembled the 2002 data into a database. Several agencies also have been monitoring summer migrants, the susceptibility of these fish to disease, and the link between temperature and migrant mortality. It is anticipated that, in coordination with RPA 143, these data will be combined with GIS and numerical modeling efforts (e.g., RPA 143) to produce a comprehensive assessment of long-term survival in relation to water temperature.

11.2 RPA Measure 143

One of the action items identified within the BiOp was measure number 143 which states: "The Action Agencies shall develop and coordinate with NMFS and EPA on a plan to model the water temperature effects of alternative Snake River operations. The modeling plan shall include a temperature data collection strategy developed in consultation with EPA, NMFS and state and Tribal water-quality agencies. The data collection strategy shall be sufficient to develop and operate the model and to document the effects of project operations." The geographic scope of measure 143 is the Snake River Basin from Dworshak Dam on the North Fork Clearwater River and Hells Canyon Dam on the Snake River to the confluence of the Snake River at the Columbia River.

In the Water Temperature Modeling and Data Collection Plan for the Lower Snake River Basin, dated October 9, 2003, the RPA 143 technical team recommended to the regional WQT that the CE-QUAL-W2 model be adopted for development in the river reaches of interest and identified a data collection strategy. The workgroup proposes to build an initial model domain for the minimum area needed for effective evaluation of operational effects on temperature (Phase 1) and expand the model in subsequent phases. The proposed phases are as follows:

Table 11-2 Model development for RPA measure 143.

Phase	North Fork Clearwater Boundary	Mainstem Clearwater Boundary	Upstream Snake River Boundary	Downstream Snake River Boundary
1	Mouth	Orofino	Anatone (RM 169)	Lower Granite Dam
2	Dworshak Reservoir Head	Orofino	Hells Canyon Dam Tailrace	Mouth
3	Dworshak Reservoir Head	Orofino	Brownlee Reservoir Head	Mouth

The USACE and BPA will be responsible for implementing the model and data collection efforts. The inter-agency technical team participating in this plan development will be asked to continue in a technical review role. They will review potential contractor Scopes of Work, field data collection and analysis, assist in defining the period of record for use in model evaluation and review and comment on reports produced during the development. Once the model has been reviewed and accepted, the team, in conjunction with the regional Technical Management Team (TMT) and WQT, will define and identify preliminary model runs required to answer questions originally posed by the team.

Scheduling of this work is highly dependent on available funding. At the end of FY2003, two years of detailed data will have been gathered on the river. FY2002 data collection was a screening data set used to assist in decisions concerning model selection. The FY2003 data collection was initiated in conformance with the data collection strategy. Beginning in FY2004 (October 2004), additional data collection will commence as well as initial model development. A tentative schedule for implementation is identified below:

FY2004 Tasks

- Collect additional field data
- Select periods for model evaluation
- Complete model setup including evaluation
- Technical team review calibration and verification report.

FY2005 Tasks

- System development to operate as real-time tool for use by regional interests
- Expand to Phase 2 Geographic Scope
- Revise Data Collection as needed to support Phase 2 and other model input improvements.

FY2006 and beyond

- Expand to Phase 3 Geographic Scope
- Revise data collection as needed to support Phase 3 and other model inputs and improvements

12 Proposed Columbia River Basin Water Temperature Measures

The following tables are a list of actions that have been proposed for 1) reducing overall river temperature, 2) reduce site-specific temperatures in the mainstem rivers (e.g. at fish bypass systems), and 3) enhance our understanding of temperature impacts in the Columbia River Basin. These lists were developed from discussions with the Corps of Engineers, the Bureau of Reclamation and the Environmental Protection Agency. Input was also solicited from other interested agencies and organizations. A matrix of these measures can be found in Appendix E. While these actions have been proposed, these actions by themselves or in concert may not reduce water temperatures, however, the ideas warrant discussion and some may warrant further investigation.

13 Proposed Mainstem Temperature Reduction Measures

13.1 (M-1) Operate Dworshak Reservoir to Release cool water in July and August to Aid juvenile migration and reduce mainstem Snake River Water Temperatures.

13.1.1 Introduction

Dworshak Dam was completed on the North Fork Clearwater River in 1971 and the reservoir was filled in 1973. Releases of hypolimnetic and metalimnetic water warmed the lower Clearwater River in the fall, winter, and spring, and cooled the river during summer (Tiffan et al 2001). Beginning in 1992, Dworshak Reservoir water as cool as 6°C has been released during July and August to decrease water temperatures in the Snake River. This action is done in an attempt to provide benefits to summer migrating juvenile and adult salmonids in the Lower Snake River system. The Corps of Engineers operates Dworshak Dam and implements this strategy on an annual basis at the request of the National Marine Fisheries Service.

In Peery et al 2002, a draft report, they estimated water temperatures in the forebay at Lower Granite Dam during summer could be decreased by 1 to 3ºC, depending on river flow and air temperature conditions, when releases from Dworshak reservoir reach 50% to 60% of Snake River flows at the dam. They also reported that these three variables were all significantly related to water temperatures recorded in the forebay of Lower Granite Dam, accounting for 72% of the variation in water temperatures using multiple linear regression analysis ($P < 0.0001$).

The following figures are meant to demonstrate the cooling effects of the Dworshak reservoir releases. The Corps understands that it is difficult to make comparisons with only a few years of data, however this is merely provided for general information.

Figure 4 demonstrates the average maximum daily temperatures of the mainstream Clearwater River near Spalding, Idaho from June to October in the time periods prior to building Dworshak Dam in 1971, after dam completion, and after the temperature augmentation measures commenced in 1992.

Figure 5 demonstrates average water temperatures as measured at the Ice Harbor scrollcase for roughly the period when dams were under construction, to the existence of Dworshak dam, to the period when Dworshak releases were being put into effect for temperature augmentation (Columbia River DART information). For comparison, a shorter data set of Lower Granite scrollcase data is provided in Figure 6 demonstrating the period when Lower Granite was built to the Dworshak flow augmentation measures commencing.

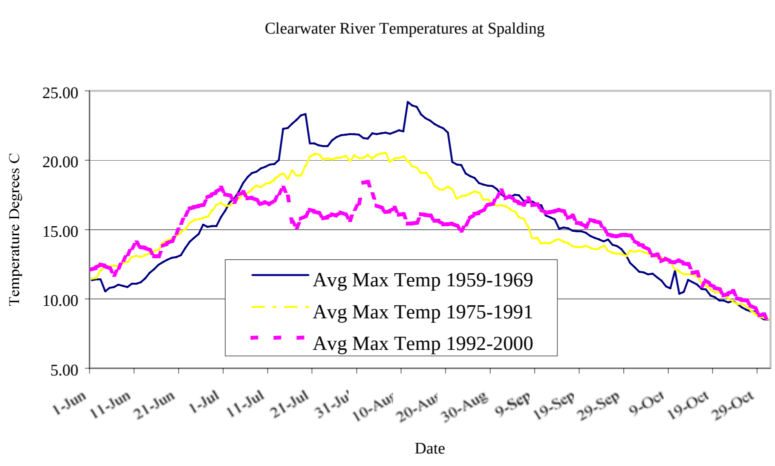

Figure 4. Clearwater average maximum daily temperatures as measured at USGS Gage at Spalding, Idaho from 1959-1969 and 1975-2000.

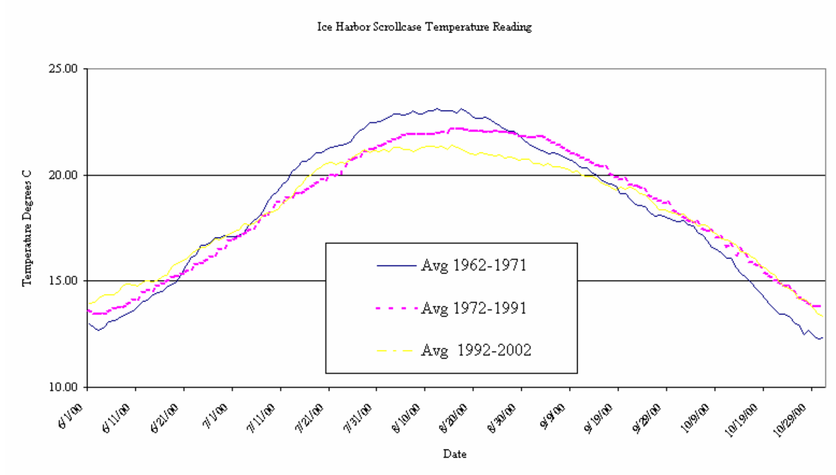

Figure 5. Water temperatures as measured at the Ice Harbor Dam Scrollcase, 1962-2002.

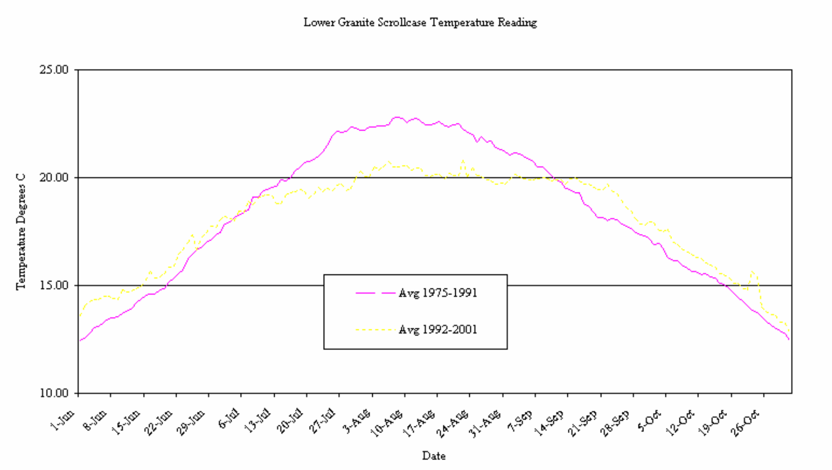

Figure 6. Water temperatures as measured at the Lower Granite Dam Scrollcase 1975-2001

13.1.2 BIOP RPA

Reasonable and Prudent Alternative (RPA) 18 provides guidelines on the operations of Hungry Horse, Libby, Albeni Falls, Grand Coulee and Dworshak dams and reservoirs. The primary emphasis of this RPA is to provide guidance for the operations of the storage reservoirs including strategic reservoir elevations and discharges during specific times of the year to benefit resident and anadromous fish. Dworshak Dam is the only storage project that is recommended for implementing temperature measures. The RPA states, "The Action Agencies shall manage Dworshak discharge to attempt to maintain water temperatures at the Lower Granite Reservoir forebay dissolved gas monitoring station at or below 68°F (20°C)."

13.1.3 Major Issues and Concerns

13.1.3.1 Negative Impacts to Rearing Juvenile Fall Chinook

The Nez Perce Tribe and the State of Idaho have expressed concern that releasing cold water from Dworshak could inhibit the growth rate of wild fall chinook salmon in the Clearwater River. NMFS has attempted to manage the risks to these fish in recent years in its recommended summer flow and temperature operations at Dworshak Dam.

In some years, the lower Clearwater River produces juveniles that have a “stream-type” (Healey 1991) early life history, opposed to the typical “ocean-type” (Healey 1991) early life history of inland fall chinook salmon. Rates of residualism as high as 85.7% in 1994 may have been an unintended result of releasing cool water from Dworshak Reservoir for summer flow augmentation. Fall chinook typically migrate out of the Snake and Clearwater rivers by August in most years. However, large volumes (approximately 609 m3/s/d) of 8.2°C water released in July, 1994 decreased water temperatures in the lower Clearwater River from 19.5 to 8.8°C. This 10.7°C drop probably worked in concert with decreasing day length to cause the high rate of residualism by decreasing growth of parr that were still rearing and had not reached smolt size. In contrast to 1994, smaller volumes (approximately 381 m3/s/d) of 10.8°C water released from Dworshak Reservoir in July and August of 1995 resulted in a drop from 19.8 to 13.0°C, and only 6.3% of fish from the lower Clearwater River residualized and completed seaward migration as yearling smolts. (Tiffan et al 2001)

13.1.3.2 Balancing of reservoir elevation versus augmentation

Currently, storage projects are prioritized to fill by June 30 (RPA 18), which maximizes the rate of water to be released in July and August for salmon flows and temperature reduction flows. Drawing the reservoir down to elevation 1520 may reduce the potential to refill to the appropriate level.

13.1.3.3 Impacts to summer migrating adult salmonids

Concerns with adult salmonid migrations are three-fold. Delay associated with high temperature, delay associated with low temperature, and delay associated with temperature differences.

The concern of high temperature is that without Dworshak flows, migrating fish would be negatively impacted by migrating through higher water temperatures. Major and Mighell (1966) concluded that the delay of Sockeye salmon near the mouth of the Okanogan River was due to a thermal block or associated factors when water temperature was greater than 21.1°C. Other reports (including Stuehrenberg et al 1993) have indicated that during the summer months, a thermal block may have occurred at the Snake River mouth near Pasco, Washington. The impacts of higher temperatures can include temperature related mortality, decreased gamete viability and/or overall loss of vigor.

Delays associated with low temperatures have been documented by adult radiotelemetry studies being conducted with NMFS and the University of Idaho. Migrating salmonids are known to harbor in mouths of tributaries that contribute cool water to the mainstem Columbia River during periods of warm temperatures. While the fish that experience these cooler temperature refugia, and continue migration, have demonstrated higher migratory success than those that do not, they are also exposed to heavier fishing pressure at these locations as well as at the mouth of the Clearwater River.

The primary issue regarding temperature differences occurs at the fish ladders themselves. Peery et al 2002 detected a delay by some fish in passing dams when temperatures exceeded 20°C and when there was a noticeable difference in temperatures between the tailrace and forebay surface, creating a sharp delineation where these two sources of water met in the fishways. Ironically, this condition was exacerbated when water was being released from Dworshak, creating a greater discrepancy between cool water temperatures deep in the reservoirs, that were subsequently passed by turbines and picked up in the tailrace, and those warmed at the forebay surface that flowed down the fishways.

13.1.3.4 Higher TDG Levels With Dworshak Discharge Rate

Spillway, low level regulating outlets and some turbine operations at Dworshak Dam can produce increased levels of total dissolved gas (TDG) in the tailwater area of the project. TDG production at Dworshak dam may contribute to elevated gas levels observed in the mainstem Clearwater River, at Lower Granite dam and can be problematic for a US Fish and Wildlife fish hatchery (Dworshak Hatchery).

One of the limitations on the amount of water released from Dworshak Dam is the TDG level in the North Fork Clearwater River. Theoretically, the spillway could be used for water temperature control; however, the spillway is not used regularly because of the high TDG levels that it produces. Typically, the spillway is only used during high runoff and flood events.

The State of Idaho and the anticipated Nez Perce water quality standards are 110% of TDG saturation. The state has requested that the Corps operate to 109%, thereby accounting for potential instrumentation error. Regional acceptance of this standard and rationale has not been reached. Operating to 109% TDG limits the volume of cold water that can be drawn from Dworshak Reservoir. Some regional interests have suggested examining of releases that approach 120% TDG supersaturation.

13.1.3.5 Bull trout

The impacts of releasing water from Dworshak Dam may negatively affect Bull trout. Radiotelemetry studies are currently being conducted that are examining this. Not only is there concern for entraining Bull trout, but also for the entraining of kokanee, which is a primary prey target for them. There is also concern as to whether extreme drawdowns of the reservoir would impact Bull trout migrations into creeks that feed the reservoirs.

13.1.3.6 SOR EIS

Further discussions of the effects can be found in the 1995 Columbia River System Operation Review/ Final EIS.

13.1.4 Feasibility and Implementation

This proposed operation is the current operating standard for Dworshak Dam. Because this is a feasible measure that is implemented yearly, no further tests for the reservoir operation would be needed for temperature impacts, however, the effects of temperature on fall chinook growth and behavior may warrant further study.

13.1.5 Schedule

This activity is currently performed yearly through the collaborative decision process of the Technical Management Team.

13.2 (M-2) Examine the Benefits of Drafting Dworshak an Additional 20 Feet during 13.3 September to provide cool water to the mainstem.

13.3.1 Introduction

Drawing down Dworshak reservoir an additional 20 feet, as indicated in the Biop, has the potential to 1) reduce water temperature, 2) eliminate thermal blocks that may delay adult migration into and through the lower Snake River, and 3) improve gamete viability of summer migrating adults. The main rationale for evaluating an additional 20-foot draft (on top of the current 80 foot drawdown) of Dworshak Reservoir in September is to determine whether cooling Snake River temperatures during September would provide an adult passage benefit.

Figure 7 demonstrates that the time period in September is warmer for a longer than what occurred prior to the Dworshak operations. It also demonstrates how cool water releases into September could cool the latter part of the fall water temperatures.

13.3.2 BIOP RPA

RPA 34 states that, “Action Agencies (AA) shall evaluate potential benefits to adult Snake River steelhead and fall chinook salmon passage by drafting Dworshak Reservoir to elevation 1,500 feet in September. An evaluation of the temperature effects and adult migration behavior should accompany a draft of Dworshak Reservoir substantially below elevation 1,520 feet.”

It also states, “an evaluation should be conducted to assess the effects of the September draft on lower Snake River temperatures and on the migratory behavior and passage timing of adult salmonids that are equipped with depth and temperature-sensitive tags. An evaluation of Dworshak refill probability indicates that this study operation would have little impact on reservoir refill by the end of June in the following year, i.e., two additional refill misses in BPA’s 50-year hydrosystem study.”

13.3.3 Major Issues and Concerns

13.3.3.1 Risk to reservoir refill and reduction of spring flows

Currently, storage projects are prioritized to fill by June 30 (RPA 18), which maximizes the amount of water to be released in July and August for salmon flows and temperature reduction flows. The State of Idaho and Nez Perce tribe are concerned that drawing the reservoir down an additional 20 feet may reduce the potential to refill to the appropriate level, thereby reducing flows for salmon the following spring.

A 50 year hydro-regulation study of Dworshak refill probability indicates the September Adult study operation, when conducted, would have little to no effect on reservoir refill by the end of June in subsequent years, i.e., there are only two additional refill failures at Dworshak on June 30, and the average of these three refill misses is less than 12 feet from full pool, with two of these misses within 9 feet of full pool. For comparison, the single refill miss under the proposed action was 15 feet from full pool. NMFS believes that this is an acceptable risk to refill of the June 30 full pool.

Moreover, a 50-year hydro-regulation study of Dworshak refill probability indicates the September adult study operation, when conducted, has no discernable effect on reservoir refill to upper rule curve elevation by April 10, and little to no effect on spring flows.

13.3.3.2 Higher TDG Levels With Dworshak Discharge Rate

As previously discussed in section 5.1.3.4, operating to 109% TDG limits the volume of cold water that can be drawn from Dworshak Reservoir. This may impact how water releases are made in September.

13.3.3.3 Cultural Resources

The Nez Perce tribe and is concerned with increased drawdown exposing cultural resources to potential looting or other additional damage as occurred on Lower Granite and Little Goose reservoirs during the Lower Snake River drawdown study (See Section 5.5.3.4)

13.3.3.4 Impacts to power system

Additional outflow in September would increase energy production in that month. An offsetting volume of flow would be lost from the January - June period as the reservoir storage level is returned to the same levels it would have been without the September draft. Loss of flow causes a loss of energy production in the January - June period. Generally, the net of the energy production changes over the year and the related energy revenue changes are expected to be small.

13.3.3.5 Recreation

Drawing Dworshak Reservoir down an additional 20 feet in September would further limit the recreational opportunities that exist there. While the State of Idaho has stated that they do not support the further reduction of reservoir elevation, thereby reducing recreational opportunities, they have indicated that they support releases of cooler water into September.

13.3.3.6 Bull trout

As mentioned in Section 5.1.3.5, releasing water from Dworshak Dam may negatively affect Bull trout. Further drawdown of the reservoir would have a presently unknown impact on this species.

13.3.3.7 SOR EIS

Further discussions of the effects can be found in the 1995 Columbia River System Operation Review/ Final EIS.

13.3.4 Feasibility and Implementation

Although the reservoir was not drawn down below elevation 1520, a field test was completed in 2002 that allowed the equivalent amount of water to be released from Dworshak Dam in September that a drawdown of an additional 20 feet from elevation 1520 to 1500 feet, would have accomplished. Although this is believed to have benefited steelhead migration at Lower Granite Dam, it did not significantly decrease the overall travel time of these fish through the Lower Snake River (Peery et al 2003).

13.3.5 Schedule

Studies began in 2002 and are ongoing.

13.4 <u>(M-3a) Operate the Four Lower Snake River Reservoirs between MOP and MOP+1 from April through roughly October.</u>

13.4.1 Introduction

Lower Snake River reservoirs that are operated at lower elevations have a reduced cross-sectional area, thereby increasing water velocity at a given flow. As a result, reduced water particle travel time can help to reduce the amount of warming that occurs due to solar radiation. In addition, juvenile migrants have demonstrated faster travel with increased water velocities; therefore drawdown to MOP would be expected to provide faster emigration and improved survival (NMFS 2000).

13.4.2 BIOP RPA

RPA 20 states, "The Corps shall operate the lower Snake River reservoirs within 1 foot of MOP from approximately April 3 until small numbers of juvenile migrants are present …" In addition, "Lower Granite Dam should not be refilled until enough natural cooling has occurred in the fall, generally after October 1."

13.4.3 Major Issues and Concerns

13.4.3.1 Dredging Injunction

The Walla Walla District of the Corps of Engineers completed a Dredged Material Management Plan and Environmental Impact Statement in 2002 for the Lower Snake River Reservoirs and McNary Reservoir. Dredging the navigation channel at the confluence of the Snake and Clearwater Rivers and the tailraces of Lower Granite and Lower Monumental dams was scheduled for the winter of 2003. However, a lawsuit was filed just prior to dredging, and an emergency injunction to the dredging was granted. Navigation dredging will not be performed in 2003 due to the lawsuit and is in question for 2004. As a result, in some locations, the navigation channel will not be the authorized 14 foot of depth at MOP or MOP+1.

In the 2003 BiOp implementation plan, the Corps stated its intention to operate the lower Snake River reservoirs within 1 foot of MOP. The Corps will notify NMFS of its decision on operational needs at Snake River projects for 2003, including any proposed deviations from MOP criteria.

13.4.3.2 Decreased Power Generation and System Flexibility

When the reservoir behind the Lower Snake River Dams is lowered in elevation, the ability to produce power is reduced due to a lessening of hydraulic head on the turbine. This in turn leads to less system flexibility with respect to power generation and storage of water in the reservoirs. In addition, the inability to fluctuate the reservoir level throughout the day causes a loss in power related revenues. With a wider operating range, more of the day-average flow through the projects can be used to produce energy in the period of the day (heavy load hours) when energy values are highest.

13.4.4 SOR EIS

Further discussions of the effects can be found in the SOR EIS.

13.4.5 Feasibility and Implementation

Discussions with the TMT will likely be held to determine if it is appropriate for operation of the reservoirs to exceed MOP where sediment has inhibited navigation if a request for this operation is tendered.

13.4.6 Schedule

Operating levels of the Lower Snake River Dams are discussed and implemented on a weekly basis through the TMT.

13.5 <u>(M-3b) Operate the Four Lower Snake River Reservoirs below MOP, e.g. at MSL 710 or Spillway Crest from April through roughly October.</u>

13.5.1 Introduction

The Lower Snake River Drawdown test was performed in 1992 as a result of the recommendations of the Salmon Summit in 1991. The test was designed to gather information regarding the effects of lowering existing reservoirs to potentially improve survival of downstream migrating salmonids. Lower Granite reservoir was drawn down primarily 20 feet, however to a maximum of 36 feet and Little Goose reservoir was drawn down a maximum of 12 feet. Lesser drawdown tests were not performed. Detailed information can be found in the Lower Snake River Drawdown Test Report, 1993. This report presented background material on the salmon runs and the effects of dam operations, what was accomplished during the drawdown test, including implementation procedures, monitoring and evaluation objectives and procedures, and results.

As mentioned in 4a, decreased reservoir elevation would lead to faster water particle travel time and reduce the overall exposure to solar radiation.

13.5.2 BIOP RPA

None

13.5.3 Major Issues and Concerns

13.5.3.1 Negative impacts to salmonids

Drawing the reservoir down may have a beneficial impact for juvenile salmon by increasing water velocity, thereby reducing smolt travel time through the reservoir. However, one of the major drawbacks of drawing the reservoir down <u>only</u> during the juvenile salmon outmigration period is that it would render the juvenile fish passage system at Lower Granite Dam unusable (if reservoir is below MOP). There are two alternatives for fish passage in the absence of the juvenile bypass systems; the turbines and the spillway. For turbine passage, the intake screens could be pulled, and fish would pass through the turbines, with most likely higher than desired mortality rates. In addition, a large number of fish would be trapped in the gatewells with no opportunity for exit, and a great number could eventually die. Although a lift tank was tested in 1994 for removal of fish from gatewells (Swan et al. 1994) to handle the number of juvenile salmon passing the project, up to 18 would need to be constructed at a very high cost. Another alternative would be to periodically dip gatewells and put fish in trucks for transporting downstream. Gatewell residence time, however, is a concern. Depending on the gatewell environment, conditions for fish can be detrimental if fish spend too much time there. The Corps does not advocate this means of fish passage during what is typically the peak of the juvenile outmigration.

If an all-spillway route were determined to be the most appropriate passage route, with no powerhouse operation, a large eddy would develop in the tailrace of the dam. A predator study

(Bjornn and Piaskowski 1999) showed that during spill operations, predators in the tailrace of Lower Granite Dam tended to seek out the lower velocity areas (although this study mentioned spill on versus spill off, without regard to powerhouse operations). If an eddy is set up, it has the potential to continually cycle juvenile fish through it and constantly expose them to more predators. Although the Corps agrees that certain turbine operations could help disrupt the eddy, the NMFS FCRPS Biop indicates that within their SIMPAS modeling efforts, they predict there would be 90-93% survival at each dam for turbine passage at the Snake River Dams (FCRPS Biop, Pages D-13-20). However, fish survival through turbines has not been measured for running at the proposed drawdown levels. Pulling fish screens and letting fish go through the turbines at the proposed forebay elevation would have unknown effects on juvenile fish survival. This operation is contrary to the agreed implementation of the Reasonable and Prudent Alternative in the 2000 FCRPS BIOP.

Without a functional juvenile bypass system, the Corps cannot transport juvenile fish around the dams. One of the benefits of transporting juvenile fish from Lower Granite Dam to downstream of Bonneville Dam is the reduced time that fish spend migrating through the hydrosystem. Fish that have been slowed down can enter saltwater smaller and less physically and physiologically developed. Because the Corps has the ability to run the bypass systems and collect fish for transportation, and deliver them to the estuary at a higher survival rate and in better physiological condition than fish traveling inriver (with a higher lipid level), drawing the reservoir down for extended periods during the juvenile fish migration seasons would most likely have a negative impact to the fish runs. The NMFS 2000 FCRPS Biological Opinion supports this.

In addition, adult passage systems for operations below MOP are currently only available at Lower Granite Dam. This system, although in place, has not been tested.

13.5.3.2 Negative biological impacts to reservoir

Rearing areas important to fall chinook and sturgeon would be rendered less usable if drawdown occurred on a seasonal basis. Invertebrates that use the Port of Wilma, Centennial Island and other known shallow water rearing areas would be desiccated and would provide little to no benefit to fish rearing in the area either during drawdown or after water up. However, possibly of even greater detriment, Bennett (1995) demonstrated that after the drawdown event in 1992, smallmouth bass changed their predation targets, from preying primarily on crayfish to a diet composed of more juvenile salmonids, caused by the reduction in the number of invertebrate species due to the drawdown. Because these invertebrate species would be negatively affected, species that rely on them as a primary source of food, including white sturgeon, channel catfish and other predatory species, all have the potential to change predation targets to salmonid smolts. Disruption of the food web on a *repetitive* basis would cause overall detrimental effects to the limnological characteristics of the reservoir and in turn, the smolts that would be migrating through or trying to rear in these locations on a yearly basis.

13.5.3.3 Negative impacts to Navigation/Hydropower/Infrastructure

Drawdown of the lower Snake River reservoirs during periods of high temperatures would eliminate barging of commodities ranging from grain to petroleum to paper products for two months out of the year. In addition, lower reservoir elevations would limit the amount of power that could be produced due to reduced head on turbines, decreasing generating capacity. In the November 1995 System Operations Review EIS, partial drawdown of the four lower Snake River projects for four and a half months was analyzed (SOS-6b). The reported 50-year average annual energy production loss from that scenario was 277 average megawatts (aMW). A seven-month (April through October) operation would add significantly to the loss. During the 1992 drawdown, damage to levees, roadways, and boat basins occurred at the approximate cost of $1.3 million.

13.5.3.4 Negative impacts to Cultural Resources

While collecting/vandalism was recognized as a potential problem during the 1992 drawdown test, it occurred at a much greater scale than was anticipated. This happened despite extensive "anti-collecting" press releases both prior to and during the drawdown along with patrolling efforts by Corps project personnel, Washington State University and members of the Nez Perce and Umatilla Tribes. Several sites in particular received heavy impacts from collecting. This undoubtedly was due in part to their proximity to Lewiston and Clarkston. Overall, the drawdown provided access to almost every site that was monitored; sites which were inspected were marked by footprints of artifact collectors or curiosity seekers. (Corps 1993 pp. 130) In addition, between lower Granite and Little Goose Reservoirs, seven Native American burials were uncovered and required attention (Corps 1993 pp 129).

13.5.4 SOR EIS

Further discussions of the effects can be found in the 1995 Columbia River Salmon Flow measures Option Analysis/EIS

13.5.5 Feasibility and Implementation

Although various levels of drawdown have been proposed, drawing the river down when fish are passing the projects would have much the same effects on fish passage at the dams, reservoir ecology, cultural resources, and navigation. This operation has been determined by the Corps to be "not feasible" and is not planned for implementation.

13.5.6 Schedule

A final report was produced in December 1993 and no further action is proposed.

13.6 <u>(M-3c) Operate Lower Granite Reservoir at Spillway Crest year round.</u>

13.6.1 Introduction

As mentioned in measure M-3a, decreased reservoir elevation would lead to faster water particle travel time and reduce the overall exposure to solar radiation.

13.6.2 BIOP RPA

None

13.6.3 Major Issues and Concerns

13.6.3.1 Negative impacts to salmonids

The negative impacts to salmonids would be the same as mentioned in section M-3b.

13.6.3.2 Negative biological impacts to reservoir

Because the permanent drawdown to spillway crest would not be done on a seasonal basis, the short term impacts to the reservoir would be substantial. However in the long term, as shallow water habitat developed in the new reservoir, it might be expected to stabilize and provide rearing habitat again for fall chinook and other species. For a discussion on repetitive drawdowns on the reservoir, please see section 5.4

13.6.3.3 Negative impacts to Navigation/Hydropower/Infrastructure

Permanent drawdown of the Lower Granite Reservoir eliminate barging of commodities ranging from grain to petroleum to paper products year round. As with temporary drawdowns, lower reservoir elevations would limit the amount of power that could be produced due to reduced head on turbines, decreasing generating capacity. And short term damage to levees, roadways, and boat basins would again occur.

13.6.3.4 Negative impacts to Cultural Resources

As in section 5.4, cultural resources would be exposed to potential damage and/or looting.

13.6.4 Feasibility and Implementation

Because of the negative impacts listed in section 5.7.3, this operation has been determined by the Corps to be "not feasible" and is not planned for implementation.

13.6.5 Schedule

A final report on a Lower Granite reservoir drawdown was produced in December 1993 and a full Lower Snake River Drawdown in 2002. No further action is proposed at this time.

13.7 <u>(M-3d) Remove Dams and Reservoirs</u>

13.7.1 Introduction

Two studies have recently been completed to look at the effects of removing dams in the Columbia River basin. These studies looked specifically at the four Lower Snake dams and John Day Dam. If determined that changes to water temperature cannot be accomplished through other means, removing all dams or those that have the highest impact to water temperatures may warrant consideration. The primary focus of this section, however, will remain on the removal of

Lower Snake River dams because this is related to the 2005 and 2008 NMFS 2000 BiOp Check-in evaluations.

The Lower Snake River Juvenile Salmon Migration Feasibility Study was finalized in 2002. This study began in 1995 as part of the recommendations of the NMFS 1995 Biological Opinion. As part of this feasibility study, the alternative of removing the Lower Snake River dams was investigated. Dam breaching would create a 140-mile stretch of river with near-natural flow by removing the earthen embankment section of each dam and eliminating the reservoirs at all four lower Snake River dams. The powerhouses, spillways, and navigation locks would not be removed, but would no longer be functional. This would further reduce water surface areas exposed to solar radiation.

13.7.2 BIOP RPA

None

13.7.3 Major Issues and Concerns

The issues surrounding removal of the dams are extensive and would overwhelm this document. A brief description of the impacts to the river system is provided here, however, more extensive and detailed information can be found in the Lower Snake River Juvenile Salmon Migration Feasibility Study (Corps 2002).

If the dams were removed, all facilities for transporting fish would cease to operate, as would hydropower operation. Other impacts include the exposing of cultural resources, an impact to the economy of the region and the reduction of water transportation to Idaho. The navigation locks would no longer be operational, and navigation for commercial and large recreation vessels would be curtailed. Similarly, recreation opportunities, operation and maintenance of hatcheries and Habitat Management Units (HMUs), and other activities associated with the modification from a reservoir environment to an unimpounded lower Snake River would require important and substantial changes. Under Alternative 4—Dam Breaching, some water quality conditions such as TDG concentrations, would likely be at or near natural conditions. However, other conditions such as water temperature would still be affected by upstream conditions and/or releases. Although it has not been modeled, releases of water from Dworshak Dam might be reduced if there is an overall smaller volume of water to cool where the 4 lower Snake River dams and reservoirs currently exist.

13.7.4 Feasibility and Implementation

Of the four alternatives investigated in the FR/EIS, the recommended plan of major system improvements most closely matches the recommendations in the NMFS 2000 Biological Opinion for the Lower Snake River Project. The NMFS 2000 Biological Opinion concluded that dam breaching on the lower Snake River is not necessary at this time, but reserved this action as a contingency management alternative if the listed stocks continue to decline in the near future (2005 to 2008). The Corps' selection of a modified version of Alternative 3—Major System Improvements (Adaptive Migration) as the recommended plan (preferred alternative) is consistent with this conclusion.

The plan includes implementation of the actions applicable to the Corps as recommended in the NMFS 2000 Biological Opinion and the USFWS 2000 Biological Opinion for system operations, configuration measures, habitat restoration, and continued research and monitoring activities (or alternative measures that result in achieving the current or revised established performance standards). In implementing the Biological Opinions' lower Snake River actions, the Corps will also contribute to the attainment of the goals identified in the Conservation of Columbia Basin Fish: Final Basinwide Salmon Recovery dated December 2000. This strategy was developed by several Federal agencies (including the Corps) as part of the Federal Caucus. It is a comprehensive, long-term plan to recover 12 anadromous fish stocks and other listed species (i.e., bull trout and sturgeon) in the Columbia-Snake River Basin.

Analyses of the effects of dam breaching on water temperature was based on both empirical data and model simulations. The results of these two analysis methods vary slightly but are in agreement. The U.S. Environmental Protection Agency (EPA) provided its water temperature modeling expertise and resources to evaluate the effects of the reservoirs using its RBM-10 model to simulate 1980, 1984, 1988, 1994, 1995, and 1997 conditions with and without the reservoirs at Snake River RM 10 (Ice Harbor) and RM 107 (Lower Granite).

Empirical data indicate that water temperatures within the study reach after dam breaching would be similar to those found on the Snake River above the existing Lower Granite pool. The maximum summer water temperature expected each year would typically reach 23°C and would exceed a 20°C benchmark temperature approximately 60 days (which are the approximate conditions found within the existing reservoirs dependent upon location and operations). Fluctuations between day and night water temperatures would typically be approximately 0.5 to 1.5°C within the water column and 1 to 2°C at the water surface. Spring water temperatures after breaching would warm faster (approximately 1 week) than the existing reservoir temperatures and would cool faster (approximately 2 weeks) in the late summer than the existing reservoir temperatures.

RBM-10 simulations indicate approximately the same maximum summer water temperatures of approximately 22 to 23°C with and without the dams. The number of days that a benchmark temperature of 20°C would be exceeded at RM 107 in an average flow year would be 46 days for the reservoir condition and 44 days for the near-natural river condition. At RM 10 the computed number of days exceeding 20°C was 57 days for the reservoir condition and 46 days for the near-natural river condition. According to RBM-10 simulations, the effect of the dams on average temperature during the hot period of the year (June through August) is minimal with temperature going from 18.9°C with the reservoirs in place to 19.1°C for a near-natural river condition.

RBM-10 simulations show greater differences in the 1994, 1995, and 1997 simulations when Dworshak Dam augmentation with cold water was used to compute temperature differences between the existing condition and the near-natural river condition. In an average flow year, the number of days the temperature exceeded 20°C at RM 107 goes from 64 with the dams to 59 without the dams.

(All preceding data was taken from Corps 2002.)

Further information on modeling water temperatures in the geographic scope of this plan will be available in the near future. EPA is developing much of this information for the TMDL process. Because the models being used for this have been updated since the Corps 2002, the newer modeling runs may present different results as what was presented in the previous section.

13.7.5 Schedule

A final report was released in 2002 and no further action is anticipated at this time. The 2005 and 2008 check-ins will determine if further action on this measure would need to be considered.

13.8 (M-3e) Draw down John Day Reservoir to spillway crest or natural river.

13.8.1 Introduction

In 2000, the Portland District ACOE completed a study on the Salmon Recovery through John Day Reservoir – John Day Drawdown Phase 1 Study. Although not looking at temperature in depth, this study indicated that drawdown of the reservoir to spillway crest would reduce water particle travel time through the reservoir from 5.7 to 2.5 days, and that complete drawdown of the reservoir would result in water travel time to 0.9 day. These drawdown scenarios would be expected to decrease the amount of time that water is exposed to solar radiation, however because of the reduced volume of water, the peaks in temperature would be expected to be higher and the water in that stretch of the river would be expected to warm and cool much faster during the daily cycle. (Corps 2002b)

13.8.2 BIOP RPA

None

13.8.3 Major Issues and Concerns

Although this was not specifically a temperature related study, the recommendations that resulted in the John Day Drawdown Test-Phase I indicated that drawdown of the John Day reservoir is not supported. (Corps 2002b) This conclusion was based on information that indicated drawdown would:

1) do little to change the survival or recovery of listed Snake River stocks,
2) have mixed results for mid-Columbia stocks,
3) have significant short term impacts to wildlife in that river reach,
4) cost between $2.0-4.7 billion for up front costs with $403-607 million annual costs over 100 years

13.8.3.1 Negative impacts to salmonids

Similar negative impacts to salmonids outlined in measure M-3c including primarily fish passage at the dam and through the reservoir.

13.8.3.2 Negative biological impacts to reservoir

Similar negative impacts to salmonids outlined in measure M-3c including primarily negative impacts to salmonids from reduced reservoir health.

13.8.3.3 Negative impacts to Navigation/Hydropower/Infrastructure

Lower reservoirs would impact navigation, power production and possibly cause damage to levees and roadways similar to what was outlined in measure M-3c.

13.8.3.4 Negative impacts to Cultural Resources

Lower reservoirs would impact cultural resources by exposing cultural resources to damage and looting, similar to what was outlined in measure M-3c.

13.8.4 Feasibility and Implementation

The Corps has determined that this operation is "Not Feasible" because of little improvements for migrating anadromous fish, negative impacts to wildlife, and a very large cost (See section 5.6.3).

13.8.5 Schedule

A final report was completed in 2000 and no further action is anticipated.

13.9 <u>(M-3f) Draw down other dams to spillway crest or natural river temporarily or</u>
13.10 <u>_year round.</u>

13.10.1 Introduction

As mentioned in measure M-3a, decreased reservoir elevation would lead to faster water particle travel time and reduce the overall exposure to solar radiation.

13.10.2 BIOP RPA

None

13.10.3 Major Issues and Concerns

13.10.3.1 Negative impacts to salmonids

The negative impacts to salmonids would be the same as mentioned in section M-3b and M-3c.

13.10.3.2 Negative biological impacts to reservoir

The negative impacts to the reservoir would be the same as mentioned in section M-3b and M-3c.

13.10.3.3 Negative impacts to Navigation/Hydropower/Infrastructure

The negative impacts to Navigation/Hydropower/Infrastructure would be the same as mentioned in section M-3b and M-3c.

13.10.3.4 Negative impacts to Cultural Resources

As in section 5.4, cultural resources would be exposed to potential damage and/or looting.

13.10.4 Feasibility and Implementation

Unknown

13.10.5 Schedule

Unknown

13.11 <u>(M-4) Grand Coulee Powerhouse Operations.</u>

13.11.1 Introduction

Grand Coulee Dam, a storage project, has three separate powerhouses, of which the two older ones (left and right) draw water from a reservoir depth of approximately 200 feet and the newer third powerplant, which draws water from around 90 feet of depth. It is thought that having powerhouse priority for the older/deeper powerhouses would have a beneficial effect on temperatures downstream by drawing water from a lower and presumably cooler level of the reservoir.

13.11.2 BIOP RPA

None directly associated with it

13.11.3 Major Issues and Concerns

The newest powerhouse has the potential to release the largest volume of water downstream (210,000 cfs). Therefore, selective powerhouse use is limited to the amount of water that can be passed through the older powerhouses (90,000 cfs). To meet peak load requirements, it is necessary to operate all powerhouses, which would reduce the efficiency of this operation for temperature management. A preliminary analysis of this option, using a one-dimensional selective withdrawal model (Vermeyen, 2000) suggests that selective operation of the left, right, and third powerhouses could result in as much as a 2° C reduction in Grand Coulee tailrace temperatures during the summer stratification period. However, the one-dimensional model does not provide for determining if lower release temperatures can be sustained for more than a few days.

In addition, the stratification that occurs in lake Roosevelt typically breaks up in September. Therefore there is no potential for cooling downstream waters after that time. This type of operation may help to lower temperatures in the summer time frame; however, it would not be able to do anything for the extended fall period of warmer temperatures as introduced by the reservoir environment.

13.11.4Feasibility and Implementation

Reclamation is currently conducting pre-appraisal analyses of this option, and will commit to additional study and testing if preliminary analyses find it is warranted.

13.11.5Schedule

TBD

13.12 <u>(M-5a) Use or Modify Water Intakes at Storage Reservoirs for Selective withdrawal.</u>

13.12.1 Introduction

Selective withdrawal has been demonstrated at storage reservoirs to draw cooler water from stratified levels of the reservoir and deliver it downstream. The three mainstem storage reservoirs in the subject area are Grand Coulee, Brownlee and Dworshak.

13.12.2 BIOP RPA

None

13.12.3 Major Issues and Concerns

Selective withdrawal currently exists at Dworshak reservoir. With the exception of Grand Coulee (Action Item 9b), there are no other federal projects that could reduce water temperature in the Mainstem Snake and Columbia rivers. Brownlee may have the potential to draw cooler water during the earlier part of the year, however, the AA's are not aware of the extent.

13.12.4 Feasibility and Implementation

No additional action is expected on this item.

13.12.5Schedule

None

13.13 (M-5b) Determine feasibility of penstock selective withdrawal at Grand Coulee

13.13.1Introduction

Selective withdrawal has been demonstrated at various locations to draw water from stratified levels in a reservoir and deliver it downstream. A proposed water temperature measure involves structural modification of penstocks to provide for selective water withdrawal at Grand Coulee Dam, - possibly similar to a Shasta Dam design.

13.13.2 BIOP RPA

None

13.13.3 Major Issues and Concerns

Although selective withdrawal has been successful at other storage facilities with lower water exchange rates, it is uncertain if there are adequate volumes of cold water in Lake Roosevelt to provide for release of cold water for an extended period of time during the summer period of peak temperatures. The logistics of constructing such a facility to accommodate 18 penstocks in 200 feet of water is a daunting and potentially very expensive task. Preliminary cost estimates, reflecting the construction that occurred at Lake Shasta, indicate that penstock construction could cost over $300 million.

Other issues to take into consideration include the potential for changing the thermal regime and productivity of resident fish stocks in Lake Roosevelt.

13.13.4 Feasibility and Implementation

Reclamation is currently conducting pre-appraisal analyses of this option, and will commit to further study and evaluation if it can be justified.

13.13.5 Schedule

If further study is justified, a 3-year study to develop a 2-dimensional water quality model to define temperature benefits, and to develop appraisal level cost information is anticipated. The need for improved bathymetric data could extend the study period by 2 years.

13.14 <u>(M-5c) Investigate cool water releases from the Hell's Canyon hydroprojects.</u>

13.14.1 Introduction

At Brownlee Dam, when the reservoir is thermally stratified (late spring to early fall), it can be divided into three layers: the epilimnion (0-35m), metalimnion (35-45m) and hypolimnion 45m-depth). Thermal stratification occurs to a greater extent in low and average water years versus in high water years as late spring drawdowns act to eliminate a portion of the deeper, colder water.

The location of the metalimnion is directly associated with the placement of the dam outlet as releases from the penstocks act to pull water across the lacustrine zones. The location of the metalimnion is therefore less variable than would be expected if Brownlee Reservoir were a natural lake. Thermal gradients act to stabilize water within the hypolimnion, resulting in water from the transition zone moving laterally through the metalimnion with little vertical mixing. Temperatures are also generally lower than those observed in the epilimnion.

Currently, downstream summer-season temperatures are reduced through deep-water releases from Brownlee Dam. Water is most commonly released at a depth of approximately 30 meters, which corresponds well with the location of the thermocline.

A target of 17.8°C has been established for this TMDL process as a 7-day moving average of daily maximum temperatures to support cold-water biota and salmonid rearing/cold-water biota in the interstate waters of the Hells Canyon Reservoir segment of the SR-HC TMDL reach. Available data show exceedances of temperature criteria throughout the surface waters of the SR-HC TMDL reach during the months of June, July, August and September. Cold-water biota and salmonid rearing designated uses are supported in the Hells Canyon Reservoir segment due to the presence of cold water refugia. Brownlee reservoir typically turns over around November.

(All preceding information taken from the Snake River Hells Canyon Draft TMDL 2001)

13.14.2 BIOP RPA

None

13.14.3 Major Issues and Concerns

If cool water were available in Brownlee Dam that could help to cool the Lower Snake River, discussions with the operator of the three Hells Canyon Dams would need to take place. In addition to the question of how much cool water there is in Brownlee, there are also significant questions about how far cool water releases from Brownlee are "felt" or can be measured downstream. Water released from Brownlee not only have to make it through Oxbow and Hells Canyon Reservoirs, about 50 miles, but also through another 100 miles of free-flowing river before reaching the head of Lower Granite pool. The river also picks up considerable gain in flow from the un-dammed Salmon River, which itself gets quite warm in the summer.

Other concerns would be similar to those of the Dworshak Reservoir releases including affect on adult migration behavior, juvenile fall chinook growth and balancing reservoir elevation with flow augmentation if cooler water can be released.

13.14.4 Feasibility and Implementation

Feasibility and implementation is currently unknown, however an agreement with Idaho Power would need to be negotiated. This would also be subject to the Hell's Canyon TMDL Implementation plan.

13.14.5Schedule

Unknown

13.15 <u>(M-6) Alter the Flood Control Rule Curves</u>

13.15.1 Introduction

System flood control strongly influences streamflow characteristics in the mainstem Snake and Columbia rivers. As described in Section 6 of the biological opinion, these hydrologic effects affect juvenile salmon survival. While current flood control operations routinely reduce even non-damaging floods, peak flows of historical magnitude (e.g., the 1948 Vanport flood) could result in substantial damage. The intent of this measure would be to refine flood control operations such that they cause the least possible reduction in runoff volumes and the probability of reservoir refill while maintaining high levels of protection from damaging floods. Preliminary analysis of modifying system flood control showed that potentially much higher spring flows were possible (Corps 1997) in some years. Much of the existing flood control operation plan dates to the 1960s, and a systematic review of flood control operations has not occurred since 1991. That study, however, was based on the fundamental premise *"that the existing flood control capability ...would remain unchanged after any rule curve modifications were made* (Corps 1991)." Thus, *"...it is conceivable that flood control criteria could be reduced substantially, and levees raised a corresponding amount to compensate."*

A broader consideration of flood control options could identify operations that would benefit the fishery without increasing the likelihood of damaging floods. The primary objective for this measure is to develop a more normative hydrograph, in the attempt to assure a relatively high proportion of migrating juvenile salmonids are "flushed" out of the river system prior to water temperatures warming up.

New stream flow prediction techniques, including Extended Stream flow Prediction (ESP) (NOAA River Forecast Center stream flow model) and remote sensing, have greatly improved since 1969. Computer improvements facilitate consideration of a broader range of alternatives and the ability to manage flood risks more closely to a real-time basis. A thorough investigation of new forecasting technologies would enhance system response and afford greater precision in system flood control operations.

13.15.2 BIOP RPA

Action 35: The Corps shall develop and conduct a detailed feasibility analysis of modifying current system flood control operations to benefit the Columbia River ecosystem, including salmon. The Corps shall consult with all interested state, Federal, Tribal, and Canadian agencies in developing its analysis. Within 6 months after receiving funding, the Corps shall provide a feasibility analysis study plan for review to NMFS and all interested agencies, including a peer-review panel (at least three independent reviewers, acceptable to NMFS, with expertise in water management, flood control, or Columbia River basin anadromous salmonids). A final study plan shall be provided to NMFS and all interested agencies 4 months after submitting the draft plan for review. The Corps shall provide a draft feasibility analysis to all interested agencies, NMFS, and the peer-review panel by September 2005.

13.15.3 Major Issues and Concerns

13.15.3.1 River Hydrology

Currently, storage projects are prioritized to fill by June 30 (RPA 18), which maximizes the amount of water to be released in July and August for salmon flows and temperature reduction flows. It is anticipated that any change to release flood control storage would result in more water in the spring since the priority now is refill by the 30th. Therefore, it is anticipated that no additional benefit for reducing mainstem temperatures would occur due to this action during late summer and fall.

Furthermore, flood control concepts are changing. Historically, efforts were made to protect all developed lands from flooding by using levees, revetments, and upstream storage. These efforts have effectively disconnected rivers from their floodplains and have had both ecological and human consequences (Benner and Sedell 1997). Ecologically, diverse and integral habitats are lost when structures isolate a river from its floodplain (Ligon et al. 1995). Riparian corridor simplification is a significant cause of salmon declines (Ligon et al. 1995). Also, by cutting off upstream floodplains from the river, vast flood storage potential is lost, and floodplain development is encouraged. Thus, when large floods occur, the outcomes in terms of property damage can be more severe than would have occurred if lesser flood protection efforts had been taken and floodplain development discouraged. By examining flood damage areas and flood protection structures throughout the river corridor, the Corps may identify opportunities to bring more connectivity to some areas of active floodplain (e.g., undeveloped land and farmland) and more effective flood protection to others (e.g., communities).

13.15.3.2 Other Concerns

The effects that changing the flood control rule curves are varied and numerous and will only be touched on lightly here. There are concerns that if more water were used to flush fish out during the spring, decreased power production would result in the summer and fall. Biologically, would pushing more water downstream during the spring, thus causing more total dissolved gas, out weigh the benefits of flushing fish out of the system earlier? These and many other questions would need to be addressed in a recon or feasibility study.

13.15.4 Feasibility and Implementation

The primary objectives of a feasibility analysis would include reducing the effects of flood control operations on the spring freshet, particularly during average to below-average runoff years; minimizing flow fluctuations during fall chinook emergence and rearing; and achieving a high probability of reservoir refill, particularly at Dworshak, Grand Coulee, Hungry Horse, and Libby reservoirs, while maintaining acceptable levels of protection for developed areas within the active floodplain. This analysis will consider all aspects of flood control, including the flood control target flow(s), associated storage reservation diagrams, the method of calculating the initial control flow, and the timing and coordination of flood control management. The study will incorporate the best currently available forecast technology for estimating runoff and peak flows. Innovative concepts, such as using an expert system to define operations in real time, which would increase system flexibility or the ability to achieve the above stated objectives should be incorporated to the extent practical. New storage reservation diagrams should include mechanisms for interpolation to facilitate higher storage contents going into the spring in some years. The Corps will also identify those improvements necessary to facilitate higher flood control target flows and estimate the cost and time needed to implement such improvements. This analysis will include all Federal, non-Federal, and Canadian projects currently operated for system flood control. Because modifying flood control operations would affect an array of interests, the Corps should consult with all interested state, Federal, Tribal, and Canadian agencies in developing its analysis. The final feasibility report will include a proposed action and respond to all concerns and comments on the draft.

13.15.5Schedule

The Corps requested authorization and funding in 2002. However, funding has not yet been confirmed.

13.16 <u>(M-7) Investigate cool water releases from Canadian hydro projects.</u>

13.16.1 Introduction

There are three major mainstem dams and one major tributary dam in Canada that are all operated by BC Hydro. These dams include Keenleyside (1968), Mica (1973, power house 1977), and Revelstoke (1984) on the mainstem and Duncan (1967) on the Duncan River. Mica, Keenleyside and Duncan are three of the Canadian Columbia River treaty projects and provide 15,500,000 acre-feet of storage. Keenleyside (Arrow) Dam is 171 feet high and has roughly 7,100,000 acre-feet of storage, Mica is roughly 800 feet high with a storage capacity of 7,000,000 acre feet, and Revelstoke Dam is 575 feet high with a reservoir that extends 81 miles back to Mica Dam (but is considered run of the river). Duncan Dam has 1.4 million acre feet of storage.

Upper and Lower Arrow Lakes existed prior to the development of the storage projects. Lower Arrow Lake was 50 miles long, averaged 1 mile wide and had a maximum depth of 600 feet. In Davidson 1969, it was reported that in September of 1961 and 1962 (prior to dam completion), temperature profiles were taken in Lower Arrow Lake and these profiles indicated thermal stratification in the lake of roughly 7-8°C between the surface and 200' deep. (This was done in an attempt to determine what might be available out of Mica dam). Davidson speculated that temperature of water released through the penstocks of Mica dam in September "should average close to 47°F (8.3°C)".

However at the outlet of the lakes the temperature was 16.8°C. At Keenleyside dam, (at the outlet of the former lake), there is little to no thermal stratification. In addition, "the surface currents through the Arrow Lakes, aided by their shallow outlets, tend to remove the warm surface waters from them in spring and summer." In the author's opinion, deep in the Upper Arrow Lake, "lies a source of cold oxygenated water that may be used to temper the river's flows at the border in September and October. Although it would be exceedingly costly to siphon this cold water from the lake, it would solve the serious problem of temperature pollution in the upper Columbia" (presumably at the international border) "at its most critical period."

13.16.2 BIOP RPA

None

13.16.3 Major Issues and Concerns

Some concerns in the Mid-Columbia with juvenile chinook growth, adult salmon migration characteristics, impacts to resident fish stocks and cost of the project and balancing reservoir elevation with flow augmentation arte some of the potential concerns.

In addition Canada may have other issues and concerns that the US agencies are not aware of. This may need further discussion in treaty negotiations.

In EPA 1971, Columbia River monthly average temperatures in August and September, 1967 were reported as being roughly 6°C at Revelstoke, B.C. and exceeding 16.5°C Well downstream from that point, at Trail, B.C. Because of this heating that can occur in that river reach, the benefits of cool water releases reaching the U.S. Columbia River could be limited.

13.16.4 Feasibility and Implementation

Unknown

13.16.5Schedule

Unknown

13.17 <u>(M-8) Investigate Banks Lake selective withdrawal to draw warm water from Lake Roosevelt.</u>

13.17.1 Introduction

Thermal stratification in Lake Roosevelt occurs during the early summer months but later dissipates in September. A layer of warm water on the surface of the reservoir may be contributing to the overall temperature of the Middle Columbia River. It has been hypothesized that drawing water from the uppermost part of the water column at Lake Roosevelt and sending it to Banks Lake may be able to cool the mainstem Columbia River by removing the water before it mixes with cooler water downstream.

13.17.2 BIOP RPA

None

13.17.3 Major Issues and Concerns

There have not been any studies done to date regarding this type of operation of Lake Roosevelt and Banks Lake. Authorization for conducting this type of study and implementing this operation would need to be sought.

Some of the biological constraints include an unknown impact to the fish and wildlife that inhabit Banks and the Seep lakes in Eastern Washington. There currently exists various recreational fisheries and a multitude of wetlands that could be impacted by having warmer water delivered to these lakes. Also, drawing water from the water column may have impacts to fish species that currently inhabit Lake Roosevelt. Unknown impacts to kokanee, bull trout and white sturgeon may be realized with the removal of water from the photic zone of lake Roosevelt, that area that has the highest biological productivity. Examinations of the seasonality of this operation may need to be examined.

13.17.4 Feasibility and Implementation

It is unknown if this operation would be feasible. Included in a feasibility study would be the modeling of water quality benefits/estimate costs.

13.17.5Schedule

If ongoing pre-appraisal analyses of this alternative find that further study is justified, a 3 year investigation is anticipated to model water quality benefits and construction costs. The need for improved bathymetric data to facilitate reservoir modeling could extend the study by 2 years.

13.18 (M-9) Investigate Groundwater Charging to Cool Mainstem Water

13.18.1 Introduction

While the concept of artificially charging groundwater is not new (early U.S. Geological Survey interest began in 1905), it is a new concept for the effect of trying to cool water in a mainstem river. The premise of this measure is to introduce water into strategic geologic locations in the Columbia Basin in such a way that it would eventually return to the river either through upwelling in the river bottom or by flow through the banks. If water were introduced to aquifers through the colder times of the year, or if sufficient cooling was found to occur from water being in contact with the underground substrate, the river would have the potential to be cooled via these return routes.

While some small-scale diversion projects have shown to provide localized cooling and warming in small streams, the fluvial processes of areas in the Lower Snake and Columbia Rivers are quite a bit more complex. A presentation was given at an American Water Resources Association conference in Portland, Oregon, 2000 and a proposal was submitted to the Bonneville Power Administration for Project 25055 - Echo Meadows Artificial Recharge Extended Groundwater and Surface Water.

13.18.2BIOP RPA

None

13.18.3 Major Issues and Concerns

This is a novel approach at cooling river water. The benefits are outlined in Section 5.15.1, however, the following section provides a list of cautions that may or may not be pertinent to the measure. These issues are not meant to dissuade the reader from considering this issue further, however they may be useful if further investigations take place.

13.18.4 Columbia Basin Project

An Associated Press Article dated October 16, 2000, reported that the Pasco Basin aquifer is continually growing as a result of 50 years of seepage from irrigation projects in the region. Most of the water in the Pasco Basin can be traced to the Columbia Basin Project, the irrigation system that transformed much of Eastern Washington into productive farmland. A large portion of the seep water settled under Franklin County, mingling with "natural" water to raise the water table several hundred feet in areas. The U.S. Geological Survey linked the rising water table that resulted to septic system failures, road damage, farmland lost to ponds and landslides along the White Bluffs of the Columbia River.

The Columbia Basin Project, including Grand Coulee dam, Banks Lake, Moses Lake and the Seep lakes are currently contributing water into the Hanford Reach of the Columbia River via through bank flows. Some of these groundwater flows are expressed in the White Bluffs of the Hanford Reach, near the primary spawning areas for Fall Chinook. Unfortunately, the flow from this water is causing severe sloughing of the Bluffs. (Figure 11) The sloughing in the photo is roughly 1.5 miles long by .3 miles wide. The channel of the river has been modified to the extent that the flows have been diverted towards Locke Island and have been eroding this culturally significant landmark.

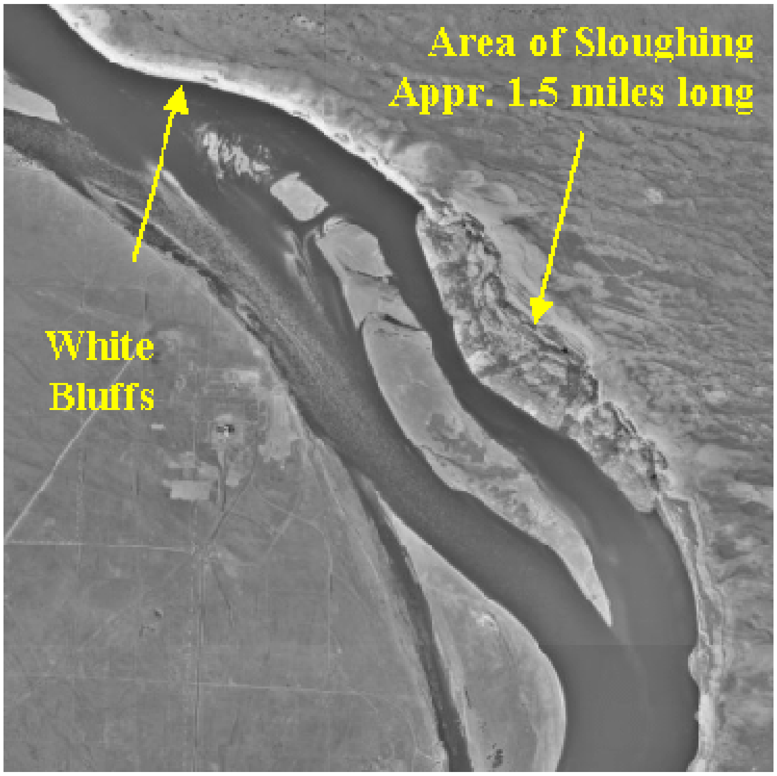

Figure 11. Aerial photo of the White Bluffs area of the Columbia River with severe sloughing of the white bluffs indicated right of center.

In 1997, the Geological Survey published a study on the decades of seepage (Could not find this study), looking at about half of the Pasco Basin. Among other things, it found that about 110,000 acre-feet a year has been seeping into the aquifer from irrigation water and canal seepage and that the study area had collected 5 million acre feet of water, mostly from irrigation systems -- and there could be substantially more water in the unstudied half of the basin. George Schlender, an Ecology Department official in Spokane, told the Tri-City Herald of Kennewick "There are places that the water is very available, and available close to the surface."

This information is included to demonstrate that it is possible to introduce water into the local water table, the Columbia Basin Project is currently transferring water to the ground water, and water is coming into the Columbia River (although not what may be considered in a beneficial manner). However if there is any impact on mainstem water temperatures, it is not known. It is also meant to demonstrate that studies on performing this type of work should not be brushed over and if looked into, should be taken seriously as to their potential effects.

13.18.5 Substrate

According to the US department of agriculture (http://www.uswcl.ars.ag.gov/IWQ/waterp~1/recharge.htm), Suitable substrates must be present in an area of deep-water injection or those wells will clog.

"Because of the increasing need for underground storage of water, more artificial recharge systems will have to be constructed on finer textured soils like sandy loams to light loams, as coarse sands and gravelly materials will not always be available. Field and laboratory studies need to be carried out to predict sustainable infiltration rates for such soils and to develop design and management criteria to minimize infiltration reductions due to soil clogging. The studies range from developing and testing infiltrometer techniques with simplified correction for divergence and limited depth of wetting, to studies of fine-particle movement in the upper soil (formation of mini-clogging layers/wash-out and wash-in) and how to avoid such formation by proper design and management procedures."

In addition, in reference to section 5.15.4 regarding the white bluffs, the appropriate soil types must be considered in an area prior to attempting this type of effort or it could have negative impacts.

13.18.6 Present Reservoir Connectivity with Groundwater

In section 5.15.4, there are discussions regarding how the creation of artificial reservoirs contributed to groundwater, however, mainstem reservoirs also contribute to localized areas of groundwater.

In a study near Ives Island regarding Chum salmon keying in on certain areas for spawning in a side channel of the mainstem river, Geist et al 2001 reported "We theorize that the majority of water within the floodplain aquifer at Ives Island originated from the pool behind Bonneville Dam 3.5 km upstream. This would explain the similar specific conductance values between the river and the hyporheic zone, and allow the water enough residence time to be affected by the heat-sink of the ground water system (Freeze and Cherry 1979)." At Ives Island, chum salmon typically spawn from early November to mid December and "Chum salmon spawned in areas where relatively warm water from the hyporheic zone upwelled into the river. This was indicated by the predominance of redds at sites where vertical gradients between the bed and river were positive, and bed temperatures were 7 to 11 C warmer than the river."

Current riverbank charging in the areas of the reservoirs was demonstrated during the 1992 Lower Granite Reservoir drawdown test (Corps 1993). Sixteen groundwater wells in the vicinity of Lower Granite Dam were monitored by the USGS to determine influence of the reservoir elevation on groundwater elevation. Water elevation in 12 of the 16 monitored wells dropped between 5 and 30 feet, some of which fluctuated to the same degree of the reservoir. It is therefore logical to assume that because reservoirs are higher than water typically got during the normal spring runoff that the riverbanks are continually charged in this area.

However what is missing in the reservoir environment is the process of bank discharge and recharge in what might be considered a more normative hydrograph. What is not known is how much cooling potential was lost due to the elimination of the high and low seasonal flows versus the current high levels of reservoirs.

Although water is believed to be expressed hyporheically in the tailrace of Bonneville Dam from the Bonneville Reservoir, this water is warmer during November and December than the river water, however, it is also where the chum salmon key in on spawning. This is mentioned to indicate that not all Hyporheic flow will contribute cooler water and this must be considered in any potential future investigations.

13.18.7 Water Quality

When intentionally introducing surface water into ground water, certain water quality parameters need to be considered. If deep underwater recharge were to be performed, hydrologic challenges might include the use of models to evaluate project benefits and potential impacts, surface-water/ground-water interaction, variability and uncertainty in surface water supplies, and monitoring design and instrumentation. In addition, there may be organic and inorganic chemistry issues, changed environmental conditions and potential for mobilization of natural or man-made contaminants, and consideration for the role of emerging contaminants. This type of water introduction may require evaluating and monitoring bacteria and viruses, including transport of viruses and bacteria, new analytical methods, and design and operation issues

One example, in Kansas (http://ks.water.usgs.gov/Kansas/pubs/abstracts/ofr.02-89.html), "After artificial recharge began, median concentrations of more than 400 chemicals including chloride, atrazine, and total coliform bacteria were all substantially less than their respective drinking-water standards and similar to concentrations in the receiving ground water before recharge. However, arsenic concentrations in the one monitoring well at the test siste near Halstead increased from 8 to 19 micrograms per liter and exceeded the new (2001) USEPA drinking-water standard of 10 micrograms per liter."

For a bibliography of water recharge papers and issues, please see http://water.usgs.gov/ogw/pubs/ofr0289/epw_historical.html

13.18.8 Feasibility and Implementation

It is unknown if this operation would be feasible. Included in a feasibility study would be the need to model water quality benefits/estimate costs.

13.18.9Schedule

Unknown

14 Proposed Site Specific Water Temperature Measures

14.1 (S-1) Modification of Dworshak National Fish Hatchery Water Supply.

14.1.1 Introduction

As indicated in the BiOp, improvements to the Dworshak National Fish Hatchery water supply would isolate hatchery operations from the effect of Dworshak Reservoir operations. At the date of publication of the BiOp, Dworshak Reservoir releases could not be conducted for optimal temperature releases because of likely adverse effects of cold water on hatchery rearing performance. This problem could be resolved by making improvements in the hatchery water supply system to accommodate releases of cooler water from Dworshak.

14.1.2 BIOP RPA

RPA 33 states, “The Corps, in coordination with USFWS, shall design and implement appropriate repairs and modifications to provide water supply temperatures for the Dworshak National Fish Hatchery that are conducive to fish health and growth, while allowing variable discharges of cold water from Dworshak Reservoir to mitigate adverse temperature effects on salmon downstream in the lower Snake River.”

14.1.3 Major Issues and Concerns

Continued negative impacts would occur to the hatchery operations if this work were not done. Although most juvenile fall chinook have moved out of the Snake River by August 1, the release of cooler water from the dam may have greater impacts to juvenile salmon rearing in the Clearwater River.

14.1.4 Feasibility and Implementation

This measure is feasible. Construction is currently underway and should be completed by the 2003 rearing period at Dworshak hatchery. Further discussions may need to be held regarding the appropriate temperature of water to be released from the reservoir.

14.2 (S-2a) Examine the temperatures in the McNary Forebay to determine if there are options to reduce water temperatures in the juvenile bypass systems

14.2.1 Introduction

McNary Dam, located near Umatilla, Oregon on the mainstem Columbia River, exhibits horizontal thermal stratification across the forebay during the warmer summer months. This is in part due to the geomorphology of the near dam area and the influence of the mixing zone of the Snake and Columbia Rivers as well as a shallow water shelf on the south side of the river near the powerhouse. During warmer times of the year, operation of turbine units closer to the warmer shallow water on the south shore of the river has a tendency to draw that water into the juvenile bypass system, causing additional stress to migrating juvenile fish within the system. This should not be misconstrued as actually cooling river water, however, rather just keeping the warmest water out of the juvenile fish facility.

A proposed action at McNary Dam includes the excavation of the reservoir on the South Shore where warm water collects. Other proposed ideas include building a levee across that shallow water area and filling in behind it to create a wetland, thereby reducing one of the sources of warming, or building a sluiceway at the earthen section of the dam to draw warmer water off the top of the reservoir, delivering it to the wetlands below the dam, and drawing cooler water to that area.

14.2.2 BIOP RPA

Action 141: The Action Agencies shall evaluate juvenile fish condition due to disease in relation to high temperature impacts during critical migration periods. This evaluation should include monitoring summer migrants at lower Columbia and lower Snake river dams to clarify the possible link between temperature and fish disease and mortality. This information will be used to assess the long-term impacts of water temperature on juvenile fish survival. High water temperatures have been linked to stress and disease in fish. It is essential to acquire a better base of information to understand the sources of fish disease and mortality at the lower Columbia and lower Snake river dams during critical fish migration periods and high temperature events. This information could be used to better understand the effect of high water temperature on juvenile fish survival.

Action 142: The Corps shall work through the regional forum process to identify and implement measures to address juvenile fish mortality associated with high summer temperatures at McNary Dam. As a starting point, the Corps shall assemble and analyze the temperature data that have been recorded in the McNary forebay, collection channel, and juvenile facilities. The Corps shall examine relationships among juvenile mortality, temperatures, river flow rates, and unit operations in detail. The Corps shall investigate the feasibility of developing a hydrothermal computational fluid dynamics model of the McNary forebay to evaluate the potential to determine optimal powerhouse operations or structural modifications for minimizing thermal stress of juvenile salmon collected in the summer and to conduct a modeling program, if warranted.

14.2.3 Major Issues and Concerns

Thermal profile data have been routinely collected at McNary Dam for more than a decade. These data formed the basis for special project operations, such as north powerhouse loading operations during the summer-warm-water temperature period. The 1995 NMFS Biological Opinion required the Action Agencies to take measures to reduce the potential for reoccurrence of the 1994 thermal-related mortality observed at McNary Dam. Coutant (1999) suggested that the cause of the observed acute mortalities was a cumulative thermal dose of exposure to high temperature water received over several days (NMFS 2000c).

14.2.4 Feasibility And Implementation

North shore powerhouse loading is currently the standard operation of the McNary powerhouse. The feasibility or effectiveness of excavating the McNary forebay is currently unknown.

14.2.5 Schedule

Studies started in 2000 are continuing and are ongoing. Included in these studies is a three-dimensional computational flow dynamics model of the McNary forebay which extends roughly a few miles upstream. This is a finer scaled model than is used in other areas of the basin and it could eventually be used to examine the effects of some of the proposed measures, including dredging, filling or drawing water off of the South shore.

14.3 (S-2b) Identify water temperature cooling methods at individual projects for juvenile fish passage.

14.3.1 Introduction

While McNary dam is a unique situation, in that geomorphology and being situated near the confluence of the Snake and Columbia rivers contributes to a horizontal thermal stratification, the other run of the river projects do not have that potential. During the temperature operations of Dworshak Dam, there is some thermal stratification in Lower Granite Reservoir, however due to the configuration of the turbines, they draw water across the vertical range of the forebay. Therefore water entering the juvenile fish facilities is currently the coolest water available.

14.3.2 BIOP RPA

None directly associated

14.3.3 Major Issues and Concerns

If a problem were discovered, a solution would need to be developed.

14.3.4 Feasibility and Implementation

Because run of river projects (with the exception of McNary Dam) do not have thermal stratification, there is not the opportunity to draw cooler water into juvenile bypass systems.

14.3.5 Schedule

Nothing is scheduled on this proposed action.

14.4 (S-2c) Identify methods to cool river water at individual projects.

14.4.1 Introduction

Dams that have thermal stratification in their reservoirs are typically thought to have the ability to provide cooler water from various levels within the reservoir to reaches of the river downstream. While it has been demonstrated that storage reservoirs typically have the potential to do this, run of the river reservoirs that have little to no stratification have little to no opportunity to deliver cooler water downstream.

Temperature studies are currently underway at Chief Joseph Dam in part to determine the potential of using cooling water there to cool water downstream. Grand Coulee will be discussed in further detail in action 7d. Improved monitoring and multi-dimensional modeling of the geographic scope of the plan may help to better understand the potential for these types of cooling measures.

14.4.2 BIOP RPA

None directly associated with it

14.4.3 Major Issues and Concerns

If a problem were discovered, a solution would need to be developed as well.

14.4.4 Feasibility and Implementation

Run of river projects pass water as it comes to them. Because there is little to no thermal stratification at run of river projects, there is little to no potential for cooling waters of the entire river. Preliminary results of studies at Chief Joseph Dam have demonstrated that there is little to no thermal stratification of Lake Rufus Woods during the periods when cooling water would be desirable. A three dimensional Computational Flow Dynamics model currently exists for the Lower Snake river and McNary reservoirs.

14.4.5 Schedule

A study began in 2002 at Chief Joseph Dam and is being planned through 2003.

15 Proposed Research Water Temperature Measures

15.1 (R-1) Conduct Acoustic and Radio Data Storage Tag studies to examine migratory behavior of adults with respect to temperatures and depth. Tracking data should overlay on simulated physical conditions.

15.1.1 Introduction

As mentioned in section 5.1.3.3, concerns with adult salmonid migrations are three-fold. Delay associated with high temperature, delay associated with low temperature, and delay associated with temperature differences. These studies are designed to enhance our understanding of the impacts of releasing cold water during a normally hot time of the year.

15.1.2 BIOP RPA

Action 34: The Action Agencies shall evaluate potential benefits to adult Snake River steelhead and fall chinook salmon passage by drafting Dworshak Reservoir to elevation 1,500 feet in September. An evaluation of the temperature effects and adult migration behavior should accompany a draft of Dworshak Reservoir substantially below elevation 1,520 feet. The rationale for evaluating an additional 20-foot draft of Dworshak Reservoir in September is to determine whether cooling Snake River temperatures during September would provide an adult passage benefit. The potential benefits are 1) reduction in water temperature, 2) possible elimination of a thermal block that delays adult migration into and through the lower Snake River, and 3) improved gamete viability. An evaluation should be conducted to assess the effects of the September draft on lower Snake River temperatures and on the migratory behavior and passage timing of adult salmonids that are equipped with depth and temperature-sensitive tags. An evaluation of Dworshak refill probability indicates that this study operation would have little impact on reservoir refill by the end of June in the following year, i.e., two additional refill misses in BPA’s 50-year hydrosystem study.

Action 115: The Corps and BPA shall conduct a comprehensive depth and temperature investigation to characterize direct mortality sources at an FCRPS project considered to have high unaccountable adult losses (either from counts and/or previous adult evaluations). Previous radiotelemetry investigations have been two-dimensional and have attempted to characterize passage routes and timing of successfully passing fish. This study will also attempt to focus on those fish that do not successfully pass and determine whether a consistent source of mortality can be identified and corrected.

15.1.3 Major Issues and Concerns

There are no major concerns with this work. However, if a problem were discovered, a solution would need to be developed.

15.1.4 Feasibility and Implementation

Studies using state of the art telemetry equipment were initiated in 2000 and are planed to continue through 2003. A draft report from the University of Idaho about temperature and adult migration is on the web at http://www.ets.uidaho.edu/coop/PDF%20Files/UItempreport2002.pdf

15.1.5 Schedule

Studies are currently ongoing with field investigations to be complete in 2003.

15.2 (R-2) Conduct Studies to examine fish behavior with respect to the water temperature in adult fish ladders.

15.2.1 Introduction

Data collected by the Corps show that water temperatures at various sections of the John Day fishways differ from 1° to 4°C (34° to 39°F) at times. Effects of such differences on fish passage are unknown. Water temperatures collected in and near fishways at Ice Harbor and Lower Granite dams for the four years 1995 to 1998 routinely exceeded what we considered optimal temperatures for migrating adult salmonids. Warmest water temperatures typically occurred during July and August during the nadir between the summer and fall chinook salmon runs and before onset of the bulk of the steelhead run. However, during warm years, such as occurred in 1998, warm water conditions can persist at the dams into October. (Peery et al 2002) Since temperature differences of a few degrees at the confluence of the Lower Columbia and Snake Rivers and at fishways at other dams have caused adults to delay; it is logical to assume adults may behave in a similar manner when they encounter a temperature difference in or near adult fishways.

Temperature data collected in the adult fishways have shown that differences occur between the fish ladders and the tailrace temperatures. In general, these temperature differences are less than two degrees Celsius. However, during late summer in years of warm weather and low flows, a temperature difference of greater than two degrees Celsius can occur. To date, the largest temperature difference recorded is four and one-half degrees Celsius in 1992 at Lower Granite.

Water released from Dworshak reservoir was effective at cooling summertime water temperatures near the forebay surface and in fishways by an estimated 1 to 3°C at Lower Granite Dam. Cooling effects from Dworshak releases were diminished at Ice Harbor Dam because of warming and the degree of mixing that occurred as water masses moved downstream, and were difficult to quantify. Best results through the lower Snake River appeared to occur when Dworshak flows were set at 20 kcfs or more, or 50 to 60% of the Snake River flow as measured at Lower Granite Dam. There was evidence from monitoring radio-tagged adult salmon and steelhead that some fish had longer travel times into and through the lower Snake River, and some fish took longer to pass Ice Harbor and Lower Granite Dams, during unfavorable water temperature conditions. There was a significant trend for later arrival of salmon and steelhead at Ice Harbor Dam during years with warm summertime water temperatures.

This project is funded from the Columbia River Fish Mitigation Program. The long-term objective of this study has been to define any problems that may exist specific to effects of fish ladder water temperature on adult salmon and steelhead and to determine feasible methods of mitigating any adverse affects.

15.2.2 BIOP RPA

Action 114: The Corps shall examine existing fish-ladder water temperature and adult radiotelemetry data to determine whether observed temperature differences in fishways adversely affect fish passage time and holding behavior. If non-uniform temperatures are found to cause delay, means for supplying cooler water to identified areas of warmer temperatures should be developed and implemented in coordination with the annual planning process.

15.2.3 Major Issues and Concerns

There are no major concerns with this work in and of itself. However, if a problem were discovered, a solution would need to be developed.

The behavioral response to water temperatures by salmon and steelhead Peery et al 2002 saw was a delay by some fish in passing dams when temperatures were unfavorable, when temperatures exceeded 20°C, and when there was a noticeable difference in temperatures between the tailrace and forebay surface, creating a sharp delineation where these two sources of water met in the fishways. Ironically, this condition was exacerbated when water was being released from Dworshak, creating a greater discrepancy between cool water temperatures deep in the reservoirs, that were subsequently passed by turbines and picked up in the tailrace, and those warmed at the forebay surface that flowed down the fishways.

15.2.4 Feasibility and Implementation

The work outlined in this measure is feasible and has been performed since 2001.

Peery et al 2002 indicated that a possible solution to this problem would be to use mixers, bubblers, or some other mechanism in the forebay to upwell cooler water to the surface near the fishway exits. This cooler water could then flow down fishways and be picked up at diffuser pump intakes to moderate fishway temperatures. With this option fish would also not have to enter the warm surface water immediately upon exiting fishways. If water from deep in the reservoir is pumped directly into fishways at existing diffusers, fish will have to transition from the tailrace to the forebay temperatures near the top of the ladder. This would move the temperature gradient from where it currently exists in the transition pool to the weired section of the fishway ladders where it was found that radio-tagged salmon and steelhead advance with little hesitation. This would also have the effect of shortening the time fish are exposed to the warmest water temperatures in the fishways.

15.2.5 Schedule

Final Reporting on this research is pending and expected in 2003. Further activity has not been scheduled.

15.3 <u>(R-3a) Perform additional monitoring of water temperatures in the Snake River and model investigations to evaluate alternative operations of Dworshak.</u>

15.3.1 Introduction

Historically during some years, temperatures in the Snake River at the confluence of the Snake River to the Columbia River have created a thermal block for adult fish returning from the Columbia River to the Snake River. To help alleviate this condition, Dworshak Dam (beginning in 1991) has been releasing additional cold water to help cool the Snake River, first on an experimental basis and since 1992 as part of the operations program. Biological goals are to optimize the Snake River/Dworshak operations in an attempt to provide optimal temperature regimes (within existing authorities and other limitations) for both anadromous and resident fish. This means having sufficient information about the Snake River temperature and how fish respond to flows and temperatures to create a thermal environment that is as supportive of fish as possible.

To examine the temperature releases from Dworshak Dam, the Corps, in cooperation with Battelle's Pacific Northwest National Laboratory, has been working with a three-dimensional computational flow dynamics model. This model exists for the Lower Snake river and McNary reservoirs but has been refined to the greatest extent for Lower Granite reservoir.

15.3.2 BIOP RPA

Action 143: By June 30, 2001, the Action Agencies shall develop and coordinate with NMFS and EPA on a plan to model the water temperature effects of alternative Snake River operations. The modeling plan shall include a temperature data collection strategy developed in consultation with EPA, NMFS, and state and Tribal water quality agencies. The data collection strategy shall be sufficient to develop and operate the model and to document the effects of project operations. The modeling plan should focus on water temperatures in the Snake River from Hells Canyon Dam and from Dworshak Dam on the North Fork of the Clearwater River to Bonneville Dam on the Columbia River. Predictive nodes should be located at the near-dam forebays and tailraces of each project. Both one- and multi-dimensional models (due to reservoir stratification) may be needed to fully define expected temperature conditions within the reach. The models should be developed to function both as a pre-season planning tool and to provide predicted outcomes of immediate operations in real time to assist in the in-season water management decision process. Existing water temperature and meteorological data may be inadequate for this purpose. Existing data and statistical tools will be used to identify locations where additional or improved data collection, in terms of precision, accuracy and frequency, would be most beneficial.

15.3.3 Major Issues and Concerns

No known negative impacts would occur, however, better understanding of the temperature augmentation of Dworshak temperature releases and other temperature issues in the Lower Snake River would result.

The State of Idaho has indicated that the modeling of various operational alternatives of Dworshak releases needs to be coupled with various operational differences in the four lower Snake dams. They believe that the optimum scenario could be missed if only Dworshak releases were examined with operation of the lower four reservoirs un-changed, and vice-versa.

15.3.4 Feasibility and Implementation

Work on this project began in March 2002 upon receipt of funding. A sub-group of the regional Water Quality Team (WQT) was established and co-chaired by NMFS and the Corps of Engineers. The subgroup was established to assist in scoping and preparation of the plan to model the Snake River temperatures. The subgroup reports to the Water Quality Team. Participants include representatives from Battelle, BPA, CRITFC, EPA, Idaho Power Company, IDEQ, NMFS, ODEQ, Fish Passage Center, USACE and WDOE.

15.3.5 Schedule

This study began in 2002 and is planned through 2007.

The major activities completed to date include:

a) Establishment of team - March 8, 2002
b) Initiation of data collection efforts - May 2002
c) Progress report issued - September 10, 2002
d) Complete review of existing data and reports
e) Complete data collection/analysis and reporting
f) Selection of model (s)
g) Development of data collection strategy
h) Implement data collection strategy
i) Submit draft plan to WQT
j) Final plan submitted to WQT – 9 October 2003

FY2004 Tasks

1. Collect additional field data
2. Select periods for model evaluation
3. Complete model setup including evaluation
4. Technical team review calibration and verification report.

FY2005 Tasks

1. System development to operate as real-time tool for use by regional interests
2. Expand to Phase 2 Geographic Scope
3. Revise Data Collection as needed to support Phase 2 and other model input improvements.

FY2006 and beyond

1. Expand to Phase 3 Geographic Scope
2. Revise data collection as needed to support Phase 3 and other model inputs and improvements

15.4 <u>(R-3b) Improve water temperature monitoring of the Columbia River System.</u>

15.4.1 Introduction

Agencies in the Columbia River Basin currently monitor a minimum of 40 sites for temperature with the TDG monitoring program. For further detail, please refer to section 1.5.

15.4.2 BIOP RPA

Action 143: By June 30, 2001, the Action Agencies shall develop and coordinate with NMFS and EPA on a plan to model the water temperature effects of alternative Snake River operations. The modeling plan shall include a temperature data collection strategy developed in consultation with EPA, NMFS, and state and Tribal water quality agencies. The data collection strategy shall be sufficient to develop and operate the model and to document the effects of project operations. The modeling plan should focus on water temperatures in the Snake River from Hells Canyon Dam and from Dworshak Dam on the North Fork of the Clearwater River to Bonneville Dam on the Columbia River. Predictive nodes should be located at the near-dam forebays and tailraces of each project. Both one- and multi-dimensional models (due to reservoir stratification) may be needed to fully define expected temperature conditions within the reach. The models should be developed to function both as a pre-season planning tool and to provide predicted outcomes of immediate operations in real time to assist in the in-season water management decision process. Existing water temperature and meteorological data may be inadequate for this purpose. Existing data and statistical tools will be used to identify locations where additional or improved data collection, in terms of precision, accuracy and frequency, would be most beneficial.

15.4.3 Major Issues and Concerns

No known negative impacts are expected, but benefits include a better understanding of temperature in the rivers.

15.4.4 Feasibility and Implementation

A study is currently in progress that is analyzing the locations of TDG monitors. This study would be expected to be placing the monitors in the expected locations that would be best for temperature monitoring as well.

15.4.5 Schedule

This study began in 2002 and is planned through 2007 in combination with the TDG monitoring program.

15.5 <u>(R-4) Investigate Cool Water Refugia in the Mainstem Rivers.</u>

15.5.1 Introduction

Adult salmonids are known to stray into areas of thermal refugia, typically where tributary stream temperatures are cooler than mainstem water. Peery et al reported that fish that do use these thermal refugia, if not harvested at that location, typically have higher upstream migratory success rates than those fish that do not use those refugia. It is logical to expect that upwelling of groundwater in the mainstem Snake and Columbia Rivers may be contributing to the thermal characteristics of the river and that fish may be using these cooler water areas to use as refuge from warm temperatures.

15.5.2 BIOP RPA

None

15.5.3 Major Issues and Concerns

Mapping these would be time consuming and difficult. Locating cool water refugia from tributaries coming in would be a rather simple task, however trying to locate areas in the riverbed where cool water might be upwelling into the river system could be difficult to find in a reservoir system.

15.5.4 Feasibility and Implementation

It is unknown if this operation would be feasible. Included in a feasibility study would be the modeling of water quality benefits/estimate costs.

15.5.5 Schedule

Unknown

15.6 <u>(R-5) Perform a "D-Temp" Study to Investigate Water Temperatures in the Mainstem Rivers more thoroughly (Similar to DGAS).</u>

15.6.1 Introduction

The development of the Dissolved Gas Abatement Study (DGAS) proved very useful in developing further plans for reducing TDG. It has been proposed that a "D-Temp" (Decrease of Temperature) study be performed to provide insight into the reduction of river water temperatures. As part of a D-Temp study, detailed multidimensional models of the entire river system might be required, including possibly the CEQUALW2 model or three dimensional computational flow dynamics model.

15.6.2 BIOP RPA

None

15.6.3 Major Issues and Concerns

The CEQUALW2 model or three dimensional computational flow dynamics model would need to be expanded to encompass the geographic scope of the water quality plan. This would require a great deal of resources and time to complete.

15.6.4 Feasibility and Implementation

A report such as this is probably feasible, however, authorization, time and resources may hinder implementation.

15.6.5 Schedule

Unknown

15.7 (R-6) Develop a multi-dimensional model for the geographic scope of the water quality plan to determine the effectiveness of water quality measures outlined in section 7 and other measures as they arise.

15.7.1 Introduction

Because some water temperature cooling methods of the mainstem river (outlined in section 5) may be using water from thermoclines in various storage reservoirs, a multi-dimensional model would be important in determining the effectiveness of those measures towards meeting water quality standards. For example, a one-dimensional model may not be able to capture the thermal effects of drawing water off of the top of Banks Lake, however a two-dimensional model may be able to do so.

A model currently exists that may be able to meet the requirements outlined under this measure. CE-QUAL-W2 (W2), a two-dimensional model developed by the U.S. Army Corps of Engineers Waterways Experiment Station, has been used throughout North America (http://smig.usgs.gov/SMIC/model_pages/cequalw2.html) including in the Lower Snake River, the Spokane River, the Tualatin River, Columbia Slough and possibly even in the Snake River downstream of Brownlee Dam to the mouth of the Salmon River.

Currently a three-dimensional computational flow dynamics model exists for the Lower Snake and McNary reservoirs. This model was primarily designed to model the cool water releases from Dworshak Dam.

15.7.2 BIOP RPA

For Lower Snake, RPA 143.

15.7.3 Major Issues and Concerns

Further development of these models from Brownlee reservoir on the Snake to the international border on the Columbia and to downstream of Bonneville may be difficult to attain due to money and time constraints.

15.7.4 Feasibility and Implementation

It is feasible to develop these types of models, however, time and money constraints may hinder implementation.

15.7.5 Schedule

Unknown

15.8 (R-7) Investigate the thermal relationships between fish health and temperature exposure

15.8.1 Introduction

High water temperatures have been linked to stress and disease in fish. It is important to acquire a better base of information to understand the sources of fish disease and mortality at the lower Columbia and lower Snake River dams during critical fish migration periods and high temperature events. This information could be used to better understand the effect of high water temperature on juvenile fish survival.

15.8.2 BIOP RPA

Action 141: The Action Agencies shall evaluate juvenile fish condition due to disease in relation to high temperature impacts during critical migration periods. This evaluation should include monitoring summer migrants at lower Columbia and lower Snake River dams to clarify the possible link between temperature and fish disease and mortality. This information will be used to assess the long-term impacts of water temperature on juvenile fish survival.

15.8.3 Major Issues and Concerns

Although a proposal was submitted to the Corps of Engineers for performing work on this topic, the SRWG indicated that this proposal would not meet the requirements of the RPA. Further discussions between the Walla Walla District Corps of Engineers and Portland NOAA Fisheries are in progress to develop a study plan for submission to the Studies Review Work Group.

15.8.4 Feasibility and Implementation

Feasibility

15.8.5 Schedule

Unknown

16 Conclusions

This document is meant to address part of the plans requested through Appendix B of the 2000 NMFS FCRPS Biological Opinion. In this document, the Corps has presented the background of temperature issues in the Columbia River Basin, the rationale for preparing the document, what has been done and what has been proposed to address water temperature issues, and supporting information for each of these measures. Much of the background information was taken from documents found in the citations, from assisting government agencies, or gathered from personnel in the Northwest Division or Portland, Seattle or Walla Walla District, Corps of Engineers. This document was not meant to be all-inclusive, in that the complete history of water temperature issues in the Columbia Basin could make for an unwieldy document and could overwhelm the reader, rather, it was meant to provide a background of temperature issues and how the Action Agencies has dealt with and is attempting to deal with them.

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APPENDIX A – TDG and Temperature Monitoring

2003 Corps of Engineers Dissolved Gas and Water Temperature Monitoring,
Columbia River Basin.

This document was very unwieldy and voluminous. It can be found on the following website.

http://www.nwd-wc.usace.army.mil/tmt/documents/wmp/

APPENDIX B – TDG Matrices

The following tables represent the recent and future efforts of the Corps of Engineers and other agencies to address TDG issues in the Columbia River basin.

Table B-1 Monitoring System Schedule

Action Item #	Type Of Measure	Project Location	TDG Measures	Major Issues or Concerns	Lead Agency	Status/ Year(s)	TMDL IP Phase	NMFS 2000 FCRPS RPA
Monitoring 1	Study	FCRPS	Review/Analysis of WQ Monitors			Dec-02		
Monitoring 2	Fieldwork	FCRPS	Install Equipment for WQ Monitors			Mar-03		
Monitoring 3	Monitoring	FCRPS	Report on WQ Monitors			Sep-03		

Table B-2 Overall System

Action Item #	Type Of Measure	Project Location	TDG Measures	Major Issues or Concerns	Lead Agency	Status/ Year(s)	TMDL IP Phase	NMFS 2000 FCRPS RPA
Systemwide 1	Study	FCRPS	DGAS		Corps	1994-2002		
Systemwide 2	Plans	FCRPS	NMFS FCRPS Biological Opinion		NMFS	2000		
Systemwide 3	Activity	FCRPS	Predator Removal/Abatement			Ongoing	II	
Systemwide 4	Operations	FCRPS	Improved O&M			Ongoing	II	
Systemwide 5	Studies	FCRPS	Turbine Survival Program			Phase I - 2003 Phase II - 2004	II	
Systemwide 6	Model	FCRPS	SYSTDG			2000		
Systemwide 7	Bio Study	FCRPS	Investigate if Adult Head Burn is Caused by High TDG			2001-2004		

Table B-3 Federal Mid Columbia River

Action Item #	Type Of Measure	Project Location	TDG Measures	Major Issues or Concerns	Lead Agency	Status/ Year(s)	TMDL IP Phase	NMFS 2000 FCRPS RPA
Fed Mid-C - 1	Operational	Grand Coulee	Shift spill to Chief Joseph Dam			2004?		
Fed Mid-C - 2	Physical	Grand Coulee	Submerge spill by extending outlet tubes			?		
Fed Mid-C - 3	Studies	Chief Joseph	Physical Model Built			1999		
Fed Mid-C - 4	Studies	Chief Joseph	Flow Deflector Models Tested			2000		
Fed Mid-C - 5	Operational	Chief Joseph	Shift power generation to Grand Coulee Dam			2004?		
Fed Mid-C - 6	Physical	Chief Joseph	Flow Deflectors			2005-2006	I	

Table B-4 Hells Canyon

Action Item #	Type Of Measure	Project Location	TDG Measures	Major Issues or Concerns	Lead Agency	Status/ Year(s)	TMDL IP Phase	NMFS 2000 FCRPS RPA
Hells-C - 1	Study	Brownlee	Spill Gate Preference			1998		
Hells-C - 2	Study	Hells Canyon	Spill Gate Preference			1998		
Hells-C - 3	Study	Hells Canyon	TDG Monitoring			1999		
Hells-C - 4	Study	Hells Canyon	Flow Deflectors			?		

Table B-5 Clearwater River

Action Item #	Type Of Measure	Project Location	TDG Measures	Major Issues or Concerns	Lead Agency	Status/ Year(s)	TMDL IP Phase	NMFS 2000 FCRPS RPA
Clearwater 1	Study	Dworshak	Identify potential methods of reducing production of TDG.		Corps	TBD – Not Currently Funded		139
Clearwater 2	Physical	Dworshak	Modifications as recommended by TDG study. Modifications may include spillway modifications, Turbine Installation etc.		Corps	TBD Based on Clearwater 1		139
Clearwater 3	Physical	Dworshak	Spillway Modifications		Corps	TBD		139
Clearwater 4	Physical	Dworshak	Turbine Installation		Corps	TBD		139
Clearwater 5	Study	Dworshak	Hydrologic Analysis		Corps	TBD		139
Clearwater 6	Study	Dworshak	Model Construction		Corps	TBD		139

Table B-6 Lower Snake River

Action Item #	Type Of Measure	Project Location	TDG Measures	Major Issues or Concerns	Lead Agency	Status/ Year(s)	TMDL IP Phase	NMFS 2000 FCRPS RPA
Lower Snake 1	Bio Study – Physical – Operational	Lower Granite	Surface Bypass Collection			1995 – 2000		
Lower Snake 2	Study – Physical – Operational	Lower Granite	Gas Fast Track			Not funded FY04 Funds requested for FY05 start. SCT Ranked low		
Lower Snake 3	Study	Lower Granite	- Sectional Hydraulic Model			TBD		
Lower Snake 4	Physical	Lower Granite	- Optimize Deflectors			TBD		
Lower Snake 5	Study	Lower Granite	- New Spill Patterns			TBD		
Lower Snake 6	Physical	Lower Granite	- Pier Nose Extensions			TBD		
Lower Snake 7	Physical	Lower Granite	- Divider Walls			TBD		
Lower Snake 8	Physical – Bio Study	Lower Granite	RSW			2003 – 2007	I	
Lower Snake 9	Bio Study	Lower Granite	Spillway Passage Survival Study			2004 – 2006	I - II	
Lower Snake 10	Gas Study	Lower Granite	Near Field Testing			2003?		
Lower Snake 11	Study – Physical - Operational	Little Goose	Gas Fast Track			2002 - TBD Not funded FY04 Funds requested for FY05 start. SCT Ranked low		
Lower Snake 12	Study	Little Goose	- General Model Tests			TBD		

Lower Snake 13	Operational	Little Goose	- New Spill Patterns			TBD		
Lower Snake 14	Study – Physical - Operational	Little Goose	- End Bay Deflectors			TBD	I	
Lower Snake 15	Study – Physical - Operational	Little Goose	- Optimize Deflectors			TBD		
Lower Snake 16	Study – Physical - Operational	Little Goose	- Spillway Divider Wall			TBD		
Lower Snake 17	Study – Physical - Operational	Little Goose	- Spillway Sectional Model Test			200?- Low SCT priority = no funding FY03/04		
Lower Snake 18	Bio Study	Little Goose	- Spill Passage Survival Studies			2004 – 2006	I - II	
Lower Snake 19	Gas Test	Little Goose	- Near Field Test			2005		
Lower Snake 20	Physical – Bio Study	Little Goose	- RSW			2005 – 2010	II	
Lower Snake 21	Study	Lower Monumental	- Physical Model Development			1999		
Lower Snake 22	Physical	Lower Monumental	- Gas Fast track					
Lower Snake 23	Physical	Lower Monumental	- End Bay deflectors			2001 – 2003	I	
Lower Snake 24	Operational	Lower Monumental	- Spill patterns			2002 - 2004		
Lower Snake 25	Physical	Lower Monumental	- Divider Wall – Report			2004		
Lower Snake 26	Physical	Lower Monumental	- Relocation of Juvenile Bypass Outfall Pipe Report			2004	I	

Lower Snake 27	Physical	Lower Monumental	- Stilling Basin Repair			2001 – 2003		
Lower Snake 28	Gas Study	Lower Monumental	Near Field Test			2004		
Lower Snake 29	Bio Study	Lower Monumental	Passage/Survival			2003-2006	I - II	
Lower Snake 30	Study	Lower Monumental	Extended Fish Screens			?	II	
Lower Snake 31	Physical – Bio Study	Lower Monumental	RSW			2006 – 2009	II	
Lower Snake 32	Physical	Ice Harbor	Flow Deflectors (4)			1996	I	
Lower Snake 33	Physical	Ice Harbor	Flow Deflectors (4)			1997	I	
Lower Snake 34	Physical	Ice Harbor	Flow Deflectors (2)			1999	I	
Lower Snake 35	Gas Study	Ice Harbor	Near Field Test			Not Scheduled		
Lower Snake 36	Operational	Ice Harbor	Spill Patterns			1999		
Lower Snake 37	Bio Study	Ice Harbor	Passage/Survival			1999 – 2005	I - II	
Lower Snake 38	Physical – Bio Study – Operat.	Ice Harbor	RSW			2005 – 2010	II	
Lower Snake 39	Phys. – Study	Ice Harbor	Divider Wall			Not Scheduled for installation		

Table B-7 Lower Columbia River

Action Item #	Type Of Measure	Project Location	TDG Measures	Major Issues or Concerns	Lead Agency	Status/ Year(s)	TMDL IP Phase	NMFS 2000 FCRPS RPA
L Columbia 1	Document	System	Final TMDL-TDG			2002		
L Columbia 2	Physical – Operational – Study	McNary	Gas Fast Track			2002 – TBD Not funded FY04 Funds requested for FY05 start. SCT Ranked low		
L Columbia 3	Physical – Operational – Study	McNary	Gate Hoists			2002 - Unresolved		
L Columbia 4	Physical – Operational – Study	McNary	Deflector Optimization			2002		
L Columbia 5	Physical – Operational – Study	McNary	Spill Patterns			2002		
L Columbia 6	Physical – Operational – Study	McNary	Divider Walls			TBD		
L Columbia 7	Physical – Operational – Study	McNary	Training Walls			TBD		
L Columbia 8	Physical – Operational – Study	McNary	Modeling			TBD		
L Columbia 9	Physical – Operational – Study	McNary	Outfall relocation			TBD	II	
L Columbia 10	Physical – Bio Study	McNary	RSW			2005 - 2010		

L Columbia 11	Physical	McNary	Turbine Replacement			2008-2015		
L Columbia 12	Bio Study	McNary	Spillway Passage Survival			2003 - 2006	I - II	
L Columbia 13	Study	McNary	Near Field Test			Not Scheduled		
L Columbia 14	Physical	McNary	Endbay Deflectors			2002	I	
L Columbia 15	Physical	John Day	Flow Deflectors (18/20)			1998 – 1999	I	
L Columbia 16	Study - Physical	John Day	RSW (Surface Bypass)			On hold	II	
L Columbia 17	Bio Study	John Day	Passage/Survival Studies			2000-2004	I - II	
L Columbia 18	Physical	John Day	Extended Screens			2004 Decision	II	
L Columbia 19	Physical	John Day	End Bay Deflectors			TBD	I	
L Columbia 20	Physical	John Day	End Bay Deflector – Bay 1			TBD	I	
L Columbia 21	Study – Physical	The Dalles	Spillway Improvement Study			2003 – 2006	I	
L Columbia 22	Study – Physical	The Dalles	Spill Wall			2004?		
L Columbia 23	Study – Physical	The Dalles	Model Studies			Ongoing		
L Columbia 24	Study – Physical	The Dalles	Spillbay Modifications			TBD		
L Columbia 25	Study - Physical –	The Dalles	Surface Bypass			2003 – 2007		
L Columbia 26	Study – Physical	The Dalles	Turbine Intake Blocks			2000-2002 Suspended	I	
L Columbia 27	Study – Physical	The Dalles	Sluiceway Outfall relocation			2000-? On Hold	I	
L Columbia 28	Bio Study	The Dalles	Spillway and Sluiceway Survival Study			2000 – 2007	I - II	
L Columbia 29	Physical	Bonneville	Spillway Deflectors (13/18)			1970's		
L Columbia 30	Physical	Bonneville	Spillway Deflectors (18/18)			2002	I	
L Columbia 31	Study - Physical	Bonneville	PH1 improvements			2003 – 2005	I	
L Columbia 32	Study – Physical	Bonneville	PH1 Surface Bypass			On hold until 2004	I	
L Columbia 33	Physical	Bonneville	PH2 Corner Collector			2003-2004	I	

L Columbia 34	Physical Study	Bonneville	Turbine Improvements (MGRs)			Ongoing	II	
L Columbia 35	Physical	Bonneville	PH2 FGE Improvement			2005 Decision	I	
L Columbia 36	Bio Study	Bonneville	Passage/Survival Studies			2000 – 2005	I - II	
L Columbia 37	Study – Physical – Operational	Bonneville	Gas Fast Track			2003 – 2007		
L Columbia 38	Study	Bonneville	Near Field Testing			2002		
L Columbia 39	Physical	Bonneville	Improve Existing Deflectors if needed			TBD		
L Columbia 40	Operational	Bonneville	Spill Patterns			2002		
L Columbia 41	Study	Bonneville	Bonneville Dam Decision Document			Final in 2005		
L Columbia 42	Study	The Dalles	The Dalles Dam Decision Document			Draft in 2004		
L Columbia 43	Study	John Day	John Day Dam Decision Document			Draft in 2005		

APPENDIX C – Clean Water Act/ESA

List of Clean Water Act and ESA actions in Appendix B that are also called for in 2000 FCRPS Biological Opinion RPA.

FCRPS Project	Description of Action	Action Type	In Biological Opinion Section
	Dissolved Gas Actions		
Systemwide	Development of water quality plan	Plan	9.4.2.4, RPA 5
Lower Granite	Gas fast-track; spillway deflector optimization evaluation	Study	9.6.1.7.2, RPA 134
Little Goose	Gas fast-track; spillway deflector optimization evaluation	Study	9.6.1.7.2, RPA 134
Lower Monumental	Gas fast-track; spillway deflector optimization evaluation; fish passage efficiency and survival	Studies	9.6.1.7.2, RPA 134
Ice Harbor	Post-installation spillway deflector evaluations; fish passage efficiency and survival	Studies	9.6.1.7.2, RPA 134
McNary	Gas fast-track; spillway deflector optimization evaluation; fish passage efficiency and survival	Studies	9.6.1.7.2, RPA 134
John Day	Post-installation spillway deflector evaluations, gas fast-track and fish passage efficiency	Studies	9.6.1.7.2, RPA 134
John Day*	Design and implement spillway end deflector	Design and implementation	9.6.1.7.2, RPA 140
The Dalles	Spill and fish passage survival evaluation; gas fast-track	Studies	9.6.1.7.2, RPA 134
Bonneville	Design/implement gas fast-track and additional spillway deflectors; fish passage efficiency	Implementation and studies	9.6.1.7.2, RPA 134
Systemwide	Complete system gas abatement study	Study	9.6.1.7.2, RPA 130
Chief Joseph	Gas fast-track; spillway deflector design and installation	Implementation	9.6.1.7.2, RPA 136
Grand Coulee	Gas abatement study; evaluate GCL-CHJ gas abatement options	Study	9.6.1.7.2, RPA 136
Libby	Evaluate gas abatement alternatives	Study	9.6.1.7.2, RPA 137
Dworshak	Evaluate gas abatement alternatives	Study	9.6.1.7.2, RPA 139
Systemwide	Total dissolved gas monitoring program	Monitoring	9.6.1.7.2, RPA 131
Systemwide*	Evaluate fixed forebay TDG monitors to determine best location	Study and implementation	9.6.1.7.2, RPA 132
Systemwide	Develop system dissolved gas model	Modeling; study	9.6.1.7.2, RPA 133
Systemwide*	Evaluate gas entrainment divider walls at FCRPS mainstem projects	Study	9.6.1.7.2, RPA 135
Lower Granite	Prototype surface spillway bypass	Construct prototype & study	9.6.1.4.5, 9.67.1.7.2, RPA 80, RPA138
John Day	Prototype surface spillway bypass	Construct prototype & study	9.6.1.4.5, 9.6.1.7.2, RPA 72, RPA 138
Ice Harbor	Prototype surface spillway bypass	Construct prototype & study	9.6.1.4.5, 9.6.1.7.2, RPA 72, RPA 138

* Action not contained in Appendix B but called for in Sec. 9 of NMFS Biological Opinion.

List of Clean Water Act and ESA actions in Appendix B that are also called for in the 2000 FCRPS Biological Opinion RPA. (continued)

FCRPS Project	Description of Action	Action Type	In Biological Opinion Section
	Water Temperature Actions		
Systemwide	Development of water quality plan	Plan	9.4.2.4, RPA 5
Systemwide	Water temperature data collection/monitoring program	Monitoring	9.6.1.7.2, RPA 143
Systemwide	Develop plan to model system water temperature and operations	Modeling; study	9.6.1.7.2, RPA 143
Systemwide	Evaluate fish ladder water temps.	Study	9.6.1.6.2, RPA 114
Systemwide	Evaluate temp effects on juvenile passage behavior and survival	Study	9.6.1.7.2, RPA 141
Unspecified dam	Conduct comprehensive depth and temp investigation to identify adult passage losses	Study	9.6.1.6.2, RPA 115
Dworshak	DWR NFH water supply improvements to allow temp oper.	Implementation	9.6.1.2.6, RPA 33
Dworshak and L. Snake River dams	Water temp control operations; evaluate effects on juvenile and adult passage behavior and pre-spawning mortality	Operations and studies	9.6.1.2.3, RPA 19 9.6.1.6.2, RPA 115, 118**, 141**
McNary	Monitor/eval temp in juvenile fish bypass facilities & effects on fish	Monitor and study	9.6.1.7.2, RPA 142
	Tributary Actions		
Systemwide	Coordinate with tributary TMDLs and fund ESA-related TMDL implementation	Study and monitoring; plan implementation	9.6.2.1, RPA 152**, RPA 154**
Columbia Basin Project	Wasteway water quality monitoring and remediation plan	Study and monitoring; plan implementation	9.6.1.2.7, RPA 39
Systemwide	BOR and BPA initiate passage, screening and flow actions in priority subbasins		RPA 149
Systemwide	BPA fund protection of non-federal habitat		RPA 150
Systemwide	BPA establish water brokerage		RPA 151
Systemwide	BPA work with Conservation reserve Enhancement Program and others to establish 100 miles of riparian buffers a year		RPA 153
	Mainstem Habitat		
Systemwide	BPA with EPA and others establish a mainstem habitat research program		RPA 155
	Estuary Actions w/LCREP		
Estuary	Monitoring		RPA 161
Estuary	Wetland Restoration		RPA 160
Estuary	Habitat Needs of Salmon		RPA 159
Estuary	Estuarine Habitat Inventory and Critieria		RPA 158

List of Clean Water Act Actions in Appendix B that are not called for in the 2000 FCRPS Biological Opinion RPA.

FCRPS Project	Description of Action	Action Type	In Biological Opinion Section
Systemwide	Development of Columbia/Snake River TMDLs for dissolved gas and temperature	Study/process	Conservation recommendation 11.8
Grand Coulee	Long-term gas abatement alternative selection study	Study	Conservation recommendation 11.9
Lower Granite	Long-term gas abatement alternative selection study; side channel spillway or raised stilling basin	Study	Conservation recommendation 11.9
Little Goose	Long-term gas abatement alternative selection study; side channel spillway or raised stilling basin	Study	Conservation recommendation 11.9
Lower Monumental	Long-term gas abatement alternative selection study; side channel spillway or raised stilling basin	Study	Conservation recommendation 11.9
Ice Harbor	Long-term gas abatement alternative selection study; side channel spillway or raised stilling basin	Study	Conservation recommendation 11.9
McNary	Long-term gas abatement alternative selection study; side channel spillway or raised stilling basin	Study	Conservation recommendation 11.9
Bonneville	Long-term gas abatement alternative selection study; baffled spillway	Study	Conservation recommendation 11.9
Systemwide	Provide funding to develop tributary TMDLs	Funding	Conservation recommendation 11.11

APPENDIX D – 2004 Monitoring Plan

CORPS OF ENGINEERS DRAFT PLAN OF ACTION FOR DISSOLVED GAS MONITORING IN 2003

INTRODUCTION

This Plan of Action for 2003 summarizes the role and responsibilities of the Corps of Engineers as they relate to dissolved gas monitoring, and identifies channels of communication with other cooperating agencies and interested parties. The Plan summarizes what to measure, how, where, and when to take the measurements and how to analyze and interpret the resulting data. It also provides for periodic review and alteration or redirection of efforts when monitoring results and/or new information from other sources justifies a change. Some information on the complementary activities of other participating agencies is provided at the end of this document.

GENERAL APPROACH

The total dissolved gas (TDG) monitoring program consists of a range of activities designed to provide management information about dissolved gas and spill conditions. These activities include time-series measurements, data analysis, synthesis and interpretation, and calibration of numerical models. Four broad categories of objectives are involved:

1) data acquisition, to provide decision-makers with synthesized and relevant information to control dissolved gas supersaturation on a real-time basis,
2) real-time monitoring, to ascertain how project releases affect water quality relative to ESA Biological Opinion measures and existing state and tribal dissolved gas standards;
3) trend monitoring, to identify long-term changes in basin wide dissolved gas saturation levels resulting from water management decisions; and
4) model refinement, to enhance predictive capability of existing models used to evaluate management objectives.

Portland, Seattle and Walla Walla Districts have direct responsibilities for TDG monitoring at their respective projects, including data collection, transmission, and analysis and reporting. The Division's Reservoir Control Center (RCC) will coordinate this activity with the Districts and other State and Federal agencies and private parties as needed to insure the information received meet all real-time operational and regulatory requirements. Districts and Division roles and functions are described in more detail in later sections of this document.

The Corps considers TDG monitoring a high priority activity with considerable potential for adversely affecting reservoir operations and ongoing regional efforts to protect aquatic biota. It will make all reasonable efforts toward achieving at least a data quality and reliability level comparable to that provided in previous years, including 2002.

Furthermore, the Corps believes it is important to maintain a two-way communication between those conducting the monitoring and the users of monitoring information. These interactions give decision-makers and managers an understanding of the limitations of monitoring and, at the same time, provide the technical staff with an understanding of what questions should be answered. Therefore, comments and recommendations received from users were and continue to be very useful in establishing monitoring program priorities and defining areas requiring special attention.

DISTRICTS/DIVISION RESPONSIBILITIES

Portland, Seattle and Walla Walla Districts Functions. Portland, Seattle and Walla Walla Districts will perform all the activities required at their TDG monitoring sites. Data will be collected and transmitted from those sites systematically and without interruption to the Columbia River Operational Hydromet Management System (CROHMS) (or any alternate database as may be specified). Normal monitoring season will be from 1 April through 15 September for all stations except Bonneville and the stations below Bonneville. Because of the Spring Creek hatchery release, monitoring for Bonneville and stations below Bonneville will be from 10 March through 15 September. Winter monitoring, where applicable, will be at least from 15 December through 15 March. If needed, TDG monitoring for Spring Creek hatchery fish may be necessary before 10 March and will be coordinated with the Portland District.

District responsibilities include but are not limited the following tasks:

- preparing annual monitoring plan of action and schedule, as described in RPA 131 of the National Marine Fisheries Service 2000 Biological Opinion
- procuring data collection/transmission instruments
- preparing and awarding equipment and service contracts
- performing initial instrument installation and testing
- setting up and removal of permanent monitoring installations, if requested
- evaluate existing stations, as described in RPA # 132 of the National Marine Fisheries Service 2000 Biological Opinion
- collecting and transmitting TDG data to CROHMS
- reviewing data for early detection of instrument malfunction
- making periodic calibration, service and maintenance calls once every 2 weeks
- providing emergency service calls as needed and/or when so notified
- performing special TDG measurements, if needed
- keeping records of instrument calibration and/or adjustments
- retrieving, servicing, and storing instruments at the end of the season
- providing final data corrections to the Division office
- performing data analysis to establish/strengthen spill vs. TDG relationship
- preparing an annual activity report
- document and report QA/QC performance

All three Districts will also be responsible for (1) preparing an annual report on instrument performances, and (2) providing the necessary material including test and data analyses, charts, maps, etc. for incorporation in the Corps' Annual TDG Report, which will be finalized by the Division. Additional monitoring at selected locations may be required on an as needed basis and as possible based on available funding. Dissemination of data to outside users will remain a Division responsibility to avoid duplication and uncoordinated service.

Division's Functions. The Division will be responsible for overall coordination of the TDG monitoring program with the Districts, other State and Federal agencies and cooperating parties. The Leader of the Water Quality Team, CENWD--CM-WR-N, is the designated TDG Division Program Coordinator reporting through the chain of command through Chief, Reservoir Control Center and Chief, Water Management Division to Director, Engineering & Technical Services Directorate. The coordinator will be a member of, and consult as needed, with the NWD- Water Quality Team.

The Division TDG Program Coordinator will provide overall guidance to District counterparts to ensure that the monitoring program is carried out in accordance with the plan outlined in this document, including close adherence to a general schedule and operating QA/QC protocols. The individual will be the main point of contact for all technical issues related to the TDG monitoring at Corps projects. The coordinator will refer problems of common regional interest to relevant forums such as the EPA/NMFS Water Quality Team (WQT) for peer review and open discussion. The individual will facilitate final decision-making on technical issues based on all relevant input from interested parties.

The Division TDG Program Coordinator will meet with District counterparts in February to discuss and firm up detailed implementation plan and schedule for the current year. Discussion will cover monitoring sites, equipment, data collection and transmission procedures, service and maintenance, budget, etc. A set of specific performance measures will be jointly prepared as a basis for reviewing and monitoring District performances. A post-season review meeting will be held annually to provide a critique of the operations and identify areas needing changes and/or improvements.

2003 ACTION PLAN

The 2003 Action Plan consists of the following eight phases observed in previous years, plus winter monitoring. These phases are as follows:

(1) Program start-up;
(2) Instrument Installation;
(3) In-season Monitoring and Problem Fixing;
(4) Instrument Removal and Storage;
(5) Winter Monitoring;
(6) Data Compilation, Analysis and Storage;
(7) Program Evaluation and Report; and
(8) Special Field Studies

The Plan of Action for all three Districts is similar to the one in 2002, with the exception of some fixed monitoring station changes and some QA/QC modifications.

A NMFS Forum Water Quality Team Subcommittee met in 2001 and 2002 to consider actions concerning RPA 132 of the Biological Opinion. RPA 132 calls for a plan to conduct a systematic review and evaluation of the TDG fixed monitoring stations in the forebays of all the mainstem Columbia and Snake river dams, in coordination with the Water Quality Team.

The Fixed Monitoring Station (FMS) Subgroup of the Water Quality Team (WQT) met on November 12, 2002 to complete the review of the FMS system for the Federal Columbia River Power System (FCRPS). The recommendations shown below in Table 1 are for the 2003 spill season.

Table 1
Fixed Monitoring Station Subgroup Recommendations for 2003 Spill Season

Fixed Monitoring Station	Recommendation/Comments
Camas/ Washougal	Continue the CWMW site with additional exploratory monitoring for the Corbett site(see below).

Corbett	Continue the exploratory efforts at the Corbett site with consideration of Corbett replacing CWMW as the downstream site for BON. .
Warrendale	The site is inconsistent with other tailwater sites in the system due to considerable mixing. Recommend eventual retirement of this site.
BON Tailrace	Consider relocation of Warrendale tailwater monitor to the BON spillway channel. NOAA Fisheries (NMFS) is reviewing the 2002 BON spill test TDG data prior to a final decision on this recommendation
BON Forebay	Recommend no change in this site.
TDA Tailrace	The station is currently inconsistent with other tailwater sites in the system due to considerable mixing with powerhouse flows. Recommend addition of an exploratory site in spill water on the north shore and within 1000 feet of the spill water but beyond aerated flow. NOAA Fisheries (NMFS) is reviewing the 2002 BON spill test TDG data prior to a final decision on this recommendation
TDA Forebay	.There are potential benefits in relocation of this site to the provisional site on the opposite end of the structure. Recommend continuing the TDA site with consideration of relocating.
JDA Tailrace	Recommend no change in this site.
JDA Forebay	Recommend continue with current sampling location and depth but recognize that some elevated readings for TDG are temperature induced. Expand exploratory sampling to added locations in the tailwaters of the powerhouse or draft tube deck location. Expand exploratory sampling to a deeper depth at the current locations in the forebay and to an upstream location adjacent to the BRZ and at depths greater than 20 ft. Recommend continued thermal profiling in the JDA forebay water.
MCN Tailrace	Recommend no change in site location. Site anchoring system in need of repairs.
MCN Forebay	Recommend expansion of exploratory investigations of the MCN forebay stations.
Pasco	Recommend no change in this site.
IHR Tailrace	Recommend no change in this site. Site installation recently upgraded with stronger, larger diameter pipe and anchoring as required.
IHR Forebay	See Forebay Fixed Monitoring Station Review discussion below
LMO Tailrace	Recommend no change in this site. Site installation recently upgraded with stronger, larger diameter pipe and anchoring as required.
LMO Forebay	See Forebay Fixed Monitoring Station Review discussion below
LGS Tailrace	Recommend no change in this site. Site installation recently upgraded with stronger, larger diameter pipe and anchoring as required.

LGS Forebay	See Forebay Fixed Monitoring Station Review discussion below
LGR Tailrace	Recommend no change in this site. Site installation recently upgraded with stronger, larger diameter pipe and anchoring as required.
LGR Forebay	.See Forebay Fixed Monitoring Station Review discussion below
DWK Tailrace	Recommend upgrading station to standards of the FMS system. Determine if station is sampling mixed waters from DWK project.
Peck	Site installation recently upgraded with stronger, larger diameter pipe.
Lewiston	Station to modified to correct existing problems with dewatering during low flow conditions.
Anatone	Site installation recently upgraded with stronger, larger diameter pipe and extended 150 feet further into the thalweg and beyond influence from the Grand Ronde discharges.

Additionally the Fixed Monitoring Station Subgroup reviewed a multi-year plan to review and evaluate the forebay fixed monitoring stations within the Walla Walla District, Army Corps of Engineers that will be implemented in FY 2003. The plan will include the completion of the tasks shown below at each of the Lower Snake River projects, i.e., Lower Granite, Little Goose, Lower Monumental and Ice Harbor and two forebay stations at McNary dams. They include review and analysis of existing data from the forebay fixed monitors for representativeness and anomalies in total dissolved gas and temperature. Also, they include evaluation and comparison of auxiliary sites at each project for performance and representativeness. Candidate sites are as follows:

- One site in powerhouse release possibly located on the after deck or draft tube deck for each project;
- One site inside the powerhouse inline with waters flowing through the structure. A possible point of sample would be plumbed to either a generator penstock, fish unit penstock, cooling water supply etc.
- Adjacent to the current fixed monitor in the forebay of the project but at an alternate depth

There will also be Quality Assurance/Quality Control modifications for the 2003 spill season. The NMFS Biological Opinion RPA 131 stipulates that QA/QC should also include redundant and backup monitoring, biweekly calibration, and spot-checking of monitoring equipment. To address these concerns the Corps has drafted Data Quality Criteria (DQC), similar to Data Quality Objectives (DQCs) described in national monitoring programs, for the fixed monitoring program. The National Water Quality Monitoring Council (http://water.usgs.gov/wicp/acwi/monitoring/), through the efforts of the Intergovernmental Task Force on Monitoring Water Quality (1992 - 1996) recommends performance based objectives. The DQCs describe the accuracy, precision, and completeness of the data needed at each station. The fixed monitoring stations will be assessed at the end of the 2003 monitoring season against these criteria and a performance report will be created and shown in the Corps annual TDG report. Adjustments will be made to the individual fixed monitoring stations that do not perform to the objectives described. The DQC approach was recommended to the Water Quality Team in 2002 instead of the redundant and backup monitoring, and spot-checking approaches since DQCs will provide greater flexibility with equipment and less impact on program cost.

Portland District will continue to use the USGS to conduct their TDG monitoring. Walla Walla District water quality staff will contract out routine instrument calibration responsibilities in 2003. Seattle District will continue to contract their routine calibration of TDG equipment. In general the 2003 plan is as follows.

Phase 1: Program Start-Up

Responsible parties (See Table 2) will be invited for a follow-up coordination meeting some time in February for final discussions on the plan of action. This will ensure a good mutual understanding of the most current objectives of the dissolved gas monitoring program, including data to be collected, instrument location, procedures to be used, special requirements, etc. The draft plan will be presented for peer review at a February meeting of the WQT.

All three Districts will ensure that adequate funding is available for 2003 monitoring activities. Portland District, having decided to continue to use the service of the USGS in 2003, will prepare the necessary MIPRs to secure those services and provide for rental and associated maintenance of the USGS's Sutron data collection platforms. Walla Walla District will review their equipment inventory and proceed with the necessary orders for new TDG instruments and DCPs, if applicable. Seattle will renew or develop new contractual arrangements as needed for the operation of the Chief Joseph and Libby stations.

All maintenance and service contracts should be completed at least two weeks before the instruments are installed in the field. Where applicable, the Districts will ensure that real estate agreements and right of entry are finalized between the landowners and the Corps. All paper work for outside contracting will be completed no later than 31 January.

To date, the districts have been initiating the MIPR processes to continue contracts through the 2002-2003 winter monitoring season and the 2003-monitoring season. Districts and division have been updating the QA/QC protocols. Temperature loggers have been placed in Dworshak Reservoir for winter monitoring. All districts will continue GOES satellite transmission.

Discussions between districts, division and contractors are expected to continue through February, at which time a final plan of action will be produced. It is also understood that the following entities will continue to operate their monitoring instruments in 2003:

- U.S. Bureau of Reclamation, below Hungry Horse, at the International Boundary and above and below Grand Coulee Dam;
- Mid-Columbia PUDs (Douglas, Chelan and Grant Counties), above and below all five PUD dams on the Columbia River; and
- Idaho Power Company, in the Hells Canyon area (as part of its Federal Energy Regulatory Commission's license renewal requirement).

Phase 2: Instrument Installation

Instruments to be installed and their assigned locations are listed in Table 3 and shown in Figure 1. Some of them are already in place for the 2002-2003 winter monitoring. The Corps network will essentially remain the same as in 2002. Walla Walla will keep the Anatone and Pasco sites in operation over the winter measuring temperature only.

As before, the station below Libby Dam will only be activated if spill for flood control at the project becomes likely.

All instruments are scheduled to have been in place and duly connected to their Sutron or Zeno DCP's no later than 10 March at Bonneville and downstream stations, and no later than 1 April at all other stations. If needed, the station below Libby will be reactivated in May or at least two weeks before the start of flow releases for white sturgeon. Monitoring stations below Bonneville are scheduled to be in place first, prior to the release of Spring Creek Hatchery fish.

Corps stations that remain in service during the 2002-2003 winter will continue their operation with minimum interruption into the spring, following the necessary instrument service and maintenance check-up and site equipment (piping) upgrades. These stations include the following: Dworshak tailwater, Pasco (temperature), Anatone (temperature), Lower Granite forebay and tailwater, Ice Harbor forebay and tailwater, McNary forebay (Oregon and Washington sides) and tailwater, Bonneville forebay, and Warrendale. An assessment of monitoring site integrity will be conducted; any damages that may have occurred over the winter will be fixed before proceeding on to calibration and testing. Selected project personnel may be requested to assist on this task as needed.

Phase 3: In-season Monitoring and Problem Fixing

Actual data collection and transmission will start prior to the first Spring Creek Hatchery release, but no later than 15 March for stations below Bonneville, and no later than 1 April for the remainder of the monitoring network. Exact starting dates will be coordinated with the Corps' Reservoir Control Center (CENWD--CM-WR-N), project biologists and cooperating agencies, based on run-off, spill, and fish migration conditions.

The following data will be collected approximately every hour:

WC, Water Temperature (^{o}C)
BH, Barometric Pressure (mm of Hg)
NT, Total Dissolved Gas Pressure (mm of Hg)
Gage depth (feet)

Oxygen pressure and calculated nitrogen pressure parameters are currently collected at Walla Walla stations and at one Seattle District station.

OP, Dissolved Oxygen Pressure (mm of Hg)
NP, Nitrogen + Argon Pressure (mm of Hg)

Data will be collected at least hourly and transmitted at least every four hours. If feasible, the previous 12 hours of data will also be sent to improve the capability of retrieving any data that may have been lost during the preceding transmission. For Portland, Seattle and Walla Walla Districts, data transmission will be done via the GOES Satellite, to the Corps' ground-receive station in Portland. After decoding, all data will be stored in the CROHMS database. Per their contract with Portland District, the USGS is planning to have the satellite data going into CROHMS and ADAPS (internal to the USGS) simultaneously to allow for some pre-screening.

Given their direct relevance to fish mortality, the first three parameters (WC, BH and NT) will be collected on a first priority basis.

Only at John Day, a second or "redundant" instrument at the John Day tailwater will be placed in the same monitoring pipe as the first instrument during the 2003-monitoring season. Both instruments will transmit to CROHMS real-time.

Daily reports summarizing TDG and related information will be posted on the Technical Management Team's (TMT) home page. To the extent feasible, the measured TDG data will be compared with model predicted values so that suspicious values can be flagged and/or discarded before they are released. Data filtering through other methods will also be made. Information provided on the homepage will include the following data:

- Station Identifier
- Date and Time of the Probe Readings
- Water Temperature, °C
- Barometric Pressure, mm of Hg
- TDG Pressure, mm of Hg
- Calculated TDG Saturation Percent (%)
- Project Hourly Spill, Kcfs (QS)
- Project Total Hourly Outflow, Kcfs (QR)
- Number of Spillway Gates Open
- Probe depth, ft
- Calculated Compensation Depth, ft

Spill bay stop settings, if different from the numbers provided in the Fish Passage Plan, will also be reported to and coordinated with the TMT. Stopsettings, however, will not be part of the water quality data set available on the TMT home page.

Reconciliation between data received to CROHMS will be made by the Reservoir Control Center staff based on the input from the field before the data are permanently stored in the Corps' Water Quality Data Base. Additional data posting in the TMT home page will continue.

Instrument reliability and accuracy will be monitored through the following basic QA/QC procedures, including Data Quality Criteria, as discussed through the WQT technical workgroup.

- Calibrations of instruments will occur every two weeks
- Competent personnel (Corps or contractor) will visit monitoring site to check for and if necessary, fix site problems (probes clogging, leaking membranes, instruments out of calibration, etc.) and recalibrate the faulty instrument(s).
- Calibration will be accomplished using a primary standard (pressure gauge, hand-held barometer, etc). A secondary standard, such as a portable lab-calibrated instrument, will be used as needed to limit sampling precision uncertainty.
- TDG membranes will be changed every two weeks with a dry, functioning membrane.
- If an emergency visit is conducted, a redundant monitor will be placed in river during emergency visit to serve as a temporary back-up to field monitor.

Draft Data Quality Criteria

This draft criteria coordinated with the NMFS forum Water Quality Team are:

Secondary TDG Standard Sensor Calibration:

Calibrate the secondary standard TDG sensor at two points using the primary NIST standard. The TDG pressure must be +/- 1 mm Hg at both pressures, otherwise the secondary standard is recalibrated. Pressures at which the sensor is calibrated must bracket the expected range of field measurements.

Laboratory calibration: Secondary Barometric Pressure Standard:

Calibrate the secondary standard barometer at ambient barometric pressure to the NIST standard. The barometer must be +/- 1 mm Hg of the primary standard otherwise the secondary standard is recalibrated.

Field instrument TDG sensor calibration:

The two point TDG sensor calibration must agree within +/- 1 mmHg at both pressures, otherwise the sensor is recalibrated. Pressures at which the sensor is calibrated must bracket the expected range of field measurements.

Field Instrument Thermistor Calibration

A check or verification still constitutes a calibration and should be documented in records.
The instrument's thermistor must agree within +/- 0.2°C with the primary NIST (National Institute of Standards and Technology) standard. This variance will be monitored and if the probe performs outside this range, it will be returned to the manufacturer for maintenance.

Field instrument post-calibration:

Following a two-week deployment, a two point TDG sensor calibration must agree within +/- 4 mmHg at both pressures. Pressures at which the sensor is calibrated must bracket the expected range of field measurements. If the pressure is not +/- 4 mmHg of the standard, the data will be reviewed and appropriately corrected. If, after data review, a correction can not be applied, the data will be removed from the database. Sensor drift can be handled using a linear correction, but it is entirely possible for someone to enter incorrect calibration values, which would result in a shift affecting all readings equally.

If the any parameter is considered suspect following these calibration checks on return to the laboratory, the data collected for the previous time period will be reviewed and if applicable, corrections will be applied or the data will be removed from the database.

Field Performance check:

After the deployment period, prior to removal of the field instrument, the TDG pressure will be compared to the secondary standard.

During initial deployment of a new instrument, after sufficient time for equilibration (up to one hour), the TDG pressure must be +/- 4 mmHg of the secondary standard otherwise another (standby) probe is deployed.

During initial deployment of the new instrument, the thermistor will be +/- 0.4°C of the secondary standard, corrected for calibration, or replace the instrument with a standby.

At each visit the field barometer pressure reading should be +/- 2 mmHg of the secondary standard or the field barometer will be returned to the manufacturer for adjustment.

The sensor must be deployed to a depth where the compensation depth is sufficient to accommodate the change in pressure relative to the atmosphere; otherwise the TDG measurements may be underestimated. If the site does not accommodate maintaining the probe at greater than the compensation depth for more than 95% of the measuring cycle, investigations will begin to re-locate the fixed monitoring station.

As a goal, data collected at each site will be 95% of the data that could have been collected during the defined monitoring period. The calculation of data set completeness is based on temperature and percent TDG, encompassing barometric pressure and TDG pressure, not the completeness of each parameter measured.

Sources of measurement error:

1. calibration
2. drift
3. probe location
4. rotation of probes from one location to another

sampling variability

If data recorded by the fixed sensors are different from those recorded during calibration procedure, appropriate corrections will be made to current as well as past data already stored in CROHMS as soon as possible. Data corrections will be provided to the Division office on an on-going basis so that they can be incorporated into the database. Significant and/or unusually large changes will be reported immediately to all customary users, including the Fish Passage Center.

The Corps, or their contractors, will have an adequate inventory of spare instruments will be maintained to ensure that at least one backup monitor will be made available for deployment as necessary. A malfunctioning instrument will be repaired within 24 to 48 hours, depending on the remoteness of the instrument location and TDG conditions (weekends may require a longer response time). High priority will be placed on fixing a faulty instrument when TDG are or expected to be in excess of the current state standards.

Contractor and/or Corps staff will maintain TDG instruments. Instruments needing repairs that are beyond the staff's capability will be shipped to the manufacturer. In-house water quality and information management will do repairs of communication network staff. USGS Stennis Center (MS) staff will handle Service and repairs of the Sutron DCPs. Service and repairs of the Zeno DCPs will be performed by a contractor.

To better understand the physical process of dissolved gas distribution across the reservoirs and its dissipation along the various pools, selected transects studies will continue to be conducted on an as-time-permits basis. An additional objective for this activity is to be able to define how representative readings from current monitoring sites really are with respect to the entire river reach. Model runs using SYSTDG (developed by the Waterway Experimental Station) or MASS1 (developed by Battelle) for the Gas Abatement Study will be performed as needed to define the range of expected/acceptable TDG levels under various spill conditions. The Corps plans to work with National Oceanic and Atmospheric Administration (NOAA) Fisheries Service to provide additional training in January 2003 to use SYSTDG during the 2003 spill season.

To help reduce response time in determining whether an emergency field visit is needed, the following decision-making procedure was developed by the WQT:

1) No emergency trips are made for the parameter of temperature or oxygen.

2) For gas and barometric pressure, if more than 25% of the hourly values are missing, then an emergency trip is needed.

3) If the difference in values between two consecutive stations is larger than 20 mm Hg for gas pressure, or 14 mm Hg for barometric pressure, then an emergency trip is triggered. Criterion 3 does not apply if:

a) there is a transient "spike" for a parameter.
b) if the higher-than-expected gas pressure value is associated with spill operations.

4) If gas parameters at a station do not fall within any of the Corps Engineering Research and Development Laboratory (ERDC) generated/RCC generated gas production curves, are not caused from operational or structural changes, and these data persist for over 48 hours, then an emergency visit is triggered.

5) If there is uncertainty with an abnormal reading at a gas monitoring station that persists for more than 48 hours, the COE will notify WQT members as soon as possible via email. The WQT should develop a recommendation to TMT, and to IT if necessary. If the COE plans to change fish passage actions because of the uncertainty, it should notify both the TMT & WQT members of the proposed change. TMT members will determine whether or not a meeting or conference call is needed and advise the COE of this need. The COE will then convene a TMT meeting, if requested to do so. If an abnormal reading at the gas monitoring

station persists for more than 48 hours, the Corps will adopt the 2000 Plan of Action language on the subject. According to the May 2, 2000 letter from the Corps to NMFS, "If the WQT chairs determine a water quality issue exists, the issue will be framed by the WQT and forwarded from the chairs of the WQT to the chair of TMT or IT, as appropriate. Each state's fishery and water quality agencies and tribes will work together prior to any TMT meeting on this issue to balance and assure consistency of the proposed actions with fishery management requirements and state water quality standards."

Phase 4: Instrument Removal and Storage

Water quality monitors will be removed shortly after the end of the monitoring season (15 September) by Corps staff or the USGS, except for those that are slated for continued winter monitoring. Those removed will be serviced by the maintenance and service contractors and stored at a convenient location until the beginning of the next monitoring season. A selected number of monitors and spare DCPs will be available for off-season special monitoring activities upon request. Seattle District owns its Sutron DCPs, and maintains and stores them as needed.

Phase 5: Winter Monitoring.

The same few stations that were selected for winter operation in 2001-2002 will be retained for compliance monitoring in the following 2002-2003 winter. These included, at a minimum, stations located at International Boundary, Dworshak tailwater, Lower Granite forebay and tailwater, Ice Harbor forebay and tailwater, McNary forebay (Oregon and Washington) and tailwater, Bonneville forebay, and Warrendale. Anatone and Pasco stations will continue to monitor temperature over the winter season. Larger diameter pipe replacement at the Anatone station, extending it approximately 150 feet further out into the thalweg of the stream, is being performed during the 2002-2003 winter.

Phase 6: Data Compilation, Analysis and Storage

Time and resource permitting, Corps staff and contractors will fill data gaps, perform statistical analyses, and develop trends and relationships between spill and TDG saturation. Efforts will be made to use the SYSTDG, MASS1, and COLTEMP (Water Temperature) models, and finding ways to facilitate and/or improve user access to the TDG and TDG-related database. The SYSTDG model (developed by ERDC) will be available for in-season gas production predictions and screening. Data collected at and transmitted from all network stations will be ultimately stored at CENWD-CM--WR-N, where they can be accessed through a data management system such as HEC-DSS or download the information from the TMT website.

Phase 7: Program Evaluation and Summary Report

An annual report will be prepared after the end of the normal (spring and summer) monitoring season to summarize the yearly highlights of the TDG monitoring program. Preparation for the annual report will begin with a post-season review, with participation by the three Corps districts and the NMFS forum WTQ. The report will include a general program evaluation of the adequacy and timeliness of the information received from the field, and how that information is used to help control TDG supersaturation and high water temperature in the Columbia River basin. Information on the performance of the instruments (including accuracy, precision and bias associated with each parameter) and the nature and extent of instrument failures will be documented. This summary should include statistics on data confidence limits. Division staff will prepare the Annual TDG Monitoring Report based on field input, other material provided by each District, and recommendations by the WQT. This report will also contain suggestions and recommendations to improve the quality of the data during the FY2003 monitoring program.

Phase 8: Special Field Studies

As provided for in Phase 3, additional monitoring of dissolved gas saturation will be conducted on an as-needed basis. The current plan for additional monitoring includes transect measurements below selected dams to: 1) establish the relationship between various spill amounts and TDG saturation, and 2) plot TDG variations within a given cross-section of the river, especially a cross-section that includes a fixed monitoring station. Special consideration will continue to be made at evaluating improvements (or any other changes) to TDG levels brought about by the new flip-lips at John Day Dam. Efforts will also be expanded in learning more about dissolved gas supersaturation dissipation along the fish migration route, possibly using monitoring made from moving fish barges and deployment of self-contained wireless probes. These on-going efforts are expected to continue for several years.

COOPERATION WITH PARTICIPATING AGENCIES

The Bureau of Reclamation, Douglas County PUD, Chelan County PUD, and Grant County PUDs currently monitor for total dissolved gases at their mainstem projects. Until recently, these groups were not directly influenced by the listings of salmon and steelhead under the **ESA**. Nonetheless, they have maintained a cooperative effort with the Corps in collecting and reporting total dissolved gas and related water quality parameters and in making this information available to the Corps for storage in their CROHMS database. Idaho Power Company is believed to have been collecting some TDG information in the Hells Canyon Complex for use in numerical modeling for FERC relicensing efforts. However, this information has not been as widely disseminated as the data from the rest of the TDG monitoring network. Following are the action plans for the cooperating agencies.

Bureau of Reclamation. Bureau of Reclamation TDG monitoring will continue at International Boundary and the Grand Coulee forebay and tailrace, and the Hungry Horse sites in 2003. Hourly data transmission to CROHMS will continue via the GOES satellite.

Douglas County PUD. TDG monitoring will continue at the forebay and tailrace of Wells Dam in 2003. Hourly data from both of these stations will continue to be sent to the Corps.

Chelan County PUD. The physical monitoring of TDG to be conducted in 2003 will be very similar to the monitoring conducted from 2000 to 2002. Chelan will continue to monitor TDG in the forebay and tailrace of both Rocky Reach and Rock Island Dams. The PUD will continue to use Hydrolab Minisondes in the forebay and Hydrolab Datasonde 4s in the tailrace. Data will continue to arrive to the Corps hourly, and efforts will be made to repair malfunctioning probes within 48 hours. Monitoring instruments will be calibrated every three to four weeks or as necessary. Chelan will also continue to conduct transects in the tailraces of both projects to validate the locations of the tailrace monitors and may institute some forebay transects to verify that forebay readings are representative of the conditions in the river at large.

Grant County PUD. TDG will continue to be monitored in the forebays and tailraces of both Wanapum and Priest Rapids Dams. Fixed site locations will not be changed and all probes will be calibrated before the season and every three to four weeks following. Hourly data will continue to be posted on the Grant Co. PUD website. The PUD will also continue weekly cross sectional monitoring at the four fixed monitoring stations in the forebay and tailraces of both projects. Calibration of the instruments was contracted out in 2001.

Table 2. List of Contact Persons in 2002

Project	Name	Position	Phone #	E-Mail
Internat'l Bndry., Hungry Horse, Grand Coulee	Dr. Sharon Churchill	Coordinator	((509) 754-0254	schurchill@ pn.usbr.gov
	Norbert Cannon	Oversight	(208) 334-1540	ncannon@ pn.usbr.gov
	Jim Doty	Transmission	(208) 378-5272	jdoty@ pn.usbr.gov
Chief Joseph, Libby	Marian Valentine	Coordinator	(206) 764-3543	marian.valentine @usace.army.mil
	Kent Easthouse	Oversight	(206) 764-6926	Kent.b.easthouse @usace.army.mil
	Ray Strode	Trouble-shooting	(206) 764-3529	ray.strode@ usace.army.mil
Wells (Douglas)	Rick Klinge	Coordinator	(509) 884-7191	rklinge@ televar.com
Rocky Reach, Rock Isl.(Chelan)	Waikele (Kelee) Hampton	Coordinator	(509) 663-8121 x 4627	waikele@chelanp ud.org
Rocky Reach, Rock Isl.(Chelan)	Mike Blalock	Data Manager	(509) 669-1732	
Wanapum, Priest Rapids (Grant)	Cliff Sears	Coordinator	(509) 754-6612	csears@ gcpud.org
	Dee Chandler	Oversight/Data Management	(509) 754-3541	dchandl@ gcpud.org
Dworshak, Low. Granite, Little Goose, Low. Monumental, Ice Harbor, McNary, Pasco, Anatone	Dave Reese	Coordinator	(509) 527-7279	david.l.reese@ usace.army.mil
	Gary Slack	Oversight.	(509) 527-7636	gary.m.slack@ usace.army.mil
	Russ Heaton	Oversight	(509) 527-7282	russ.d.heaton@ usace.army.mil
John Day, The Dalles, Bonne-ville, Warrendale, Skamania,Camas	Jim Britton	Coordinator	(503) 808-4888	james.l.britton@ usace.army.mil
	Joe Rinella	USGS/Contract Coordinator	(503) 251-3278	jrinella@ usgs.gov
	Dwight Tanner	USGS/Oversight	(503) 251-3289	dqtanner@ usgs.gov
Division Pgm. Coordination	Dick Cassidy	Program Coordinator	(503) 808-3938	richard.a.cassidy @usace.army.mil
	Laura Hamilton	Program Oversight	(503) 808-3939	laura.j.hamilton@ usace.army.mil

Table 3. 2002 Dissolved Gas Monitoring Network

STATION CODE	STATION NAME	*OWNERS*
CIBW*	US/Can Boundary	USBR
HGHW	Below HGH	USBR
FDRW	GCL Forebay	USBR
GCGW	GCL Tailwater	USBR
LIBM (#)	LIB Tailwater	NWS
CHJ	CHJ Forebay	NWS
CHQW	CHJ Tailwater	NWS
WEL	WEL Forebay	DOUGLAS CO.
WELW	WEL Tailwater	DOUGLAS CO
RRH	RRH Forebay	CHELAN CO.
RRDW	RRH Tailwater	CHELAN CO.
RIS	RIS Forebay	CHELAN CO.
RIGW	RIS Tailwater	CHELAN CO.
WAN	WAN Forebay	GRANT CO.
WANW	WAN Tailwater	GRANT CO.
PRD	PRD Forebay	GRANT CO.
PRXW	PRD Tailwater	GRANT CO.
PAQW	Col. Above Snake	NWW
DWQI*	DWR Tailwater	NWW
PEKI	Peck/Clearwater	NWW
LEWI	Lewiston/Clearwater	NWW
ANQW	Upper Snake at Anatone	NWW
LWG*	LWG Forebay	NWW
LGNW*	LWG TW	NWW
LGS	LGS Forebay	NWW
LGSW	LGS Tailwater	NWW
LMN	LMN Forebay	NWW
LMNW	LMN Tailwater	NWW
IHR*	IHR Forebay	NWW
IDSW*	IHR Tailwater	NWW
MCQW*	MCN FB/Wa	NWW
MCQO*	MCN FB/Or	NWW
MCPW*	MCN Tailwater	NWW
JDA	JDA Forebay	NWP
JHAW	JDA Tailwater	NWP
TDA	TDA Forebay	NWP
TDDO	TDA Tailwater	NWP
BON*	BON Forebay	NWP
WRNO*	Warrendale	NWP
CWMW	Camas	NWP

(#) during spill only (*) winter monitoring station USBR= U.S. Bureau of Reclamation NPP= Portland District NPS= Seattle District NPW = Walla Walla District LB=Left bank RB=Right bank MC=mid-channel

Figure 1. 2003 Dissolved Gas Monitoring Network

APPENDIX E – Water Temperature Matrix

This appendix is a matrix of all of the suggestions that were received as of 2/28/2003, and as discussed in section 7 of this water temperature document.

Action Item #	Mainstem Cooling Water Temperature Measures	Anticipated Effect on Temperature and other Benefits to Salmon Recovery	Major Issues or Concerns	Lead Agency	Feasibility of Implementation (Who) -why	Appropriate Next Step	Tests/Studies Required to Implement	Status/ Year(s)	NMFS 2000 FCRPS RPA
M-1	Operate Dworshak Reservoir to Release cool water in July and August to Aid juvenile migration and reduce mainstem Snake River Water Temperatures	Reduction of Water Temperature in the Mainstem Snake and Clearwater Rivers During July and August	- Possible Negative Impact on Growth of Juvenile Fall Chinook - Balancing of Reservoir Elevations vs. Augmentation of flows - Possible Impacts to Adult Salmonid Migration (positive or negative) - TDG Issues with discharge rate - Possible effects to Bull Trout - Further Discussion of effects can be found in the SOR EIS	Corps	Feasible (Corps)	See Action Item 2	None - Implemented Yearly	Tested In 1991, In operation since 1992	19
M-2	Examine the Benefits of Drafting Dworshak an Additional 20 Feet during September to provide cool water to the mainstem	Reduction of Water Temperature in the Mainstem Snake and Clearwater Rivers During September	- Possible Conflict with NMFS 2000 FCRPS BIOP RPA 18 in that Refill Risk to April upper Flood Control Rule Curve is increased. However, NMFS feels there is an acceptable risk of refill to the June 30 full pool. - TDG Issues with discharge rate - The Nez Perce Tribe is concerned with drawdown exposing cultural resources to potential looting or other damage - Idaho does not favor additional impacts to recreation at Dworshak - Further Discussion of drafting dworshak below 1520 can be found in the SOR EIS	Corps	Feasible (Corps)	Data Analysis and Report of the first year of study (See Action Item 5)	One year of study done, Implementation needs to be studied	A Field Test was Completed in 2002	34
M-3a	Operate the Four Lower Snake River Reservoirs between MOP and Mop+1 from April through roughly October	This is thought to reduce the water surface areas exposed to solar radiation and increase water velocities to limit time exposure to solar radiation	- For 2003, Snake River Dredging Litigation may cause operations of Lower Granite Reservoir to exceed MOP+1 for navigation - Decreased Power Generation and system flexibility - Further discussions of the effects can be found in the SOR EIS	Corps	Feasible (Corps)	None	None - Implemented Yearly	In Progress	20

Action Item #	Mainstem Cooling Water Temperature Measures	Anticipated Effect on Temperature and other Benefits to Salmon Recovery	Major Issues or Concerns	Lead Agency	Feasibility (Who) - why	Appropriate Next Step	Tests/Studies Required to Implement	Status/ Year(s)	NMFS 2000 FCRPS RPA
M-3b	Operate the Four Lower Snake River Reservoirs below MOP, (e.g. at MSL 710 at LGR) or Spillway Crest from April through roughly October	This would further reduce the water surface areas and increase water velocities to limit time exposure to solar radiation	- Temporary draw downs are expected to have continual negative impacts to salmonids - Negative Biological Impacts to Reservoir - Negative Impacts to Navigation/Hydropower/Infrastructure - Negative Impacts to Cultural Res. - Further discussions of the effects can be found in the 1992 Columbia River Salmon Flow Measures Option Analysis/EIS	Corps	Not Feasible (Corps) - fish passage - reservoir ecol. - navigation - hydropower - cultural res.	None	Done	Studied in 1992	-
M-3c	Operate Lower Granite Reservoir at Spillway Crest Year round	This would reduce the water surface areas and increase water velocities to limit time exposure to solar radiation	- Negative Impacts to Cultural Resources - Negative impact to Navigation/Hydropower/Infrastructure	Corps	Not Feasible (Corps) - fish passage - reservoir ecol - navigation - hydropower - cultural res	None	Done	Studied in 1992	-
M-3d	Remove Dams and Reservoirs	This would further reduce the water surface areas exposed to solar radiation and increase water velocities to limit time exposure to solar radiation	- Discussions of the effects can be found in the 2002 Lower Snake River Juvenile Salmon Migration Feasibility Study	Corps	Not Warranted at this Time Under ESA	None Anticipated for CWA	Done	Study Completed in 2002	-
M-3e	Draw down John Day Reservoir to spillway Crest or Natural River	This would reduce the water surface areas and increase water velocities to limit time exposure to solar radiation	- Discussions of the effects can be found in the 2000 John Day Drawdown Study - Cost Prohibitive	Corps	Not recommended (Corps) - Cost - Power - questionable benefits - wildlife	None	Done	Study Completed in 2000	-
M-3f	Drawdown other dams to spillway crest or natural river, temporarily or year round	If Lower Granite and John Day reservoir draw downs are thought to reduce temperature, it is logical to hypothesize that other dams in the Columbia River could be drawn down with similar proposed temperature benefits	-Dams to be considered for drawdown would need to include those in Hells Canyon , Grand Coulee, Canada and PUD dams. -Depending on the operation, drawdown of any reservoir might be expected to have the same impacts as noted in Action item 3b	Unknown	Unknown	Unknown	Unknown	-	-

Action Item #	Mainstem Cooling Water Temperature Measures	Anticipated Effect on Temperature and other Benefits to Salmon Recovery	Impacts or Issues	Lead Agency	Feasibility (Who) -Why	Appropriate Next Step	Tests/Studies Required to Implement	Status/ Year(s)	NMFS 2000 FCRPS RPA
M-4	Grand Coulee Powerhouse Operations	Selective operation of the Left, Right, and Third Powerhouses would be evaluated to determine if there is potential to cool Grand Coulee releases during critical periods.	- Power Constraints may limit benefits – stratification breaks up in September	BOR	Unknown (BOR)	Decision to Proceed with Study	Modeling of Water Quality Benefits/Estimate Costs	Planning	-
M-5a	Use or Modify Water Intakes at Storage Reservoirs for Selective withdrawal	Selective Withdrawal has been demonstrated at various locations to draw water from a cooler layer in a reservoir and deliver that cooler water downstream	- Except for Grand Coulee (See action Item M-5b) there are no other federal projects that could reduce water temperature in the mainstem Columbia and Snake River. - Currently exists at Dworshak Dam	Corps	Not Feasible at ROR projects (Corps) - No Potential	Action Item M-5b	No Additional Action	None	-
M-5b	Determine feasibility of penstock selective withdrawal at Grand Coulee	Selective Withdrawal has been demonstrated at various locations to draw water from a cooler layer in a reservoir and deliver that cooler water downstream	- Implementation Authority, Possible Resident Fish Constraints in FDR Lake - Possibly Cost Prohibitive	BOR	Unknown (BOR)	Decision to Proceed with Study	Modeling of Water Quality Benefits/Estimate Costs	Planning	-
M-5c	Investigate cool water releases from the Hell's Canyon hydro projects	The Hell's Canyon projects are thought to have some stratification in them during some times of the year, with selective withdrawal, it may be possible to tap a layer of water for downstream cooling effects	- Unknown, however, at a minimum, similar concerns with the Dworshak Reservoir releases - No Authority	Unknown	Unknown (Corps)	TBD	TBD	TBD	-
M-6	Alter the Flood Control Rule Curves	Currently, storage projects are prioritized to fill by June 30 (RPA 18), which maximizes the amount of water to be released in July and august for salmon flows and temperature reduction flows. It is anticipated that any change to release flood control storage would result in more water in the spring since the priority now is refill by the 30th. Therefore, it is anticipated that no additional benefit for reducing mainstem temperatures would occur due to this action.	- TBD, but a t a minimum, augmentation versus reservoir refill, and impacts to the flood plains	Corps	TBD	Federal Appropriation for a Study has been approved	Study Required	TBD	35

Action Item #	Site Specific Water Temperature Measures	Anticipated Effect on Temperature and other Benefits to Salmon Recovery	Major Issues or Concerns	Lead Agency	Feasibility (Who) - Why	Appropriate Next Step	Tests/Studies Required to Implement	Status/ Year(s)	NMFS 2000 FCRPS RPA
M-7	Investigate cool water releases from Canadian hydro projects	US Agencies are not aware of the potential for temperature augmentation associated with releases of water from Canada	- Unknown, however, at a minimum, similar concerns with the Dworshak releases - No Authority	Unknown	Unknown (Corps)	TBD	TBD	TBD	-
M-8	Investigate Banks Lake Selective Withdrawal to draw warm water from Lake Roosevelt	Drawing water from the upper part of the water column into Banks lake may make more, cooler water available in the Mainstem river.	- Implementation Authority -Temp. Constraints in Banks Lake - Possible Resident Fish Constraints in FDR Lake	BOR	Unknown (BOR)	Decision to Proceed with Study	Modeling of Water Quality Benefits/Estimate Costs	Planning	-
M-9	Investigate Groundwater Charging for Cooling Mainstem Water	Charging groundwater in strategic areas may provide areas of upwelling of cooler water from the river bottom, providing cool water refugia and helping to reduce overall river temperature	-Current groundwater contributions -Groundwater contamination -Effectiveness -Appropriate substrate	Unknown	Unknown (Corps)	Unknown	Unknown	-	-

Action Item #	Site Specific Water Temperature Measures	Anticipated Effect on Temperature and other Benefits to Salmon Recovery	Major Issues or Concerns	Lead Agency	Feasibility (Who) - Why	Appropriate Next Step	Tests/Studies Required to Implement	Status/ Year(s)	NMFS 2000 FCRPS RPA
S-1	Modification of Dworshak National Fish Hatchery Water Supply	No change to the reaches affected by the Dworshak Temperature Releases unless cooler water can be released due to modifications at hatchery.	- benefits to the Dworshak hatchery water supply - If cooler water is released, need to consider impacts to juvenile salmon rearing	Corps	Feasible (Corps)	None	Done	In Progress To be Completed in 2003	33
S-2a	Examine the temperatures in the McNary Forebay to determine if there are options to reduce water temperatures in the juvenile bypass systems	Better Understanding of Impacts to Juvenile Salmon Survival related to temperature. Using mixers in the forebay or excavating the shallow water of the forebay on the South Shore may help to disrupt the temperature gradient that occurs there	- Turbine discharge limited -Feasibility of excavation has not yet been evaluated	Corps	Feasible (Corps)	Complete analysis and Report	Studies in Progress	In Progress	142
S-2b	Identify water temperature cooling methods at individual projects for juvenile fish passage	Drawing water through specific turbines has been shown to draw cooler water into juvenile fish facilities at McNary Dam	- If a problem is discovered, implementation of a solution would also need to be studied	Corps	TBD	Complete analysis and Report	Nothing Scheduled	None	141
S-2c	Identify methods to cool river water at individual projects	Selective Operations at various facilities may have potential for cooling the river (See Action 7d)	- If a problem is discovered, implementation of a solution would also need to be studied	Corps	TBD	Complete analysis and Report	Study in Progress at Chief Joseph Dam	In Progress	-

Action Item #	Research Related Water Temperature Measures	Anticipated Effect on Temperature and other Benefits to Salmon Recovery	Major Issues or Concerns	Lead Agency	Feasibility (Who) -Why	Appropriate Next Step	Tests/Studies Required to Implement	Status/ Year(s)	NMFS 2000 FCRPS RPA
R-1	Conduct Acoustic and Radio Data Storage Tag studies to examine migratory behavior of adults with respect to temperatures and depth. Tracking data should overlay on simulated physical conditions.	Better Understanding of Impacts on Adult Salmon Behavior related to Temperature Releases	- If a problem is discovered, implementation of a solution would also need to be studied - Continued Dworshak Operations	Corps	Feasible (Corps)	Complete Study, Analysis and Report	Study in Progress, 2003 last anticipated year of field study	Ongoing 2000-2003	34, 115
R-2	Conduct studies to examine fish behavior with respect to water temperature in adult fish ladders	Better Understanding of Impacts on Adult Behavior related to temperature	- If a problem is discovered, implementation of a solution would also need to be studied	Corps	Feasible (Corps)	Complete analysis and Report	Study In Progress	In Progress	114
R-3a	Perform additional monitoring of water temperatures in the Snake River and model investigations to evaluate alternative operations of Dworshak	Better Understanding of Impacts of Dworshak Releases	- No Known Negative Impacts – Better understanding of river temperatures	Corps	Feasible (Corps)	Complete analysis and Report	In Progress	In Progress 2002-2007	143
R-3b	Improve water temperature monitoring of the Columbia River System	This action is being performed concurrently with Action Item 8a	- Better understanding of river temperatures	Corps BPA BOR	Feasible (AAs)	Complete analysis and Implement	Study In Progress for TDG	In Progress	-
R-4	Investigate Cool Water Refugia in the Mainstem Rivers	Determine if areas of cool water refugia exist in the mainstem rivers and determine if it is feasible to somehow try to connect these habitats	-Difficult to ascertain -Difficult to quantify	Unknown	Unknown	Unknown	Unknown	-	-
R-5	Perform a "D-Temp" study (Similar to a DGAS Study)	Outline and Define the potential to decrease water temperature in the Columbia River with a modeling study	-Authorization -Funding -Schedule	Unknown	Unknown	Unknown	Unknown	-	-
R-6	Develop a multi-dimensional water quality model for the geographic scope of the water quality plan to determine the effectiveness of water quality measures outlined in Section 7 and other measures as they arise	There currently exists some two and three dimensional models for parts of the Snake and Columbia rivers, further development of models would need to be developed to encompass the geographic scope of the plan.	-Authorization -Funding -Schedule	Multiple but Unknown	Unknown	Unknown	Unknown	-	143 Partial
R-7	Investigate the thermal relationship of temperature on fish diseases.	High water temperatures have been linked to stress and disease in fish. A better base of information to understand the sources of fish disease and mortality at the Columbia Basin dams is needed.	- If a problem is discovered, implementation of a solution would also need to be studied	Corps	Feasible (Corps)	Rework of proposals	Studies anticipated through the AFEP process	Planned for the course of the BiOp	141

APPENDIX F – Corps Perspective

The following information is provided to give the Corps of Engineers perspective on water temperature in the Columbia River Basin. This section may or may not reflect the perspectives of other federal, state, tribal or private agencies. The purpose of this section is to demonstrate that the Snake and Columbia rivers have regularly exhibited periods of high temperatures both pre- and post-impoundment and that there are various causes of increased water temperatures (including the dams).

Data used in this section has been taken from published sources and regional Internet sites. The Corps has not done any detailed analysis or additional research beyond this for this plan, as this was not the purpose of this document. Modeling efforts, much of which has been done by EPA, have been underway for a number of years to evaluate the effects of human activities on river water temperatures. Much of the EPA effort has been performed for various studies and the TMDL process.

Historic water temperatures in the Snake and Columbia rivers are an often-debated topic. Historic measurements in the Columbia and Snake Basins were often done either sporadically, over short periods of time, or with unknown levels of accuracy. Some historic data has been met with skepticism and questions have been raised about the viability of historic data because scientific methods may not have been as rigorous as preferred. The Corps believes that although much of this data may not be suitable for modeling, it should not all be completely rejected.

F-1 Historic Warm Water in the Columbia and Snake Rivers

The mainstem Columbia and Snake rivers have always experienced warm water during specific times of the year, quite often exceeding 20°C. Early ancillary data from the Lower Columbia River downstream of Portland, Oregon can be found in the 1878 Report of the Commissioner, United States Commission on Fish and Fisheries, page 807. In 1875, water temperatures were 20°C or greater for 39 and 31% of the days in July and August respectively (Table 3). While the limited air temperature data for Portland at that time did not indicate that it was an abnormal air temperature year, http://www.wrh.noaa.gov/Portland/TM239/PG46.html, the precipitation in Portland for July as reported by the National Weather Service was one of the lowest on record (1871-1999 Avg. = 0.63, 1875 = .02) http://www.wrh.noaa.gov/Portland/TM239/PG65.html.

	% of Days when 12am Temp >= 20C	
	1875	
	July (1-31)	August (2-14)
Columbia River Clifton, Oregon	39%	31%

Table 1. Columbia River midnight single point water temperatures as measured at Clifton, Oregon in 1875.

While this may indicate that this information was not collected in an average year, it can be considered as evidence of historic warm water in the Lower Columbia prior to impoundment. Additional evidence of warm historic temperatures can be seen in the Bonneville scrollcase data. From 1949-1959, a period when few mainstem dams were in place, temperature records indicate that both maximum and average temperatures regularly exceeded 20°C during August for that period (Figure 1).

Some data was collected in the Snake River prior to the completion of the Hells Canyon Complex, one example was temperature data collected by the USFWS from 1955-1957 (USFWS 1958). They reported that the average daily temperature for July and August in 1957 for sites near Hells Canyon met or exceeded 20°C between 61 and 100% of the time (Table 2).

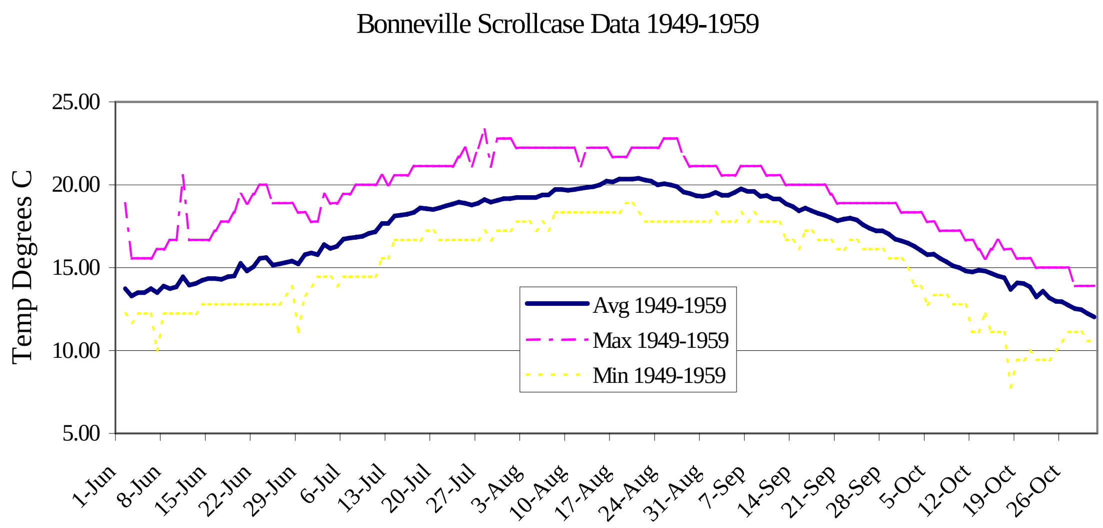

Figure 1. Maximum, minimum, and average Bonneville Dam Scrollcase temperatures 1949-1959 as reported at DART.

	% of Days when Avg. Temp >= 20C	
	1957	
	July	August
Clarkston, WA	61%	84%
Oxbow Dam Site	100%	87%
Brownlee Dam Site	100%	84%

Table 2. Percentage of days when average daily water temperature exceeded 20°C between the upstream and downstream ends of Hells Canyon.

F-2 Current Mainstem Water Temperatures

The Corps believes that water temperatures in the Snake and Columbia mainstem rivers are warmer today than they were historically. However, the Corps also believes that to characterize hydropower development as the only reason current temperatures are warmer than historic is incorrect. The Corps believes that water temperatures are warmer because of three major factors including:

1. Construction and Operation of the Federal and Private Columbia/Snake Mainstem Dams
2. Climate Changes
3. Upstream Influences

F-3 Mainstem Dam Construction and Operation

The presence of dams has modified natural temperature regimes in the mainstem Columbia and Snake River Basin reservoirs. They are known to have affected water temperature by extending water residence times and by altering the heat exchange characteristics of affected river reaches (Yearsley 1999). Some of the most significant changes to the river include the change of cross sectional area, slowing of water velocities and the alteration of the seasonal hydrograph. Of concern to the region are the water temperatures from July through November. This is due primarily to the biological impacts of the yearly peak of warm water temperatures, as well as the extended period of time when water is warmer than under a natural hydrograph scenario.

Seasonal temperature fluctuations generally decrease below larger reservoirs that are thermally stratified and have hypolimnetic discharges. Downstream temperatures are cooler in the summer as cold hypolimnetic waters are discharged, but warmer in the fall as energy stored in the epilimnion during the summer is released (Spence et al. 1996). Thus, operation of storage reservoirs affects both the thermal characteristics of the river and the thermally regulated aspects of salmon survival. For this reason, the thermal effects of reservoir operation are an important consideration in developing system operations aimed at protecting and restoring listed salmonids.

Maximum temperatures in the mainstem Snake River, where salmon survival is most tenuous, are generally lower in summer than before the series of storage and mainstem reservoirs was installed. This is also true in the mainstem Columbia River The assumption that temperatures may have increased is correct when applied to temperatures seen in late summer and fall, when the latency of reservoir storage is exhibited. Besides a lowering of maximum summer temperatures, the peak temperatures have been shifted to later in the year. Localized temperature increases have been caused by the hydropower system. In particular, shoreline areas inhabited by underyearling Chinook salmon during their summer rearing and outmigration have increased. (ISG 2002)

The Program also seems to assume that river temperature is linked to volume of flow and water velocity. These are not necessarily linked. Thalweg temperature (the temperature of most of the water volume) and its timing are affected by water storage and release schedules.

Localized temperatures and their cumulative effects on thalweg temperatures are affected by reservoir topography more than by river flow rates. (ISG 2000)

During the summer, water temperatures within the Lower Snake reservoir system have a 1 to 2°C smaller day and night temperature fluctuation than upstream inflow to the Lower Granite reservoir. Daily temperature fluctuations in this reach range from roughly 0.5 to 1.5°C in the upstream reach to day and night temperature fluctuations below the reservoir system of approximately 0.4 to 1.0°C (0.7 to 1.8°F). In addition, temperatures at any point within the lower Snake River reservoir system are typically zero to 2°C warmer or cooler than the Snake River water flowing into the reservoir system at the Lower Granite reservoir depending on the time of year, location, flow conditions, current flow augmentation and temperature control operations, and voluntary spill/power operations (Corps 2002).

Average water temperatures within the reservoir system warm slower by approximately 1 week and cool slower by approximately 2 weeks than the Snake River water flowing into the Lower Granite reservoir. Flow augmentation with cold water from the Dworshak reservoir on the North Fork Clearwater River is effective in reducing water temperatures in the Lower Granite reservoir. (Corps 2002)

F-4 Climate Changes

Peery et al 2002 used recently collected and historic data to evaluate effects of warm water conditions on passage of adult salmon and steelhead in the lower Snake River, especially in relation to temperature exposures in fishways. They reported, “temperatures in the forebay of Ice Harbor Dam have trended upwards in the fall (September and October) since 1962, which can be explained at least partially by an increase in air temperatures during August and September in the region since 1948.”

In addition, Petersen and Kitchell (2001) reported in great detail, “large-scale climate oscillations, or regime shifts, have likely caused water temperature in the Columbia River to vary several degrees between 1933 and 1996” and “average June July temperatures in the Columbia River during 1954-1990 were significantly correlated with temperatures in the Fraser River in British Columbia. Since the Fraser River has not had extensive hydro development, this correlation suggests regional temperature control…” They also reported “an index for the Columbia Basin suggested that climate shifts occurred in 1946, 1958, 1969, and 1977”. They also reported, “Beginning about 1975, summer water temperatures have risen steadily, suggesting broad scale climate effects, since all dams were operational by the early 1970s…”

F-5 Upstream Influences

Numerous upstream activities are believed to have influenced water temperatures in the Columbia River basin. These include the construction and operation of upstream dams, point source returns, agriculture practices, forestry practices and urban development. Although some of these contributions may be small, the cumulative effects of these temperatures all contribute to overall river temperature at the mouth. For example, in a 1971 EPA study, “temperatures of the Columbia River in Canada will be affected by the regulation of Mica and Arrow lake dams on the Mainstem Columbia… ” (EPA 1971) Although the extent of the impacts to mainstem Columbia temperatures in the U.S. are uncertain, the Corps believes that there may have been some substantial impacts. For example, Anglin et al 1999 reported that the hydrograph of the Columbia River at the Priest Rapids Gage was not significantly altered until after the completion of the Canadian hydrosystem. The Corps believes that this has had an affect on temperatures as well. From the Rock Island Scrollcase data for the same periods, temperature differences can be seen.

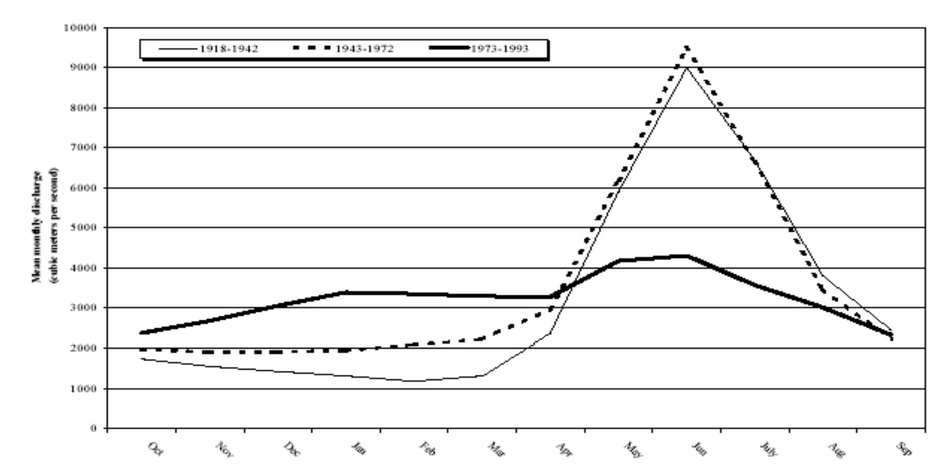

Figure 2. Columbia River Hydrograph as measured at Priest Rapids Gage. Time periods designate pre-Grand Coulee, Grand Coulee to Mica Dam, and post Mica Dam.

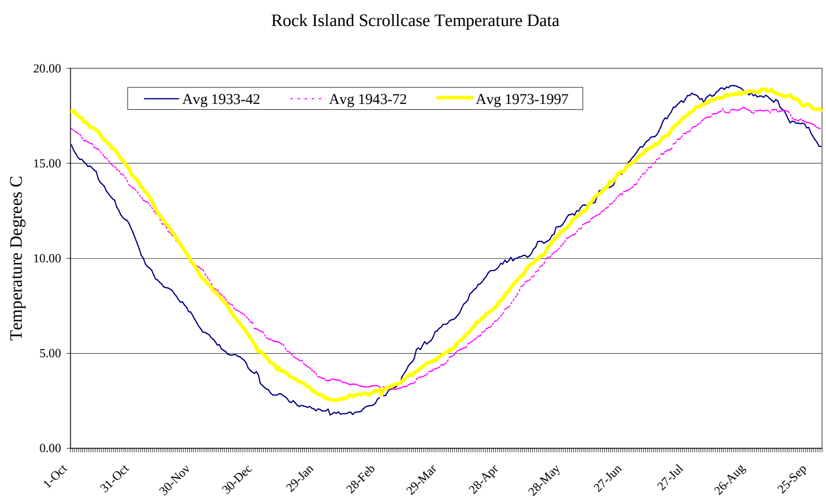

Figure 3. Columbia River average daily temperature as measured at Rock Island Dam scrollcase. Time periods designate pre-Grand Coulee, Grand Coulee to Mica Dam, and post Mica Dam completion.

APPENDIX G – Suggested Changes for 2004 Document

Dave Zimmer – May 30, 2003

If Paul makes more changes to the WQ Plan, we would like to have action item M-5b measure changed to read "Determine feasibility of penstock selective withdrawal at Grand Coulee." Thanks, Dave Z

Dave Ponganis – May 19, 2003

I followed up with Paul to see if we could do something to the table on TDG action to help organize it like we have for the temperature actions. App B has the TDG actions already w/o any numbering and different headings. Paul and I believe the TDG actions are more defined than the temperature ones and we're not sure we want to use the same headings for both temperature and TDG. Paul has proposed the following (see attached file). The hard part would be to fill out the issues/concerns. One option would be to fill that in over the next year for next year's update. Let me know what you think, and then we can see if I can get some dollars to get it done. Dave

Action Item #	Type Of Measure	Project Location	TDG Measures	Major Issues or Concerns	Lead Agency	Status/ Year(s)	TMDL IP Phase	NMFS 2000 FCRPS RPA
Clearwater 1	Study	Dworshak	Identify potential methods of reducing production of TDG.		Corps	2004 Funds Requested		139
Clearwater 2	Physical	Dworshak	Modifications as recommended by TDG study. Modifications may include spillway modifications, Turbine Installation etc.		Corps	TBD based on 2004 Study		139
Clearwater 3	Physical	Dworshak	Spillway Modifications		Corps	TBD		139
Clearwater 4	Physical	Dworshak	Turbine Installation		Corps	TBD		139
Clearwater 5	Study	Dworshak	Hydrologic Analysis		Corps	TBD		139
Clearwater 6	Study	Dworshak	Model Construction		Corps	TBD		139

Kent Easthouse – December 5, 2003

Significant updates were provided to section 5.3 including updates to sections 5.3.1 and 5.3.2, addition of 5.3.2.1 through 5.3.2.5, and changes in dates for lines 1, 5 and 6 in Table 5-1. In addition, appendix table B-3 was updated.

Rock Peters – December 6, 2003

Suggested Changes:	Table B-2	Systemwide 7	Regarding head burn, change end date to 2004
	Table B-7	L Columbia 17	change dates to 2000-2004
	Table B-7	L Columbia 22	change to spill wall and 2004 date.
	Table B-7	L Columbia 23	Change date to ongoing
	Table B-7	L Columbia 24	To be determined for the date

Table B-7	L Columbia 31	On Hold for the date
Table B-7	L Columbia 35	2005 decision
Table B-7	L Columbia 39	change measure to “if needed” and TBD for date
Table B-7	L Columbia 41	add in a measure for Bonneville decision document
Table B-7	L Columbia 42	add in a measure for The Dalles decision document
Table B-7	L Columbia 43	add in a measure for John Day decision document

Mark Smith – December 6, 2003

Table B-7	L Columbia 3	Change in Status/Year
Table B-7	L Columbia 4	Change in Status/Year
Table B-7	L Columbia 5	Change in Status/Year
Table B-7	L Columbia 6	Change in Status/Year
Table B-7	L Columbia 7	Change in Status/Year
Table B-7	L Columbia 8	Change in Status/Year
Table B-7	L Columbia 9	Change in Status/Year
Table B-7	L Columbia 11	Change in Status/Year
Table B-7	L Columbia 12	Change in Status/Year
Table B-6	L Snake 24	Change in Status/Year
Table B-6	L Snake 25	Change in Status/Year
Table B-6	L Snake 26	Change in Status/Year
Table B-6	L Snake 28	Change in Status/Year
Table B-6	L Snake 29	Change in Status/Year
Table B-6	L Snake 30	Change in Status/Year
Table B-6	L Snake 39	Change in Status/Year

John Kranda – December 8, 2003

Changes to Section 5.8.4, updates to reflect new information

Randy Chong – December 11, 2003

The entire last half of Section 2.5 was revised to reflect the events of 2003.
Updated section 5.6.1 to reflect status
Updated section 5.6.2 to reflect status
Updated section 5.8.1 to reflect status

Update section 15.3.5 to reflect new planning measures

Table B-5	Clearwater 1	Change in Status/Year
Table B-5	Clearwater 2	Change in Status/Year
Table B-6	L Snake 2	Change in Status/Year
Table B-6	L Snake 3	Change in Status/Year
Table B-6	L Snake 4	Change in Status/Year
Table B-6	L Snake 5	Change in Status/Year
Table B-6	L Snake 6	Change in Status/Year
Table B-6	L Snake 7	Change in Status/Year
Table B-6	L Snake 11	Change in Status/Year
Table B-6	L Snake 12	Change in Status/Year
Table B-6	L Snake 13	Change in Status/Year
Table B-6	L Snake 14	Change in Status/Year
Table B-6	L Snake 15	Change in Status/Year
Table B-6	L Snake 16	Change in Status/Year
Table B-6	L Snake 17	Change in Status/Year
Table B-6	L Snake 25	Change in Status/Year
Table B-6	L Snake 26	Change in Status/Year

Table B-6	L Snake 28	Change in Status/Year
Table B-7	L Columbia 2	Change in Status/Year
Table B-7	L Columbia 6	Change in Status/Year
Table B-7	L Columbia 7	Change in Status/Year
Table B-7	L Columbia 8	Change in Status/Year
Table B-7	L Columbia 9	Change in Status/Year
Table B-7	L Columbia 11	Change in Status/Year
Table B-7	L Columbia 12	Change in Status/Year

Paul Ocker - December 11, 2003

Revised Appendix A to reflect 2003 Water Management Plan.
Replaced tables in main body of text with appendix tables for better continuity.
Reformatted Table of Contents

Tim Wik – December 11,2003

Table B-6	L Snake 7	Change in Status/Year
Table B-6	L Snake 8	Change in Status/Year
Table B-6	L Snake 20	Change in Status/Year
Table B-6	L Snake 31	Change in Status/Year
Table B-6	L Snake 38	Change in Status/Year