Commissioners:
MICHAEL DONEEN
T. JAMES DAVIS
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Chief Executive Officer/Manager:
WILLIAM C. DOBBINS

Public Utility District No.1 of Douglas County

1151 Valley Mall Parkway • East Wenatchee, Washington 98802-4497 • 509/884-7191 • FAX 509/884-0553

April 27, 2000

Mr. David P. Boergers
Federal Energy Regulatory Commission
888 1st Street N.E.
Washington, D. C. 20426

Subject: Wells Hydroelectric Project - FERC No. 2149 WA
Annual Report - Fish Settlement Agreement

Dear Mr. Boergers:

In accordance with paragraph E of the order approving the Settlement Agreement issued January 24, 1991, Public Utility District No. 1 of Douglas County submits the enclosed annual report of activities related to this Settlement Agreement. A copy of the January 24, 1991 order is enclosed for your reference.

As directed by the order, the annual report addresses activities during the previous year. This annual report covers activities performed in 1999 and those planned for 2000.

Very truly yours,

Robert W. Clubb, Ph.D.
Chief of Environmental & Regulatory Services

nvh

Enclosures

c: (with report, but not appendices)

Mr. Ron Boyce
Mr. Tim Brewer
Mr. Brian Cates
Mr. Robert Dach
Mr. Mike Erho
Mr. Cary Feldmann
Mr. William Frymire
Mr. Harry Hall
Mr. Stuart Hammond
Mr. James Hastreiter
Mr. Robert Heinith
Mr. Garfield Jeffers
Mr. Brett Joseph
Mr. Jerry Marco
Mr. Richard Nason
Mr. Mark Quehrn
Mr. Nolan Shishiolo
Mr. Tim Weaver
Mr. Rod Woodin
Mr. Ron Wright

DOC # 34303

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Before Commissioners: Martin L. Allday, Chairman;
Charles A. Trabandt, Elizabeth Anne Moler,
Jerry J. Langdon and Branko Terzic.

Public Utility District No. 1 of Douglas County, Washington	))	Project No. 2149-002 Docket No. E-9569-002

ORDER APPROVING SETTLEMENT AGREEMENT

(Issued January 24, 1991)

This is the most recent of a series of settlement agreements that have emerged from our consolidated proceeding on anadromous fish issues on the mid-Columbia River in Washington State. Before us today is a comprehensive, uncontested, long-term settlement of such issues arising out of the operation of Wells Project No. 2149, located in Douglas and Okanogan Counties, Washington. We will approve the settlement, with clarifications and conditions that are consistent with our approval of related recent settlements.

BACKGROUND

In 1979, the Commission consolidated and set for hearing in Docket No. E-9569 a set of related petitions seeking modification of the operation of five licensed projects on the mid-Columbia River to protect and enhance salmon and steelhead trout. 1/ The petitions were filed by various state and federal fishery agencies and Indian tribes, and sought to protect anadromous fish migration downstream through project facilities. Wells Project No. 2149 was one of the five projects. The proceeding has generated a series of interim and long-term settlements. Most recently, the Commission approved long-term settlements resolving the Vernita Bar Phase (Priest Rapids Dam) of the proceeding, 2/ and issues involving Rock Island Project No. 943-002 (Chelan County). 3/ We also have had occasion to approve a settlement of fishery issues in Project No. 2149-017, a related proceeding

1/ 6 FERC ¶ 61,210 (1979).

2/ 45 FERC ¶ 61,401 (1988).

3/ 46 FERC ¶ 61,011 (1989).

involving the raising of the surface elevation of the reservoir. 4/

On October 30, 1990, the parties in the above-captioned proceeding filed an offer of settlement with the presiding administrative law judge. On November 19, 1990, the Commission's trial staff filed comments in support of the settlement. On December 4, 1990, the presiding administrative law judge certified the settlement and the staff's comments to the Commission for decision.

The parties to the settlement are Public Utility District No. 1 of Douglas County, Washington (the PUD); Puget Sound Power & Light Company, Pacific Power and Light Company, the Washington Water Power Company, and Portland General Electric Company (collectively, the Power Purchasers); and the Washington Department of Fisheries, the Washington Department of Wildlife, the Oregon Department of Fish and Wildlife, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, the Confederated Tribes and Bands of the Yakima Indian Nation, the Confederated Tribes of the Umatilla Indian Reservation, and the Confederated Tribes of the Colville Reservation (collectively, the Joint Fishery Parties).

As summarized by the trial staff in its comments, the settlement agreement provides for the following.

The agreement has a term from its execution date to the expiration of the license (2012) plus any annual licenses. During that time, the agreement is intended to satisfy the PUD's obligations under Article 41 of the license. The agreement is not subject to modification prior to March 1, 2004. There are procedures (discussed, in part, below) for the resolution of disputes.

The PUD has agreed to provide juvenile and adult fish passage and a hatchery program. The juvenile fish passage system will be a program of controlled spills using five bypass baffles. The agreement specifies criteria for the operation, timing, and performance of the bypass system. The adult passage system will use the existing fish ladder. Criteria are established for water depth over the weirs, entrance gate settings, and jet and trashrack operations.

The PUD's hatchery program is designed to mitigate fish passage losses at the Wells Project. The physical structures include adult collection sites, a central hatchery facility and acclimation facilities. The amount of compensation is to be

4/ 30 FERC ¶ 61,285 (1985).

Report to the Federal Energy Regulatory Commission for activities under the Long-Term Settlement Agreement between Fisheries Agencies and Tribes and Public Utility District No. 1 of Douglas County, Washington for the 1999 Calendar Year

WELLS HYDROELECTRIC PROJECT

F.E.R.C. PROJECT NO. 2149

Public Utility District No. 1 of
Douglas County, Washington
1151 Valley Mall Parkway
East Wenatchee, Washington 98802-4497

April, 2000

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Foreword

On January 24, 1991, the Federal Energy Regulatory Commission approved a Settlement Agreement to resolve anadromous fish issues for the Wells Hydroelectric Project on the Columbia River in Washington State. The Agreement was a product of negotiations with state and federal fisheries agencies and tribes on the operations of the Wells Project (No. 2149). The F.E.R.C. directed that the licensee of the Wells Project has certain reporting responsibilities. This document is intended to fulfill portion (E)(d) of the Order requiring an annual report to be filed by April 30. This is the tenth annual report under the Agreement and will cover the period between January 1 to December 31, 1999.

Report to
the Federal Energy Regulatory Commission
of activities under the Long-Term Settlement Agreement
between Fisheries Agencies and Tribes
and Public Utility District No. 1
of Douglas County
for the 1999 calendar year

(1) Development of Studies, Plans and Evaluations

The Public Utility District No. 1 of Douglas County (District) worked closely with fisheries agencies and tribes to carry out various studies and obligations specified in the Settlement Agreement. These included various monitoring studies and operation plans.

1.1 Annual Bypass System Operations Plan for 1999

The Settlement Agreement calls for the District to provide an Annual Bypass System Operational Plan to members of the Wells Coordinating Committee (WCC) by December each year. The District submitted the 1999 plan on November 20, 1998 to the WCC for review. The spring and summer migrations of juvenile salmonids in the Columbia River are monitored by hydroacoustics along with in-turbine fyke netting at Wells Dam. There was concern how hydroacoustic information would be used beyond the "real time" detection's that indicate the presence or absence of fish (99-2). Rick Klinge (District) explained that while other technologies may provide a greater amount of information, the dual beam technology was adequate for the start and suspension of bypass operations at Wells.

The Bypass Team decides on bypass operations at Wells during both spring and summer migration periods. Representatives from the agencies, tribes and District make up the team (Agreement II.F.3). Brian Cates (US Fish and Wildlife Service; USFWS), Jerry Marco (Colville Confederated Tribes; CCT) and Rick Klinge for the District (99-2) were the 1999 Bypass Team members.

1.2 Project Survival Study

The Settlement Agreement specified that the District, in consultation with the Joint Fisheries Parties (JFP), will develop a study of juvenile mortality associated with Wells Dam by 1990 (Agreement IV,C,5). Results from this work would adjust compensation levels of the hatchery programs. The WCC opted not to pursue this study until 1998. A survival study was agreed to and was conducted in 1998 to test the single release methodology in the mid-Columbia and verify assumptions on recovery rates at Rocky Reach, McNary and John Day dams. The study showed this tool was valid for determining survival estimates. For 1999, an additional study was planned using hatchery steelhead (99-1). There would be 60,000 PIT tagged steelhead released between the forebay and tailwater areas. Additionally there was a PIT tag /radio tag comparison release in the Okanagan River. A Section 10 Permit for handling a listed Endangered Species was issued. PIT tag detection system was installed at Rocky Reach Dam (99-2).

It was recommended that a Survival Workshop be scheduled to review the 1999 data as soon after the field season as possible (99-5). Data from 1999 would be in the hand of the WCC two weeks before the meeting scheduled for October 7 (99-6).

Shane Bickford (District) passed out a draft study plan for a survival study in 2000 for review (99-7). The plan called for yearling steelhead to be released from Pateros and the tailrace. Bickford said he

would like to add the Okanogan portion of the Wells survival in for 2001. There was some discussion how production and research fish would be handled over the up coming years. The study plan was modified and resubmitted at the November meeting (99-9). The modified plan had an extended study period. Also a comparison of survival between species will be part of the 2001 study (99-9). The WCC supported the 2000 study plan (99-9; See Appendix A). By December, many of the needed contracts for the 2000 study were in place (99-10).

There were questions about a repeat of the 2001 yearling chinook study in 2002 with steelhead (99-9). The District believes the HCP requires a total of three years of survival studies, not three years of survival studies for each species, potentially fifteen years of studies. Some members of the WCC were under the impression three years per species was what had been agreed to (99-9).

1.3 Radio Telemetry Study for 1999

Pursuant to a request from National Marine Fisheries Service (NMFS), the mid-Columbia PUD's planned an adult steelhead radio tag study for 1999. Steelhead would be collected at the Priest Rapids Dam tap and tagged. Washington Department of Fish and Wildlife (WDFW) would perform the tagging and would amend their existing Section 10 for sampling the summer steelhead run at large at Priest Rapids Dam. There was discussion about liability of the study and appropriate entity for the Section 10 Permit (99-1). Questions of tributary monitoring, trap modifications and protocol for handling fish during times of high temperatures were discussed (99-1). Other concerns included telemetry surveys on spawning grounds, additional detection gear in problem areas at dams and collection of various flow data around problem points in ladders (99-2). The issue of radio tags affecting egg viability would be assessed at Wells Hatchery (99-2). It was agreed that tributary surveys would be done by aerial surveys after November.

The proposed study would tag 400 adult steelhead at Priest Rapids Dam with monitoring at Wanapum, Rock Island, Rocky Reach and Wells to collect passage information. In addition steelhead would be tracked to the spawning grounds by means of aerial surveys. A plan for monitoring passage at Wells Dam was identical to sockeye and chinook plans in previous years (99-4). Passage would be monitored as side gates to both ladders were opened and closed.

1.4 Interim Protection Plan

The District developed an Interim Protection Plan (IPP) for the Wells Project until the Habitat Conservation Plan could be finalized (99-1). NMFS contended to develop a Biological Opinion (BO) for steelhead to evaluate the IPP. By July, NMFS Washington DC staff was reviewing the draft BO (99-5) and by August it was distributed to the PUD's for comment (99-6). The draft BO was still being worked on at the end of the year.

1.5 Okanagan Sockeye Habitat Study

The District initiated a cooperative effort with the fisheries parties in British Columbia to study improvements to habitat in the Okanagan drainage. The project was envisioned to replace the sockeye mitigation obligation from the Cassimer Bar Experimental Hatchery to a location where supplementation of the natural population could occur. The WCC supported this investigation in 1998 (99-1). The District entered into a contract with British Columbia Conservation Foundation (BCCF) to review measures that would benefit Okanagan sockeye as well as find the support by Canadian agencies. The WCC spent a day reviewing options that might be acceptable with the Canadian fisheries managers. Chris Bull, on contract with BCCF, provided a review of potential habitat improvements that would provide an increase in

sockeye production (99-2). Measures included restoration of old stream channels, spawning channel development, and development of spring fed side channels. Other topics like water rights, organic loading, and the caring capacity of the system were discussed. Byron Louis with the Okanagan Nation Fisheries Commission provided information on Federal court cases in Canada that supported fishery and management rights of the First Nations. The WCC believed that the Okanagan Basin Technical Working Group[1] (OBTWG) could provide guidance for sockeye mitigative measures. The OBTWG felt this could be as early as May (99-2).

Phase I of the project prepared a draft report that outlined 18 options for improving fish habitat that would increase the sockeye population. From a Phase 1 report, a second document (Phase 2 draft; Appendix B) was developed that went into greater detail how measures would be implemented. This document would be the basis for recommendations to the District and the WCC on actions the Canadians would support to help improve conditions for sockeye. A meeting was schedule soon into the New Year for review of these options.

There was discussion how the District would shift its sockeye responsibility into Canada and if the compensation would be handled under the Long-Term Settlement Agreement or the Habitat Conservation Plan. Bob Heinith said that in addition to juveniles there is also a loss of adults as a result of the Wells Project (99-2).

The WCC met with the OBTWG and interested parties in October (99-8). Presentations outlined current agreements for mitigation on sockeye, the status of environmental conditions in the Okanagan basin and measures that might be considered. Measures that are being given consideration by the OBTWG are in the area of habitat restoration, spawning channel development, improvements in management of river flows, control of water temperatures, irrigation water screening, and tap and haul of adults around thermal problems (99-8). While the OBTWG represented several different philosophical approaches to fish management, the group is operating in unison. The meeting allowed for clarification of the position held by the WCC, improved coordination between parties on both side of the boarder, a need for a benefit analysis was identified and the endorsement of an ecosystem approach.

1.6 Okanogan Sockeye Pilot Program

Since 1991, there have been several strategies tried for replacing unavoidable losses of sockeye smolts at Wells Dam. Initially fingerling releases into the south basin of Osoyoos Lake. After some acclimation, yearling releases into the lower Okanogan River and pre-smolt releases in the fall of Osoyoos Lake. Adult sampling opportunities over many years have yielded very few records of fish from these efforts. Because of the lack of success of the program (adults on the spawning grounds with the natural population), options have been pursued in British Columbia in the proximity of the existing population.

The 1997 sockeye brood year (97BY) fish, released in the spring, suffered tremendous losses from bacterial kidney disease once their size exceeded 70 mm. Both U.S. and Canadian pathologists felt that it is a mistake to raise sockeye in a hatchery environment to a yearling size (99-4). After discussion about release and rearing strategies, it was agreed to place the 98BY and 99BY sockeye on a fall pre-smolt release scheduled for Osoyoos Lake (99-4).

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[1] Members of the OBWTG are Byron Louis and Howie Wright, Okanagan Nation Fisheries Commission; Kim Hyatt, Elmer Fast, Mike Flynn and Keith Bolton, Fisheries and Oceans; Ian McGreggor, Brian Symonds, Steve Mathews, British Columbia Ministry of Environment.

1.7 Spring Chinook Broodstock Collection Protocol

The WCC received a plan from WDFW to collect all spring chinook broodstock at Wells Dam in 1999 (99-3). Larry Brown (WDFW) believes the run would only produce 140 spring chinook at Wells. In 1996, it had been agreed by most of the joint fisheries parties that when the spring chinook return at Wells Dam was under 500 adults, the entire run would be intercepted. These fish would be held for broodstock at the Methow Hatchery and the Winthrop National Hatchery. Because of the low forecast, it was recommended that the entire adult run be collected at Wells (99-3).

There was discussion if the WCC wanted to collect spring chinook brood in tributaries in 2000 (99-7). The jack return in 1999 was greater in proportion to the entire run than normal. This would likely translate to a good adult year in 2000. Tributary traps have not been used for brood collection since 1993. The HCP specifies management of the Methow spring chinook as a composite population. The WCC felt there was no compelling reason to return to the tributary traps for spring chinook.

1.8 Dissolved Gas Monitoring

The District made improvements to the reporting procedures of TDG from both the forebay and tailwater at Wells. An automated system would provide data on the hour to the Corps of Engineers. Data in 1999 was collected at 15 minute intervals and archived for future analysis. TDG values are monitored from May through mid-September.

A study was proposed to look at how location of spill would affect TDG built at Wells (99-3). The plan provided a six week schedule to utilize forced spill events under 60 kcfs through a variety of locations and gate settings. WCC felt that because spill events were not regulated for duration or volume, the results would be hard to evaluate. The WCC requested a redraft with schedule spill events and volumes. There was no further development of a study plan for the year (99-4).

1.9 Quantitative Analytical Reports for mid-Columbia Projects

NMFS requested the participation of the mid-Columbia PUD's in a qualitative analytical report (QAR) to aid in the long-term assessment of the Habitat Conservation Plan. Several sub-groups were established (99-3,4). Stocks in each of the mid-Columbia tributaries would be modeled. Climate and environmental effects as well as treaty harvest would be part of the model in determining if recovery will occur (99-4).

1.10 7Q10 Guidelines

The Washington Department of Ecology prepared a series of draft guidelines for dams to meet dissolved gas standard of 115% in the tailwater when flows are under what is referred to as the 7Q10 flow. The quantity of discharge is derived from the peak daily average flow over seven consecutive days, in a ten year period. Flows in the Columbia are considered after the 1974 completion of the Canadian storage projects (99-5). The calculated 7Q10 value for Wells Dam is 262,000 cfs.

1.11 Housekeeping

The Okanagan Wilderness League had requested timely dissemination of minutes and meeting agenda so they might hear discussion on issues in the Methow River (99-6). There was discussion about

who might review minutes and timing on distribution of final version of the minutes. The WCC felt a two-week review of the minutes would be adequate.

1.12 2000 Bypass Operational Plan

The District submitted to the WCC a Bypass Operational Plan for 2000, as per Section II.F.1 of the Settlement Agreement on November 16, 1999. The plan outlined scheduled hatchery releases above Wells Dam and anticipated the starting and completion date of bypass operations (99-9; Appendix C).

(2) Results of Studies, Evaluations and Monitoring Efforts

2.1 Operation of the Juvenile Bypass

Hydroacoustic sampling was started on March 15 to help collect background index levels of activity prior to the spring migration. The juvenile bypass was initiated on April 8 in anticipation of the arrival of released hatchery fish from both the Methow and Winthrop Hatcheries. The juvenile bypass was operated for 79 days for the spring migration and 61 days for the summer migration (99-6). It was estimated the bypass operated during 98.2% of the juvenile migration (99-7). A total of 3.27 million acre feet (MAF) of water was used for operation of the bypass (Appendix D). The WCC requested that calculation of bypass operations during periods of forced spill (99-6). For Wells Dam, it was determined that forced spill occurred 9.1% of the hours the bypass operated in 1999.

2.2 Sockeye Pilot Program

Sockeye production from 1997 broodstock was being held in the Cassimer Bar Hatchery at the beginning of the calendar year (99-1). The fish were selected from parents that had a low propensity for BkD (ELISA testing). During the winter months of 1998-99, high losses to bacterial kidney disease occurred. There were 17,348 fish released into the lower mile of the Okanogan River in March at a size of 10 fpp.

The 98 brood year fish were released into Osoyoos Lake in October. It is estimated that 21,532 fish were liberated at 56 fpp.

Collection of 1999 brood sockeye started on July 12 at Wells Dam (99-5) with a season goal of 140 adults. By August this goal was met (99-6). Eggs were incubating at the Cassimer Bar Hatchery at the end of the year.

2.3 Dissolved Gas Monitoring

Flows in the Columbia River in the spring and summer of 1999 were at 113% of average at Grand Coulee Dam. Because of mild spring temperatures, the run off in the Columbia was much longer than normal and forced spill up stream of Wells Dam was kept to a minimum. Monitoring at Wells showed a range of hourly total dissolved gas of 103% to 115% in the forebay and 104% to 134% in the tailrace (Appendix E). The operation of the bypass had little to no effect on TDG build, even though 6.7% and 9.1% of the river was dedicated to bypass operations in the spring and summer respectively. Spill beyond bypass flow showed that there was approximately a 1% increase in tailwater TDG with every 4% of river that was spilled.

2.4 Spring Chinook Salmon Hatchery

The 1999 return of spring chinook adults was greater than the pre-season forecast and broodstock collection at Wells needed to be revised from 100% collection (99-4). On June 9, half way through the trapping period, WDFW proposed three trapping options for the remainder of broodstock collection. The committee decided to release 50 trapped adults back into the Methow and change the trapping schedule from seven days to three. By July, there were 291 adults collected (99-5). The 95 brood year showed surprising rates of returns (99-6). Large numbers of Entiat Hatchery adults were found in the broodstock that were collected at Wells Dam. While there was lengthy discussion on potential options, NMFS recommended that the eggs be destroyed unless some research program could be developed to utilize them. To allow these fish to naturally spawn in the Methow would be inconsistent with the HCP and ESA policies (99-6). The Twisp identified fish would continue to be managed as a separate population.

As part of the evaluation of the Methow Hatchery, spawning ground surveys were conducted to collect data on returning adults spawning in the wild. Surveys conducted in 1999 showed escapement into all major tributaries (99-7; see Appendix F).

2.5 Survival Study

A summary of results from 1999 were distributed by September (99-7). Survival from 15 replicates from Pateros to the tailrace had a weighted average survival of 0.943 ±2.1 (Appendix G).

2.6 1999 Steelhead Ladder Passage Study

In 1999, the mid-Columbia PUD's funded research to follow passage of steelhead adults from below Priest Rapids Dam through the mid-Columbia projects and into tributaries. Tagging started on July 13 and continued through August (99-5,6). By November, there had been 151 steelhead that had passed Wells Dam with tracking into the Methow and Okanogan Rivers (99-10). The median project passage time was 0.6 days (99-10).

2.7 1999 Pikeminnow removal program

Douglas PUD contracted to have Pikeminnow (*Ptychochelius oregonesis*), removed from the Wells tailrace and reservoir in 1999. Both long-line and sport gear were used. Between May 18 and October 9, there were 9,001 Pikeminnows over ten inches removed and 1,381 under ten inches removed (Appendix H). The tailrace area had the highest catch per unit of effort (CPUE 2.61) followed by the lower reservoir (2.54) and Okanogan River (1.93). The catch was comprised of 59% females. A total of 8,409 pounds of Pikeminnows were removed in 1999.

(3) Outline of Action Taken Toward Fulfillment of the Settlement Agreement

3.1 Methow Spring Chinook Facility

The Settlement Agreement calls for a hatchery based compensation program for spring chinook composed of adult collection sites; a central hatchery facility for incubation, early rearing, and adult holding, and acclimation facilities for final rearing (Agreement IV). During 1999, hatchery personnel reared and released progeny from adults that returned in 1997 and 1998.

The Settlement Agreement calls for evaluation of the hatchery program. Several aspects of the hatchery were evaluated. A final report was being finalized in the spring of 2000 for the 1997 evaluation.

3.2 Cassimer Bar Sockeye Hatchery

The Settlement Agreement calls for a pilot effort to culture Okanogan sockeye for three years at 8,000 pounds of production (IV.A.3.(a)(2)) with an evaluation to gauge the success of the program. Brood have been collected since 1993 at Wells Dam. Information on culture of sockeye at the Cassimer Bar facility was collected by the CCT.

3.3 Contract for Professional Services in Implementing the Settlement Agreement.

During 1999, the District contracted with Mike Erho to serve as Studies Coordinator for the Wells Coordinating Committee. Mr. Erho also serves as coordinator for the Mid-Columbia Coordinating Committee and Rock Island Coordinating Committee. The District also contracted with Dr. Skalski to provide statistical evaluation of methods and studies.

3.4 Juvenile and Adult Fish Passage Operations at Wells Dam

During 1999, the juvenile bypass system operated as per conditions outlined in the Settlement Agreement (II,C,D,and F). The bypass team recommended operations based upon information from hydroacoustics and fyke net samples at Wells.

The ladders operated during the year at the criteria established by the fisheries agencies and tribes (Agreement III. B; C; D; E; F). Annual maintenance was performed to both ladders outside of the fish passage times.

3.5 Steelhead Production at Wells Hatchery

The Settlement Agreement specified that the District will fund additional steelhead compensation of 30,000 pounds at 6 fish per pound after 1991 (IV.3.a), bringing the total obligation to 80,000 pounds. Records from the Wells Hatchery show that 493,026 steelhead or 74,908 pounds were liberated in 1999.

3.6 Other Actions Toward Fulfillment of the Settlement Agreement

The District funded evaluations and studies that are part of the District's responsibility in the Settlement Agreement. These were described in Sections 2 and 3.

(4) Explanation of Alternatives Chosen

4.1 Sockeye Pilot Program

The District worked with the WCC and OBTWG to move the sockeye mitigation program currently at Cassimer Bar to British Columbia. The District believes that the highest probability of success to mitigate for unavoidable sockeye losses at Wells Dam lay with measures as close to the spawning area as possible. Two workshops were scheduled in 1999 to specifically deal with this issue. A draft report was prepared for how potential habitat improvements might assist in rebuilding the Okanogan sockeye population.

(5) Chronology of compliance for 1999

Items (3) and (4) above contain chronology of compliance in 1999. Documentation that the Joint Fisheries Parties were consulted prior to implementation of changes is provided in the minutes of the Wells Coordinating Committee. These records are included as Appendix J .

(6) Schedule of Activities for 2000

The following schedule of activities is planned for 2000

Dec. (99)	Develop Annual Bypass System Operation Plan between District, Agencies and Tribes
January	Meeting with District, Agencies and Tribes on adult passage concerns
March 1	Annual Bypass System Operation Plan finalized
March 1	Determine Bypass Team members for bypass season
March 1	Develop Annual Passage Monitoring Plan between District, Agencies and Tribes
March 15	Begin monitoring juvenile migration via hydroacoustics
April 1	Bypass barriers in place
April 10	Start of Project Survival Study
April 15	Anticipated start of the juvenile migration
May 1	Start collecting spring chinook broodstock at Wells Dam
July 1	Start collecting sockeye broodstock at Wells Dam
October	Production Plan annual review between District, Agencies and Tribes
November	Pre-draft Results from 2000 survival study
November	Planning for 2001 survival study
on going	Planning sockeye mitigative strategies
on going	Planning for operations and protocols of the Methow River Spring Chinook Facilities

(7) Minutes of Meetings

7.1 Minutes of the Wells Coordinating Committee for 1999

The Wells Project was removed from the mid-Columbia proceedings on January 24, 1991 as the Settlement Agreement between the fisheries agencies and tribes was approved by F.E.R.C. Minutes from the meetings of the WCC for 1999 are attached as Appendix I.

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Dissolved Gas Monitoring at Wells Dam Forebay and Tailrace, 1999

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Project Survival Estimate for Yearling Summer Steelhead Migrating through the Wells Hydroelectric Facility, 1999

Appendix H
1999 Public Utility District No. 1 of Douglas County Northern Pikeminnow Removal and Research Program

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Minutes of the Wells Coordinating Committee for 1999

Appendix J
1999 Membership List of the Wells Coordinating Committee

Appendix K
The Long Term Settlement Agreement for the Wells Hydroelectric Project

Appendix J

1999 Membership list of the Wells Coordinating Committee

Ron Boyce
Oregon Department of Fish and Wildlife

Mike Erho
Wells Coordinating Committee Chairman

Cary Feldmann
Power Purchasers

Bob Heinith
Umatilla Tribes

Bob Dach
National Marine Fisheries Service

Rick Klinge
Douglas County P.U.D.

Jerry Marco
Colville Confederated Tribes

Paul Ward
Yakama Indian Nation

Brian Cates
U.S. Fish and Wildlife Service

Rod Woodin
Washington Department of Fish and Wildlife

PROJECT SURVIVAL STUDY PLAN FOR WELLS DAM, 2000

APPENDIX A

WELLS DAM STEELHEAD SURVIVAL STUDY 2000

STUDY PROPOSAL

Submitted: September 20, 1999

Modified: November 5, 1999

Shane Bickford
Fisheries Biologist
Public Utility District No. 1 of Douglas County

INTRODUCTION

The 1990 Wells Settlement Agreement and the proposed Wells Habitat Conservation Plan both require the Public Utility District No. 1 of Douglas County to conduct juvenile survival studies at the Wells Hydroelectric Project. The results of these studies will guide the implementation of future mitigative strategies for juvenile salmonids migrating through the Wells Project. The proposed Wells HCP agreement requires three years of survival studies to be conducted in order to determine the survival of plan species.

Results from the 1998 Wells survival study indicated that yearling hatchery chinook migrating from the mouth of the Methow River (Pateros) through and to 1,000 feet below Wells Dam averaged 0.997 ($\hat{SE}$= 0.015) in 1998 (Bickford et al., 1999a). A similar PIT-tag survival study was conducted in 1999 with yearling summer steelhead. The primary objective of the 1999 survival study was to estimate the relative survival of yearling steelhead smolts migrating from the mouth of the Methow River through and to 1,000 feet below Wells Dam. Steelhead survival averaged 0.943 ($\hat{SE}$= 0.016) in 1999 (Bickford et al., 1999b *Draft*).

The second objective of the 1999 survival study was to evaluate the feasibility of conducting paired PIT-tag survival studies in the Okanogan River. Problems encountered during 1999 included significant difficulty in handling and transporting fish to the Okanogan release site without incurring higher rates of pre-release stress relative to the Pateros and tailrace release groups. Sources of additional stress included longer transportation distances, different barge loading techniques and modified release protocols. Future survival studies in the Okanogan River will need to reduce these sources of bias. Particular issues to be addressed include improving river access, reducing pre-release stress, streamlining loading techniques and developing on-site acclimation prior to release. Additional challenges include modifying the existing transportation and release techniques at Pateros and in the tailrace to match those to be developed for the Okanogan River. This would include the development of on-site acclimation at all three release sites (Okanogan, Pateros and tailrace).

Unfortunately, construction of on-site acclimation sites at all three release locations cannot be competed in time for the survival study scheduled for 2000. Until on-site acclimation facilities can be established, the District proposes to study summer steelhead survival from the Methow River through and to the tailrace of Wells Dam. Estimates of survival generated from Pateros to the tailrace represent survival through the lower reservoir, forebay, Wells Dam and Wells tailrace for 100% of the naturally produced steelhead smolts and 85% of the composite (hatchery and natural) steelhead smolts passing Wells Dam. No weighting scenario is proposed for steelhead survival estimates generated from survival studies conducted in 2000.

Following the development of on-site acclimation in the summer of 2000, the District proposes to conduct a yearling chinook survival study in 2001. If the survival estimates from this study are sufficiently precise, the resultant survival estimates would be weighted at 75% Pateros/tailrace and 25% Okanogan/Pateros/Tailrace.

METHODS

Estimation Methodology

Survival estimates generated for the 2000 juvenile survival study will be based upon the single and paired single release-recapture model (Cormack, 1964; Jolly, 1965; Seber, 1965; Burnham et al., 1987). This particular release-recapture methodology has been successfully used to estimate project specific survival for juvenile chinook and steelhead passing through Snake and Mid-Columbia river dams. Chinook and steelhead survival studies based upon the Single release-recapture model were successfully implemented at the Wells Dam during the 1998 and 1999 spring outmigration (Bickford et al., 1999a; Bickford et al., 1999b *Draft*).

Collection, tagging, handling and release methodologies employed during the 2000 survival study will be identical to techniques utilized during the 1998 and 1999 survival studies. Steelhead smolts intended for tagging will be collected as they volitionally exit the earthen rearing ponds at the Wells Fish Hatchery. Collection efforts are anticipated to commence on April 20, 2000. Tagging will commence on April 24, 2000. Tagged fish will be released starting on April 26, 2000 and will be continue until at least May 14, 2000 (10 replicates). If additional steelhead continue to volitionally emigrate from the hatchery rearing ponds, the 2000 survival study will continue to mark and release fish until May 26, 2000 (15 replicates).

Precision Objectives

The primary objective of the 2000 survival study will be to estimate the survival of summer steelhead passing from the mouth of the Methow River to below Wells Dam at the specified precision level ± 0.05, 95% of the time (ie., $\varepsilon = 0.05$, $\alpha = 0.05$).

Sample Size

To accommodate the needs for this study, additional hatchery summer steelhead production was provided to compensate for the lost productivity associated with handling, tagging and release locations. These additional fish are being reared at the Wells Fish Hatchery. Goals of this study include the collection, tagging and release of at least 20,200 steelhead smolts at Pateros and 20,200 steelhead smolts in the Wells tailrace. Depending upon fish availability beyond May 14, 2000, up to 10,100 additional steelhead will be releases at each of the two release sites. At the Pateros and Wells tailrace release sites 10-15 replicate releases of PIT-tagged fish will take place. The study plan calls for a replicate release of fish at the primary release sites every other day until at least 10 replicates and as many as 15 replicate releases have been completed.

Study Animals

Yearling summer steelhead raised at the Wells Fish Hatchery (WFH) are the preferred stock for this study. Steelhead used for this study need to be representative of normal sized steelhead smolts. Steelhead less than 160 mm in fork length will not be tagged for use in the 2000 survival study to ensure that only migratory steelhead (smolts) are tagged. Steelhead smolts will be collected from the steelhead production at large as they volitionally exit the earthen rearing ponds at the WFH.

Tagging

Study animals will be PIT-tagged at the WFH facility. Tagging will take place in a manner similar to Bickford et al. (1999) and Prentice et al. (1987). ISO 134 kHz PIT-tags will be the utilized during the 2000 survival investigation.

Release Strategies

PIT-tagged fish will be released approximately 36 hours after being PIT-tagged at the Wells Fish Hatchery. Release sites and sample sizes for the proposed 2000 survival study can be found in Figure 1 and 2. The Methow and Wells tailrace release groups are referred to as the treatment and control (T & C) release groups, respectively. The treatment and control release groups will consist of 2,020 fish per replicate and between 10-15 replicates. The maximum number of steelhead released for the development of survival estimates through Wells Dam is 60,600 fish. To allow PIT-tagged fish to travel together through Wells Dam, the Pateros releases will occur 4-6 hours before the tailrace release group. Similar release strategies in 1998 and 1999 have resulted in almost identical passage distribution and timing at downstream dams.

Preliminary, release site and sample size information for a 2001 chinook survival study can be found in Figure 3.

SUMMARY

The 1990 Settlement Agreement and the proposed Wells HCP require Douglas County PUD to conduct survival studies on juvenile salmonid migrants passing through the Wells Hydroelectric Project. Results from survival studies in 1998 and 1999 indicate that PIT-tag survival studies are viable and accurate tools in assessing juvenile fish survival through Wells Dam. Hatchery steelhead migrants will be collected as they volitionally exit the earthen rearing ponds at the Wells Fish Hatchery. Tagging will take place at the Wells Fish Hatchery and fish will be released at one site above and one site below the dam. At least 40,400 and as many as 60,600 PIT-tagged steelhead will be released at two locations in order to estimate survival from Pateros to 1,000 feet below Wells.

Survival estimates generated from the 2000 steelhead survival study are expected to have a precision level of ± 0.05, 95% of the time (ie., $\varepsilon = 0.05$, $\alpha = 0.05$). Information related to the physiology and travel time of Wells Fish Hatchery steelhead will also be generated from this study.

The District's intent is to conduct a chinook survival study in 2001. The 2001 yearling chinook survival study will assess survival from Okanogan to Pateros and from Pateros to the Wells tailrace. On-site acclimation will be utilized to ensure that pre-release handling conditions are equalized for all three release locations proposed for study in 2001.

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Figure 1 : Steelhead release sites, 2000.
Minimum Sample Size = 40,400 fish

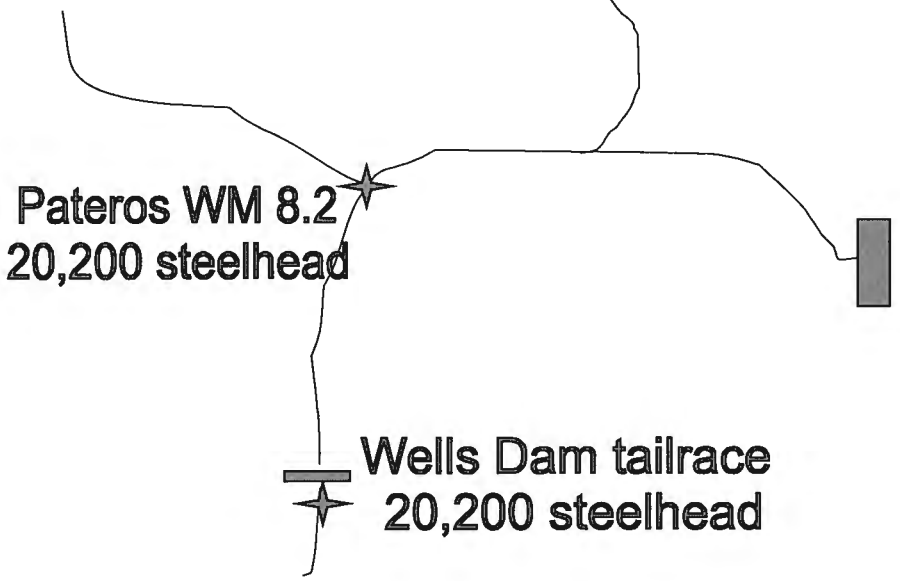


Figure 2 : Steelhead release sites, 2000.

Maximum Sample Size = 60,600 fish

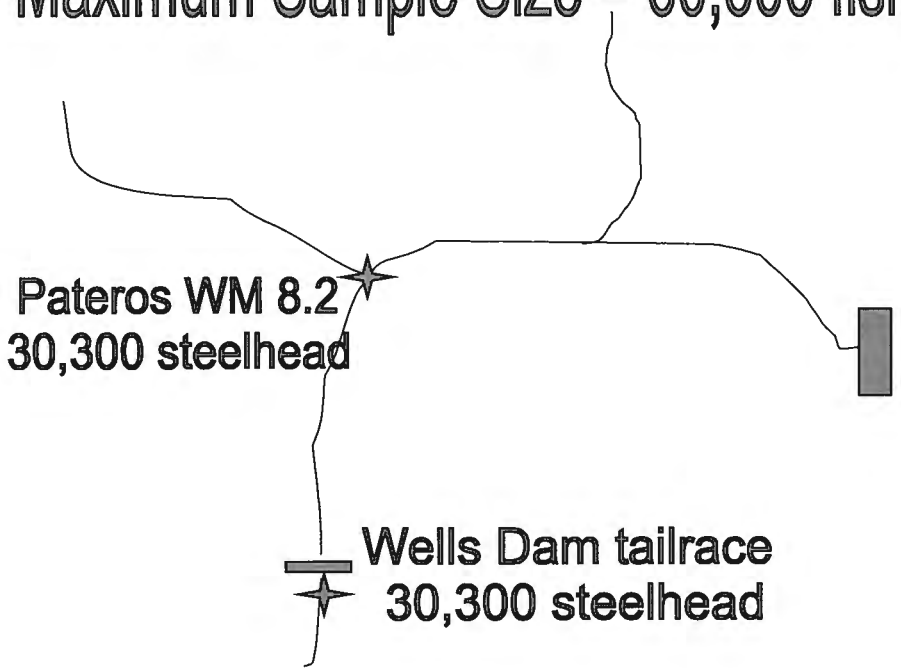
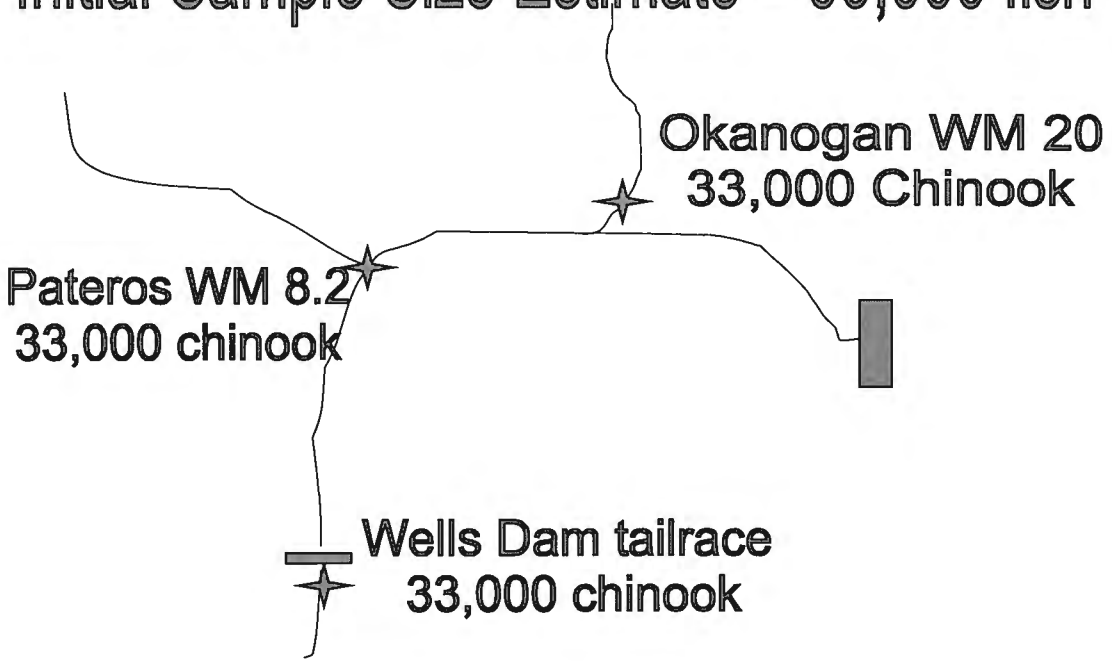


Figure 3 : Chinook release sites, 2001.

Initial Sample Size Estimate = 99,000 fish



FISHERIES HABITAT IN THE OKANAGAN RIVER; PHASE 2 DRAFT REPORT

APPENDIX B

GLENFIR RESOURCES

DRAFT

Fisheries Habitat in the Okanagan River

Phase 2:

Investigation of Selected Options

Prepared for

Public Utility District No. 1 of Douglas County, Washington

by

Chris Bull, R .P. Bio.

December, 1999

Managed and Administered by the British Columbia Conservation Foundation

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Preface

This is the second of two reports intended to facilitate discussions between parties interested in improving conditions for fish within the Okanagan River system. Both reports contain anecdotal as well as formally documented scientific information and are currently considered to be in draft form: therefore neither should be cited. They will remain in draft form for an indefinite period to accommodate suggestions for improvement.

The initial (Phase 1) report reviewed the factors limiting fish production, and presented 18 options for offsetting some of those limitations. At the completion of Phase 1, the Okanagan Basin Technical Working Group (OBTWG) selected the following for further investigation:

1. Trap and transport sockeye salmon to investigate losses during migration
2. Construct a hypolimnetic siphon from Skaha Lake
3. Recommend modified flow releases
4. Procure water licenses
5. Inventory water diversions and encourage screening
6. Construct spawning channel
7. Restore portions of the flood control channel to a more natural state
8. Revegetate streambanks

This phase 2 report organizes these options within 3 major goals and provides additional information which will help to determine which options should be implemented.

Acknowledgments

This project was funded by Public Utility District No. 1 of Douglas County Washington, and was initiated by Richard Klinge. It was managed by Blair Hammond of the British Columbia Conservation Foundation.

Information, ideas and scientific direction were contributed by members of the OBTWG including Byron Louis and Howie Wright of the Okanagan Nation Fisheries Commission; Bill Green of the Canadian Columbia Intertribal Fisheries Commission; Keith Bolton, Elmer Fast, Mike Flynn, Kim Hyatt, and Barry Rosenberger of the Canada Department of Fisheries and Oceans; Ian McGregor and Bruce Shepherd, of BC Ministry of Environment, Lands and Parks.

Additional contributors included Richard Klinge and Shane Bickford of Douglas County Public Utility District No. 1; Rich Townsend of the University of Washington; Doug Lofthouse, Ken Woo and Vic Ewart of Fisheries and Oceans Canada; Ray Jubb, Steve Matthews, and Brian Symonds of BC Ministry of Environment, Lands and Parks; Patrick Slaney of BC Watershed Restoration Program; Chief Clarence Louie, Roger Hall, and Ron Hall of the Osoyoos Indian Band; Ray Levesque of Oliver; Arvid Benzler of Town of Oliver; Robert Newbury of Newbury Hydraulics; and the members of the Wells Dam Coordinating Committee.

The Glenfir Resources project team for phase 2 included Chris Bull, John Harrop, Leah Hartley, Alan Wood (Alan Wood Consulting Inc), Stuart Mould (Mould Engineering), Larry Lemke, and Marshal Weitzel (Aztec Drafting Services).

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SUMMARY

This discussion paper considers 8 options for improving the production of native fish in the Okanagan River system. The options were chosen by the Okanagan Basin Technical Working Group (OBTWG) from a set of 18 outlined in the phase 1 report. We have placed them within three larger goals depending on whether they reduce losses of adults, increase egg to fry survival, or restore river habitat to a more natural condition.

Reduce losses of adults:

Fish counts indicate significant losses between Wells Dam and the spawning ground above Osoyoos Lake. What portion of these losses is attributable to differences in counting methods at the two sites and what portion is due to mortality en route is not known. The answer could be obtained by conducting a $300,000[1] **trap and transport** study. Radio-tagged fish would be trucked from Wells to the spawning ground and their numbers would be compared with a similar sized control group which would be allowed to migrate normally. If mortality during migration was significant, the transported fish should outnumber the controls on the spawning ground. Efforts could then be made to determine the cause and provide a remedy. Equal abundance of both groups would indicate a discrepancy in counting procedures. DCPUD is presently working on the costs, benefits and risks of this option and will provide further information. Preliminary results indicate costs may be outweigh benefits in most years.

Warm water reduces the survival of several species of fish in the system. One possible solution is to **construct a hypolimnetic siphon from Skaha Lake** to Okanagan River. Water from deep within the lake could cool the river by 2°C, but costs would surpass $1,000,000 and benefits would cease as the water sank into the depths of Vaseux Lake. A siphon from Vaseux Lake might cool the spawning areas but costs would exceed $2,000,000. Alternative methods for cooling include revegetation of streambanks and maintenance of river flows.

Increase egg to fry survival:

Flows in the Okanagan River and water levels in Okanagan Lake are regulated primarily for flood control and licensed water use, and secondarily to protect kokanee and sockeye. In recent years, inflows reached record highs. As the lake was drawn down in anticipation of these inflows, kokanee eggs and fry were desiccated and frozen. After the freshet arrived, large releases from the dam scoured river gravel causing sockeye, kokanee and whitefish fry to emigrate prematurely.

With these events it is tempting to **recommend modified flow releases.** However, extreme flows encountered in recent years were attributable to radical weather, and under more normal conditions flow releases could be kept within the guidelines of the storage plan. Major changes to the plan would not benefit fish but annual operations could be improved if the correlation between water releases and fish losses was more thoroughly understood. Managers need to know what level of loss is normal and tolerable; whether kokanee alevins can escape falling lake levels; how to make wise tradeoffs between kokanee and sockeye; and how to predict annual emergence dates. This

[1] Costs are in Canadian dollars

information would allow flow releases to be timed more precisely. A $150,000 applied research program could answer these questions over a 3 year period.

Fisheries agencies could **procure water licenses** on Okanagan River as a safeguard against low flows. Two such applications have been made by the Fisheries Section of MELP but have not been adjudicated.

Under the Water Act, licenses are expected to be associated with existing works. Consequently fisheries structures such as spawning channels, Newbury Riffles etc., justify water licenses and these should be applied for as the opportunities arise.

New legislation is being considered to protect fish from low flows. In the meantime, water managers say there is sufficient water in Okanagan River to meet preferred fisheries flows. Moreover these flows are assured by the operation plan, international agreements on transboundary flows, and federal/provincial agreements.

Unscreened irrigation intakes were suspected of causing substantial fry mortality so Okanagan Nation Fisheries Commission recently undertook a program to **inventory water diversions and encourage screening.** Surprisingly, 88% of intakes along Okanagan River complied with screening requirements, however six major inlets leading into oxbows remain unscreened. Correcting these would be difficult and expensive and should be preceded by a $20,000 program to determine whether they trap migrating fry and to what extent.

To **construct a spawning channel** on the Okanagan System would supplement existing spawning and significantly increase egg to fry survival. Regulated flows would eliminate the risk of scouring and desiccation which occur from time to time in the river. For maximum efficiency a channel should be constructed solely for kokanee and sockeye. Careful monitoring and maintenance are required for optimal egg to fry survival. A number of potential sites have been evaluated but further possibilities should be explored if this option is approved.

Restore river habitat to a more natural condition

Construction of rock riffles throughout channelized portions of the river would substantially increase the amount, complexity and quality of fish habitat. It would also ease fish passage, beautify the river, and reduce the cost and danger associated with drop structures. The Okanagan Nation Fisheries Commission and Fisheries Renewal BC are investigating the feasibility of riffle installation.

Additional off channel habitat could be created by breaching dikes between the river and adjacent oxbows. This has limited benefit in the lower reaches but further upstream it would supply spawning and rearing habitat for rainbow trout. According to MELP the three best prospects are the Thorp, Blue Sage and Long Oxbows.

In some areas dikes could be set back to allow natural meander, but for the most part costs and risks likely outweigh the benefits.

Revegetation of streambanks would be very valuable for fish, particularly adjacent to pool/riffle complexes. Vegetation would provide shade for cooling, protective cover, habitat for other species, and leaf litter which forms a base for the food chain. It also has considerable aesthetic value.

Many Okanagan River tributaries are small and intermittent, but Vaseux Creek, Shuttleworth Creek and Inkaneep Creek are important and contribute both fish and spawning gravel to the mainstem. Stream assessment and a plan for their protection and restoration would be beneficial. Park Rill Creek is a much smaller and much more stable system and could be improved with minor trouble and expense.

Implementation

The OBTWG envisions a natural ecosystem approach. This sometimes results in benefits which are difficult to quantify in the short term, but become apparent as adult returns increase over a long time period.

Implementation will be preceded by an approval process involving the OBTWG, DCPUD and the Wells Coordinating Committee. Following approval, implementation steps unique to each option will be followed.

Opportunities for partnering are plentiful. It would also be valuable to consult with groups which are attempting to coordinate resource stewardship initiatives throughout the Okanagan Valley.

INTRODUCTION

The principle objective of this project is to identify ways to improve conditions in the Okanagan River system so that all native species of fish can be maintained at self sustaining levels. The Okanagan Basin Technical Working Group (OBTWG) has agreed that this objective should be pursued within an ecosystem framework, emphasizing natural solutions that will work for a long time.

Most attempts to rebuild fish stocks concentrate on "bottlenecks" - the major factors limiting the population. For some species the bottlenecks are not known; for others the major bottlenecks are presently insurmountable. It follows that the best current strategy is to offset losses by increasing survival where possible.

There is currently sufficient spawning and rearing habitat for nerkids (kokanee and sockeye) in the Okanagan system (Hyatt and Rankin, 1999). What they require is improved rates of survival. Other species would benefit from an increase in the quality and quantity of habitat, particularly in areas which have been channelized.

Improving conditions in Osoyoos Lake would entail expensive, risky, or unnatural procedures such as controlling predators and competitors, lake fertilization, and net pen rearing. Such approaches have been rejected by the OBTWG in favor of improving conditions in the river. The options they have chosen will:

1. reduce losses of adults;

2. increase egg to fry survival; or

3. restore natural river habitat.

These objectives form the major divisions of this report. Specific options chosen from phase 1 are discussed individually under each heading.

PART 1

REDUCE LOSSES OF ADULTS

1. TRAP AND TRANSPORT SOCKEYE SALMON TO INVESTIGATE LOSSES DURING MIGRATION

Description

All sockeye salmon passing Wells Dam are thought to be Okanagan River stock, and yet counts of sockeye on the spawning grounds are consistently much lower than counts at Wells Dam (Table 1). Whether the differences are due to pre-spawning mortality, differences in counting procedures, undetected beach spawning or other reasons, is unknown, and further investigation has been recommended by the Okanagan Basin Technical Working Group (OBTWG).

Table 1 - Approximate escapements of Okanagan sockeye at Wells Dam and the Okanagan River spawning grounds (from Phase 1 report).

YEAR	WELLS DAM	OK RIVER	YEAR	WELLS DAM	OK RIVER
1967	113,323	35,000	1983	97,925	3,500
1968	81,530	15,000	1984	81,054	37,600
1969	17,352	3,500	1985	53,170	30,000
1970	50,667	7,500	1986	34,876	13,000
1971	48,172	35,000	1987	39,948	15,000
1972	33,398	35,000	1988	33,980	25,000
1973	37,178	8,000	1989	15,895	15,000
1974	16,716	3,500	1990	7,597	2,500
1975	22,286	10,000	1991	27,492	10,000
1976	27,619	11,040	1992	41,844	15,000
1977	21,973	8,475	1993	27,843	2,150
1978	7,458	1,050	1994	1,665	700
1979	22,655	2,000	1995	4,801	3,000
1980	26,573	5,000	1996	17,703	20,000
1981	28,234	15,000	1997	25,754	15,000
1982	19,005	7,000	1998	4,130	1,500

Losses could be investigated by trucking a group of radiotagged fish from Wells Dam to the north end of Osoyoos Lake (Figure 1) and comparing their numbers with a similar sized control group which migrated normally. If migratory losses were significant, the transported fish should outnumber the controls. Efforts could then be made to determine the cause and provide a remedy. Equal abundance of both groups would indicate a discrepancy in counting procedures.

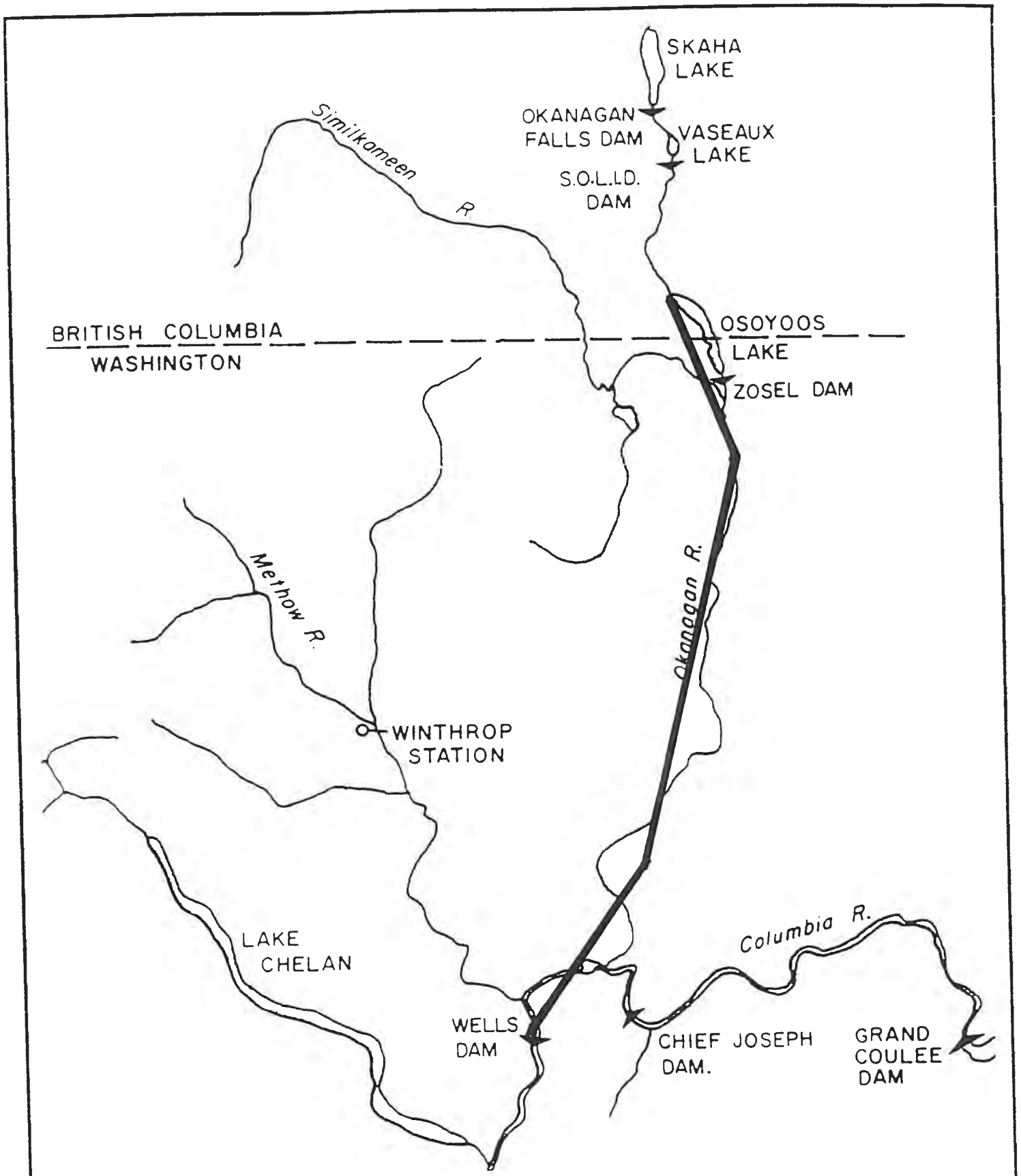


FIGURE 1 - TRUCK AND TRANSPORT ROUTE

Experimental design

The number of fish to be transported will be worked out if this option is approved. It requires assumptions about survival rate and levels of detectable differences between the test and control groups. This is not a simple procedure and will involve competent statisticians.

The final design of this option will list a number of precautions to ensure "due diligence" in protecting both the fish and the water they are taken to. For instance, the transport truck would be filled with water at the release site prior to picking up the fish. This would avoid the remote possibility that water at Wells Dam could contain something not normally found at the release site. High standards of care would be taken during transportation, including regular checking by an experienced fish culturist.

Details of radio tracking and other procedures will be worked out in the final design.

Benefits and Costs

Theoretically this exercise will shed light on the sources of mortality during migration. Perhaps it might even lead to a reduction in mortality. Moreover, it may be possible to compare the spawning success and gamete viability of the two groups (Hyatt and Green, personal communication).

If the studies indicate a discrepancy in counting procedures, alternative enumeration methods could be used. Biosonics has just completed a contract for ONFC which determined that present visual counting methods could be replaced by electronic recording of sonic counts (Wright, personal communication).

On the downside, it is possible that the transport option will provide very little knowledge over what is known from radio tagging carried out by DCPUD in 1997. The experiment will cost several hundred thousand dollars (tags alone are nearly $400 each) so there is a need to carefully consider benefits. DCPUD is presently working on the costs, benefits and risks of this option and will provide results to the OBTWG upon completion. Preliminary results indicate costs may be outweigh benefits in most years.

Risks

Handling, tagging , transport and interference with natural migratory behavior could result in disorientation and a reduction in spawning effectiveness in some of the fish and in the death of some others. However, losses should be offset by avoiding problems usually encountered along the migration route.

There is also a risk that this program will not reveal the reasons for discrepancies between the counts at Wells Dam and the spawning grounds. In this case the experiment will not have been justified.

The usual risks encountered with fish transplants (genetic changes; introductions of new pathogens and parasites; possibility of spillage into new waters etc.) will not be a problem in this case, since fish will only be transported within the waterway in which they would normally move.

Authorization

Authorization for transporting fish must be obtained first of all from the Okanagan Technical Working Group and then by formal application to the Canada/British Columbia Fish Transplant Committee. Authorization for border crossing and weigh scales should eventually be sought in writing ahead of time so that no delays are encountered when live fish are being transported.

Implementation Steps

The following steps are adapted from suggestions provided by Dr. K. Hyatt of the OBTWG:

1. Review of DCPUD report on costs , benefits and risks
2. Approval (the approval process is outlined in part 4 of this report)
3. OBTWG reviews and comments on methodology
4. DCPUD refines the proposal and resubmits it to OBTWG
5. Steps 2 and 3 are reiterated until OBTWG and DC PUD are satisfied
6. OBTWG prepares a letter of support and forwards an application for approval in principle to the federal/provincial transplant committee
7. Following approval in principle funding is obtained
8. OBTWG and DCPUD prepare final design and apply for transplant committee approval
9. Trap and Transplant is carried out

2. CONSTRUCTION OF A HYPOLIMNETIC SIPHON FROM SKAHA LAKE

Rationale

Our Phase 1 report showed that water temperatures cause losses of Okanagan sockeye, whitefish and presumably kokanee and trout. High temperatures in the U.S. Okanogan River have blocked sockeye migration (Major and Mighell, 1966) and have caused actual deaths (Hansen, 1993). In Canada, high temperatures are suspected of causing disease, affecting swimming ability and lowering energy reserves (Canada/British Columbia Okanagan Basin Agreement, Task 162, 1973). Both salmon and trout are thought to be affected from time to time (B. Shepherd, personal communication).

The preferred temperature range for spawning sockeye is reported as 10.5 - 12.2 °C (Canada/British Columbia Okanagan Basin Agreement, Task 162, 1973). The Okanagan River generally reaches this range between October 10 and October 22 (Hansen, 1993; Klinge, unpublished and Shepherd, unpublished). These dates correspond with the peak of spawning (Hyatt and Rankin, 1999) indicating that sockeye hold in Osoyoos Lake waiting for the right temperature. The effect of delays on adult survival and viability of gametes is unknown but presumably deleterious (Hyatt, personal communication).

There is little doubt that cooler water would help. One idea for achieving it is a siphon which would draw 10°C water from the depths of Skaha Lake and discharge it at the base of the dam at Okanagan Falls (Figure 2).

Description

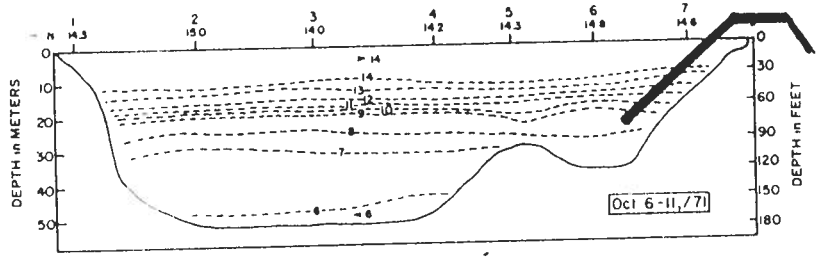
Siphons have been used in Chain Lake, Upper Pitt River, Upper Seaton Creek and several other places, but seldom for cooling purposes (Cooper et. al., 1977; MacDonald, 1995; and MacDonald, personal communication).

In Skaha Lake the hypolimnetic region capable of delivering 10°C water is located below the 20 meter contour (Canada/British Columbia Okanagan Basin Agreement, Task 121, 1973). Approximately 1300 meters of pipe would be required to reach from this area to Skaha Lake Dam. Engineers suggest using electrically fused high density polyethylene (HDPE) pipe which exhibits low friction and can deliver high volumes of water at low pressure. It would be floated into position and then sunk with weights. A standard 48 inch outside diameter pipe with a wall thickness of DR 32.5 would deliver 2 m^3/sec. Larger pipes are not standard and are very expensive (T. Fiala, personal communication).

Additional requirements include an on/off valve and a vacuum release valve to maintain the siphon effect and a spillway at the discharge to prevent erosion of the streambed.

Benefits

Theoretical volumes and temperatures of both river and siphon water were required to calculate benefits. We selected the best scenario for success of the siphon and assumed low volumes of warm river water and the largest practical volume of cool siphon water. The volume of siphoned water was restricted to 2 m^3/sec, since more would require a prohibitively expensive pipe.



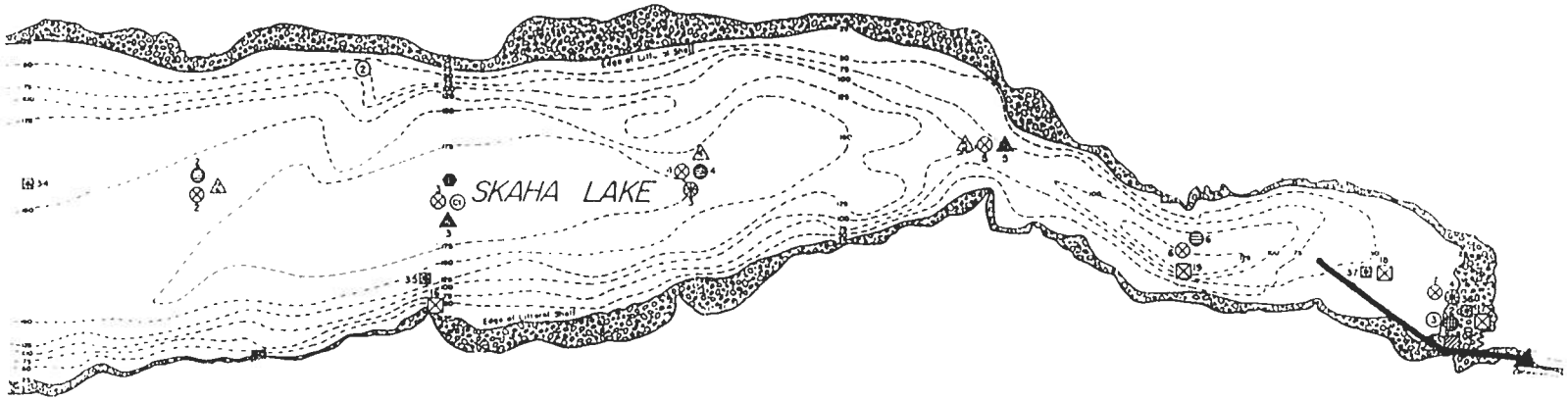


Figure 2 - Hypolimnetic Siphon on Skaha Lake *

*Source Canada - British Columbia Okanagan Basin Implementation Agreement Task 121, 1973 Bathymetric lines in feet

The benefits in terms of cooling were calculated using a proportional formula which is simple but valid (R. McDonald, personal communication).

$\Delta T = [(Vs \times Ts) + (Vr \times Tr)] \div (Vs + Vr)$
Where:
ΔT is the new temperature after mixing
Vs is the volume of water siphoned
Vr is the volume of river water
Ts is the temperature of the siphoned water
Tr is the temperature of the river water

Hence when the river is running at a volume of 8 m^3/sec and a temperature of 20°C and the siphon is running at 2 m^3/sec and 10°C, the temperature after mixing will be:
$\Delta T = [(2 \times 10) + (8 \times 20)] \div (2 + 8) = 18°C$.

In other words, under conditions favorable to the siphon, the river temperature can be dropped 2°C at the point of complete mixing. At a more normal river temperature of 15°C, the amount of cooling would be only 1°C.

Once the water entered Vaseux Lake, it would likely dive beneath the warm epilimnion and into the cooler hypolimnion. The residence time for water in Vaseux Lake is normally only 10 days (Canada/British Columbia Okanagan Basin Agreement, Tech. Supp. IV, 1974). However the lake is probably stratified and dimictic so cool water would remain below the thermocline until fall turnover. Thus the benefits of the cooler water would not be carried as far as the spawning grounds below McIntyre Dam.

A siphon from Vaseux Lake to McIntyre Dam would be more effective, however costs would also be much greater. Hypolimnetic depths are found only in the northern basin (Figure 3) so a 3100 m pipe would be required. Pipe costs exceed $1,800,000 and total costs exceed $2,000,000. If this option is accepted for implementation a more sophisticated modeling program is recommended to increase the likelihood of success.

Costs

More sophisticated information is needed to accurately predict the cost, but experts advise that 48 inch diameter HDPE pipe costs approximately $590 per meter installed which would place pipe cost in the range of $800,000. It is safe to assume that total costs will exceed $1,000,000 (Fiala, personal communication).

Risks

The possibility of warming the metalimnion of Skaha Lake was discounted. The volume of cool water to be withdrawn will be insignificant and withdrawal will occur after the period of maximal solar heating.

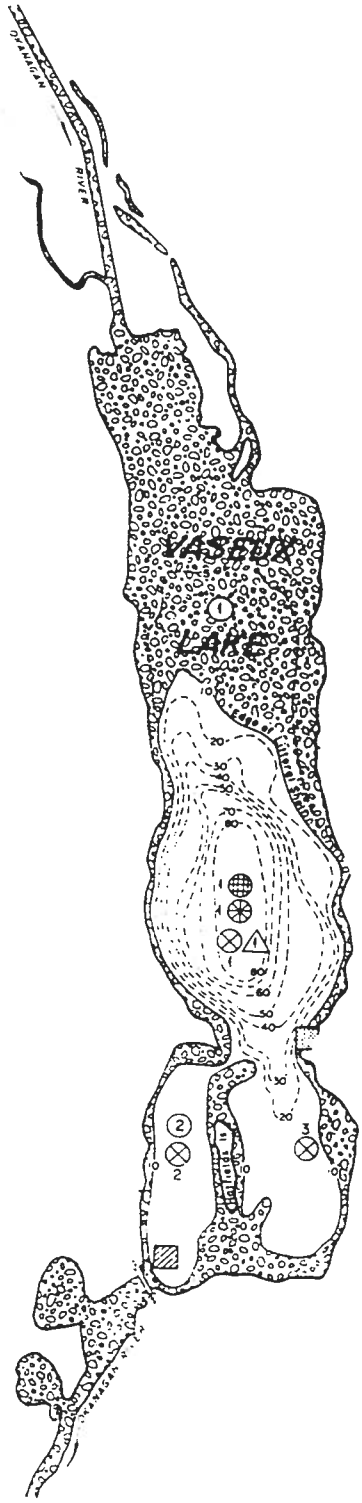


Figure 3 - Bathymetric Map of Vaseux Lake*

*Source Canada - British Columbia Okanagan Basin Implementation Agreement Task 121, 1973 Bathymetric lines in feet

Other problems from raising hypolimnetic water seem unlikely given the volumes involved, but they should be considered. Hypolimnetic water could be anoxic, could contain high numbers of *Mysis relicta*, and could cause gas supersaturation problems (B. Shepherd - personal communication). The highest risk at the present time is the possibility that the siphon would not deliver the expected results. Consequently, more sophisticated modeling should be pursued prior to embarking on a project of such magnitude.

Alternatives

River temperature is affected not only by atmospheric conditions and surface temperature of the storage lakes, but also by groundwater returning to the river . Groundwater increases with river flow until the river reaches about 14 m^3/s. At higher flows the groundwater contribution becomes less. Accordingly, the Fisheries Service, Environment Canada, (1973) recommended that during hot spells river flows should be kept between 8.5 m^3/s and 14 m^3/s. The preferred flows for sockeye, discussed in Part 2 of this report, ensure that these minimums are met between August 1 and October 31.

Streambank vegetation helps to cool small streams (Beaudry, Hudson, and Hickey, 1999). On a large system like the Okanagan River with a north/south aspect the effects of shading will be less dramatic, but still important. This topic is raised again in the restoration section (Part 3).

Implementation Steps

1. Approval (the approval process is outlined in part 4 of this report).
2. Feasibility studies and costing (including site survey and hydraulic and thermal modeling)
3. Review of hypolimnetic water quality
4. Final design, engineering, plans and costing
5. Approval of final design
6. Agency approvals
7. Water license application
8. Notification of interested and affected parties
9. Contractual arrangements
10. Construction
11. Operation, maintenance and adaptive management

PART 2

INCREASE EGG TO FRY SURVIVAL

1. RECOMMEND MODIFIED FLOW RELEASES

Introduction

Flow releases resulting from water storage on Okanagan Lake directly affect the survival of kokanee and sockeye. Kokanee eggs are destroyed as Okanagan Lake levels drop but sockeye eggs expire if insufficient water is released into the river. Thus, if one population is fully accommodated the other one suffers. The storage plan tries to accommodate both populations by lowering Okanagan Lake as far as possible before kokanee spawn in mid October while storing sufficient water to meet "preferred flows" for salmon throughout the winter. The compromise has advantages for both kokanee and sockeye but is optimal for neither.

This section of the report investigates the feasibility of improving flow release operations to increase egg to fry survival of both populations. What follows is a description of the operating system, an examination of its effects on fish, and a list of actions that might improve the situation.

Description of the storage system

The Okanagan water storage system was constructed in the early 1950's to prevent flooding and to supply water for agricultural, industrial, and domestic use. While flood control is the highest priority for system management, there has been significant effort to regulate lake levels and outflows to meet the needs of fish.

The British Columbia Ministry of Environment, Lands and Parks (MELP) manages storage. MELP's River Forecast Center in Victoria is responsible for long term forecasting of inflows, while the Engineering Section in Penticton operates the system. The two groups work together in accordance with an operating plan based on recommendations of the Canada/British Columbia Okanagan Basin Implementation Agreement (1974), computer models, and adaptive management.

Eighty per cent of the water entering the Okanagan Basin passes through Okanagan Lake. Storage and outflows are controlled by a dam at the outlet. Storage on other lakes in the system is minor, and can be disregarded for this discussion.

The amount of water which will enter Okanagan Lake in any particular year is impossible to predict accurately, and has varied from 74 to 1401 million cubic meters (Figure 4). The discharge capacity of the system is limited, so if inflows are large, water cannot be released fast enough to avoid flooding. Water managers try to minimize flood damage by forecasting the amount of inflow then lowering the lake to provide enough storage before freshet begins. If the drawdown is insufficient, flooding occurs. If it is excessive there may not be enough stored water to accommodate agriculture, industry, domestic use and fishery needs later in the summer. Decisions on how much water to release in advance of the freshet are based upon prescribed lake levels, existing snowpacks and long term weather forecasts. For further details on the operating plan, refer to reports of the Okanagan Basin Agreement, 1974 (listed in references cited).

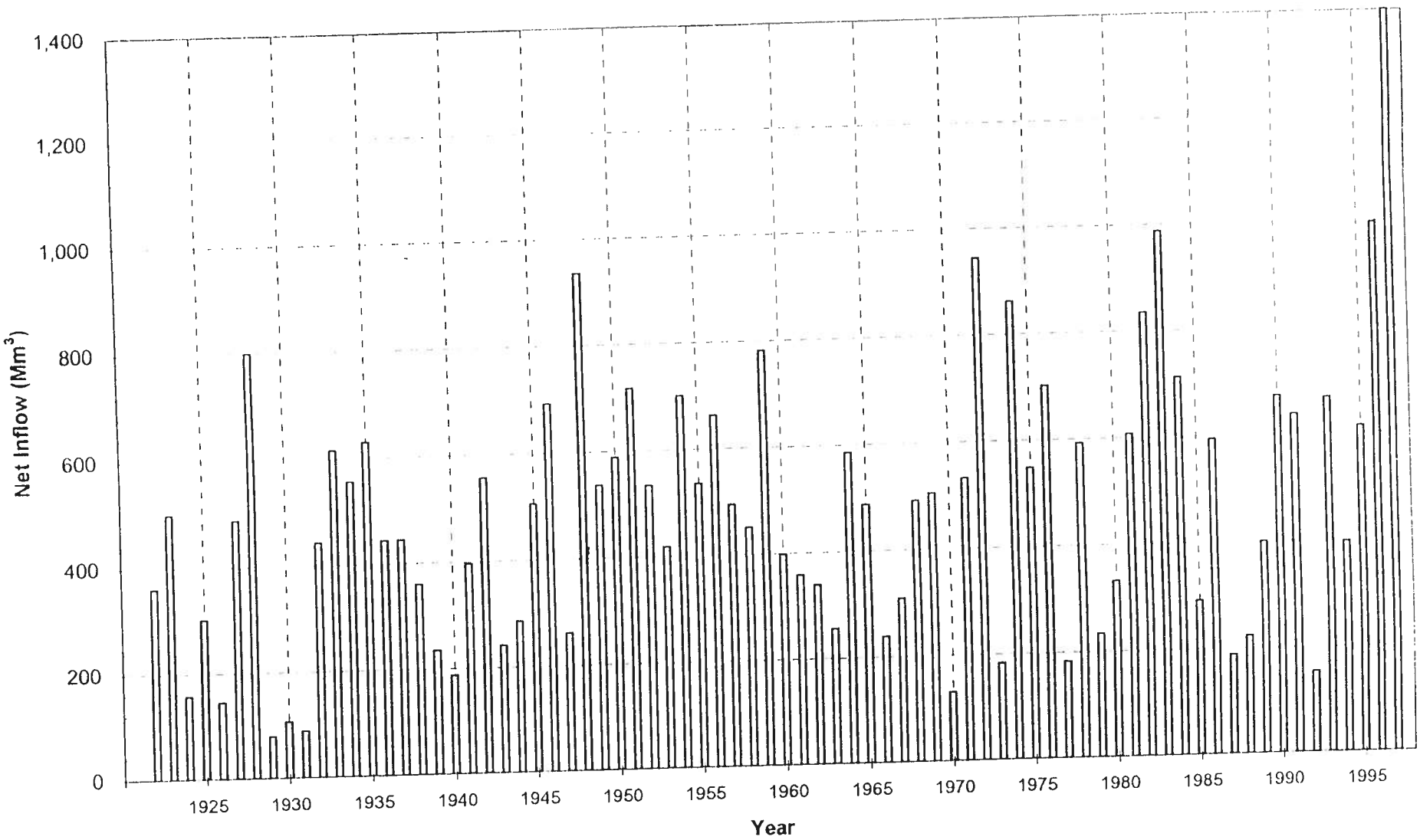


Figure 4 - Okanagan Lake Annual Net Inflow Volume*

*Source Ward and Associates Ltd., 1998

Effect of lake level changes on kokanee

Shore spawners are an essential component of the Okanagan Lake kokanee population, and are genetically distinct from stream spawners (Dill, 1997). After Halsey and Lea (1973) showed that shorespawner egg survival was limited by lake drawdowns, an attempt was made to stabilize lake levels at critical times. Storage procedures suggest that lake drawdown be limited to 15 cm between mid October (when spawning begins) and February 1 (when water levels are adjusted to accommodate spring inflows). An additional 20 cm drop is anticipated in February (O'Riordan, Zackodnik, and Symonds, 1997). These drawdown objectives are usually met, but substantial drawdowns prior to fry emergence in mid April are occasionally unavoidable if flooding is to be minimized (Table 2, and Figure 5).

Table 2 - Okanagan Lake drawdowns (October 15 - April 15). Drops beyond the 35 cm objective (ie 15 cm + 20 cm) are shaded. Source: Water Survey of Canada, 1999.

Year	Drop in Lake Level (cm)
1982/83	51
1983/84	23
1984/85	27
1985/86	24
1986/87	16
1987/88	25
1988/89	12
1989/90	18
1990/91	42
1991/92	13
1992/93	10
1993/94	26
1994/95	27
1995/96	34
1996/97	50

Since the initial work of Halsey and Lea in 1973 there have been several studies of Okanagan Lake shore spawners (Matthews and Bull, 1981; Harris, 1984; Dill, 1996 and 1997; Shepherd, undated, and 1997; Shepherd, Sebastian and Ashley, 1998; and Wong, 1999). All the studies show that lake level fluctuations destroy a significant number of eggs, but none show a connection between lake levels and the number of adult shore spawners. In fact Shepherd (undated) found that in some cases large numbers of spawners came from broods hatched in a year of severe drawdowns. Shepherd et. al. (1998) sum up the situation as follows:

"...lowering the lake in fall and winter months can adversely affect kokanee egg survival. It was not possible to determine whether lake drawdown is a primary cause of the decline in kokanee numbers as there are several other factors at play including lake capacity and competition for preferred food between Mysis relicta and kokanee fry..."

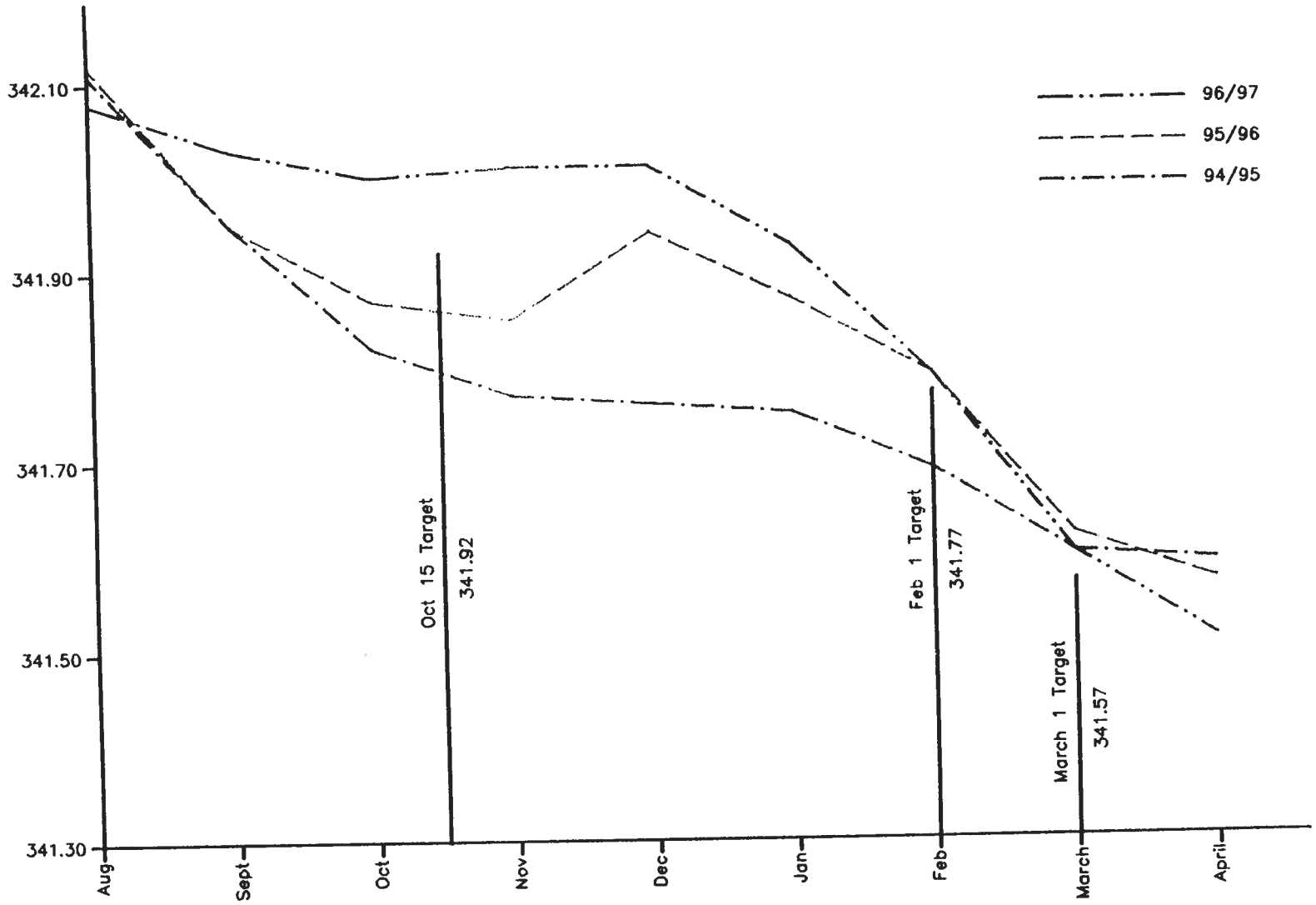


Figure 5 – Water levels (meters) in Okanagan Lake throughout the kokanee spawning and incubation period

Shepherd et. al. (1998) also think that prior to the construction of storage, the lake level fluctuated as much or more than it does today. If so, perhaps shore spawners have evolved to tolerate a significant variance in lake levels. Matthews and Bull (1981) and Fast (1981) found that after kokanee hatch, but before they emerge a month later, they are able to migrate lakeward through the gravel and escape falling water levels. However, Dill (1997) did not find any evidence of alevin migration.

Even if kokanee shorespawners are able to tolerate a wide range of water levels, there is clearly a point at which drawdowns will cause population declines. Given that the shorespawner population decreased by over 90 % between 1973 and 1997 (Wong, 1999) it would be foolhardy not to work towards the best possible survival of them at all life history stages.

Since stabilizing lake levels for kokanee increases the risks of flooding and damage to river dwelling fish, operational constraints should not be more rigorous than necessary. Setting the most appropriate lake levels will require a better understanding of kokanee shorespawners. Until such information becomes available, it is wise to heed the "risk aversion" or "precautionary principle" and continue to assume that the lowest level of lake drawdown is the most beneficial.

Effects of river flows on sockeye, kokanee and whitefish

Whenever possible, releases from Okanagan Lake are regulated to fit the "preferred" flow regime for sockeye salmon. This regime was initially proposed in 1963, and then improved through field surveys and modeling. Details may be found in the Canada/British Columbia Okanagan Basin Agreement, Task 162 (1973). Further revisions were made in the early 1970s, to protect shore spawning kokanee.

Final recommendations for preferred flows for sockeye salmon are outlined in the Canada/British Columbia Report on the Okanagan Basin Agreement (1982). These flows, shown in Table 3, are considered acceptable limits rather than optimum flows (M. Flynn - personal communication).

Table 3 - Preferred fishery flows for the Okanagan River (Canada/British Columbia Report on the Okanagan Basin Agreement, 1982).

Life History Stage	**Dates**	**Preferred Range (m^3/sec)**	**Additional Information**
Adult migration	August 1 - Sept. 15	8.5 - 12.7	
Spawning	Sept. 16- Oct 31	9.9 - 15.6	
Incubation	Nov. 1 - Feb 15	5.0 - 28.3	Incubation flows ≥50% spawning
Fry migration	Feb 16 - April 30	5.0 - 28.3	After Feb. 1 flood control takes precedence & 28.3 may be exceeded

Since this schedule was completed in 1982, river flows have often fallen below the preferred minimum level but they have seldom been far below (Table 4).

Table 4 - Minimum flows (m^3/sec) in Okanagan River during adult migration (August 1 - September 15), spawning (September 16 - October 31) and incubation/fry migration (November 1 - April 30). Preferred minimums are shown in brackets after each life history title. Flows below the preferred range are shaded. Sources Canada/British Columbia Report on the Okanagan Basin Implementation Agreement, 1982; and Water Survey of Canada, 1999.

	Life History Stage (preferred minimum flow)		
	Adult Migration (8.5 m^3/sec)	Spawning (9.9 m^3/sec)	Incubation & fry migration (5 m^3/sec)
1982/83	24.9	13.5	12.8
1983/84	15.6	11.4	7.5
1984/85	14.0	10.9	5.9
1985/86	7.8	8.9	5.3
1986/87	11.8	9.8	5.7
1987/88	7.1	9.1	3.6
1988/89	5.5	4.6	3.7
1989/90	6.8	9.6	7.4
1990/91	9.5	6.6	5.0
1991/92	9.6	9.4	4.8
1992/93	7.3	8.6	3.1
1993/94	11.9	10.0	5.1
1994/95	9.9	7.0	5.5
1995/96	16.4	9.5	6.2
1996/97	12.8	9.5	5.1
1997/98	64.4	7.4	13.8

The consequences of deviations from the preferred minimums have not been fully investigated. However, low flows during the migration and spawning periods are thought to generate high water temperatures which affect migration timing, swimming ability, energy conversion, and vulnerability to disease (Canada/British Columbia Okanagan Basin Agreement, Task 162, 1973). Throughout the incubation period low flows can de-water the redds resulting in loss of sockeye, kokanee and whitefish eggs through desiccation and freezing (Hourston et. al., 1954; Hansen, 1993; and Peters et.al., 1998). Juvenile rainbow and northern pike minnow are also killed when side channels are dried up (Shepherd, personal communication).

In the last two decades, high flows have been more problematic than low flows. The preferred maximum levels have been exceeded fairly frequently and on several occasions flows have been double the recommended level (Table 5 and Figures 5, 6 and 7). This has been unavoidable because of recent extremes in weather. For instance, in 1996 the snowpack was the highest ever recorded. In 1997, the snowpack went 40% higher (B. Symonds, personal communication).

The exceptionally high flows have been destructive. In 1997, when April discharges hit 2 ½ times the preferred maximum, 43% of the sockeye and kokanee fry were prematurely flushed out of the gravel (Shepherd, 1997). There is evidence that even a modest reduction in extreme flows would be helpful. Shepherd's work showed that when maximum flows were reduced from 73 m^3/sec to 55 m^3/sec, the percentage of premature fry was reduced from 43% to 14%. Further investigations of a similar nature would improve our understanding of the effects of high flows.

Table 5 - Maximum flows (m^3/sec) encountered in Okanagan River during adult migration (Aug. 1 - Sept. 15), spawning (Sept. 16 - Oct. 31) and incubation/fry migration (Nov1 - April 30). Preferred flows are shown in brackets after each life history title. Flows exceeding the preferred range are shaded. Flows at least double the preferred range are both shaded and bolded. Sources: Canada/British Columbia Report on the Okanagan Basin Implementation Agreement, 1982; and Water Survey of Canada, 1999.

	Life History Stage (preferred maximum flow)		
	Adult Migration (12.7 m^3/sec)	Spawning (15.6 m^3/sec)	Incubation & fry migration (28.3 m^3/sec)
1982/83	**57.1**	**33.3**	**73.3**
1983/84	**43.2**	17.8	42.8
1984/85	**30.2**	15.7	14.1
1985/86	13.5	12.3	26.8
1986/87	**40.9**	14.1	24.1
1987/88	11.0	11.3	12.4
1988/89	6.5	6.3	12.3
1989/90	**29.7**	30.3	11.6
1990/91	**59.9**	11.1	54.1
1991/92	**41.6**	10.7	22.6
1992/93	8.3	11.8	10.4
1993/94	**63.9**	11.3	54.6
1994/95	24.6	16.3	35.1
1995/96	**27.2**	21.6	**73.4**
1996/97	**41.0**	14.9	**73.3**
1997/98	**77.6**	**71.8**	26.2

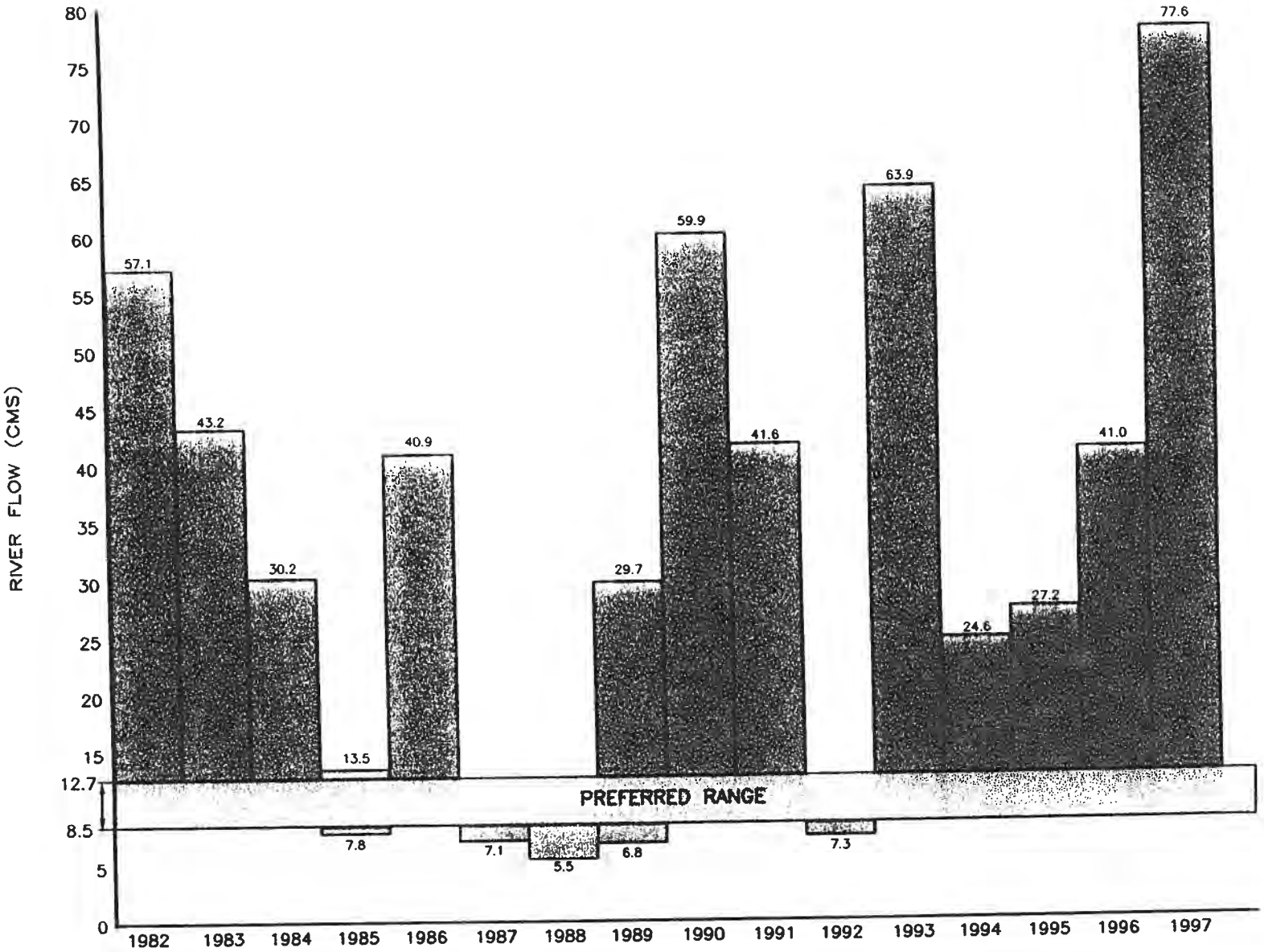


Figure 6 – River flows (cms) exceeding the preferred range during adult migration (August 1 – September 15)

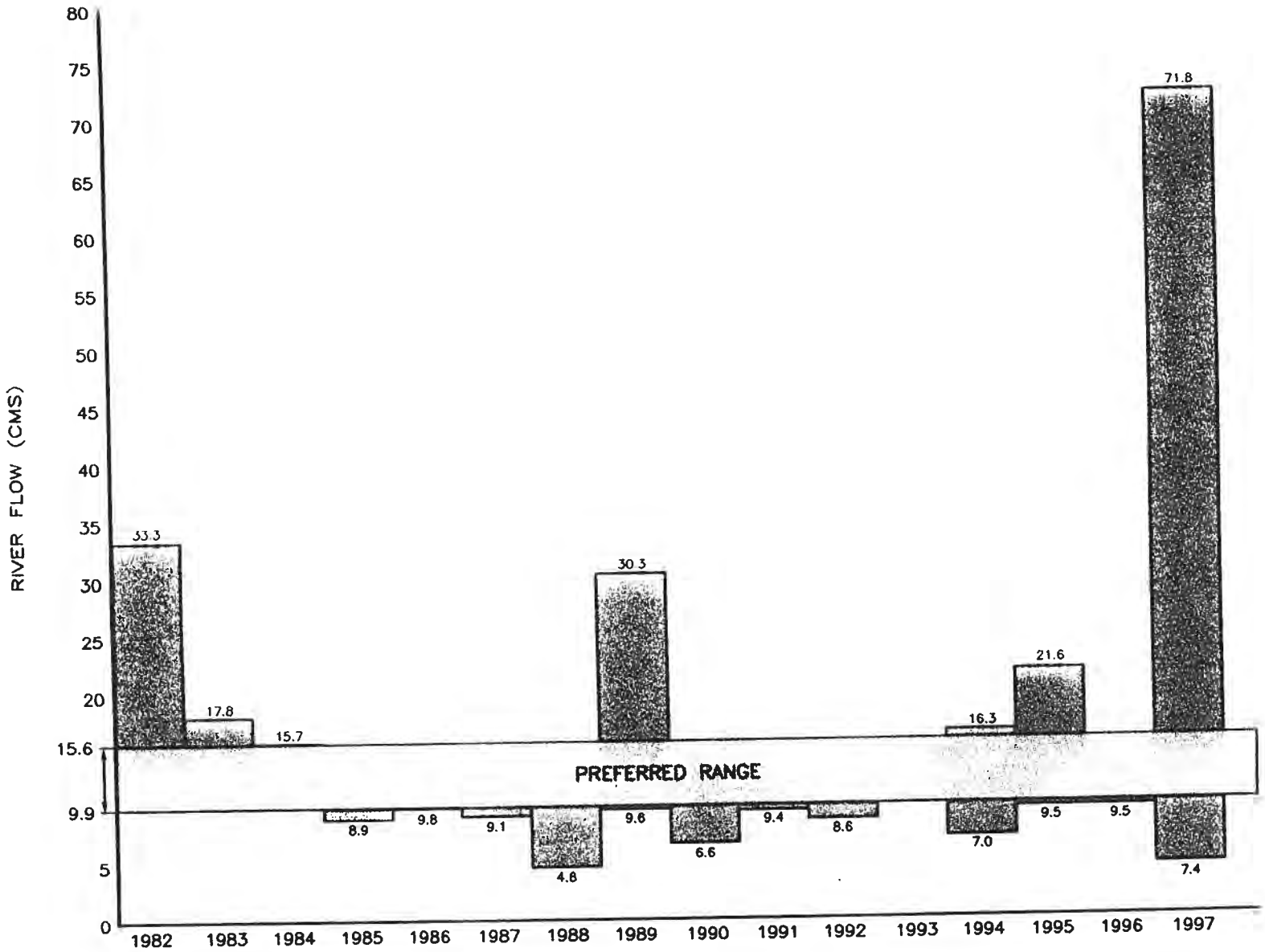


Figure 7 – River flows (cms) exceeding preferred range during spawning (September 15 – October 31)

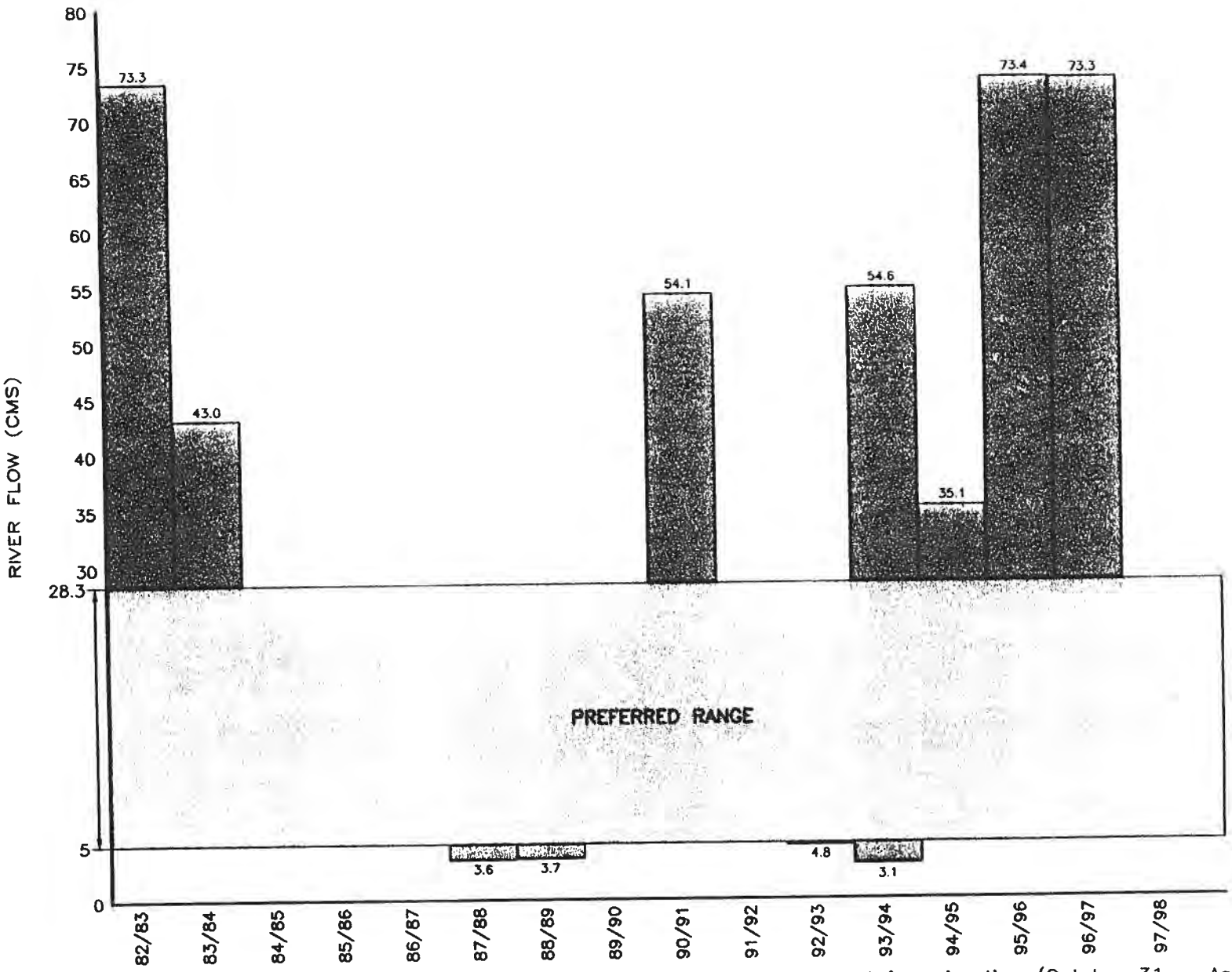


Figure 8 – River flows (cms) exceeding preferred range during incubation and fry migration (October 31 – April 30)

Suggestions for improvement

The foregoing shows that despite a fairly good plan, both kokanee and sockeye are, at times, adversely affected by flow releases. We now examine possibilities for improvement.

Construct more storage

Additional storage would help to absorb excessive flows, but this is not practical. The only sites with significant capacity are Vaseux and Skaha Lakes and storage cannot be added to them due to shoreline development.

Bypass channels

Bypass channels, to divert excessive flows around the spawning areas, also offer little promise. Areas large enough to accommodate a sufficient sized bypass are limited in length.

The SOLID irrigation canal skirts around the spawning ground, and was considered for use as a bypass during the spring of 1997. However, the capacity of the SOLID Canal is only 3.5 m^3/sec which is incidental in comparison to the volume being released, which at times approached 100 m^3/sec (B. Symonds and S. Mould, personal communication). Because of this and concerns about maintenance costs and liability, the idea was dropped.

Another site considered for a flow bypass was the irrigation channel which parallels the river on the west bank south of Highway 97 Bridge (see Appendix 1, Reach 11, Aerial plate 13). However, this channel has insufficient capacity (B. Symonds, R. Jubb, and S. Mould, personal communication). In addition, land owners in this area are already upset about flooding and would object to any schemes which might increase the problem (Okanagan River Channel Landowners Society meeting, November 23, 1999 - personal communication).

Short bypass channels could be constructed in some locations such as spawning channel site E (Appendix 1, Reach 12 Plate 14); Inkaneep Park (Appendix 1, Reach 11, Plate 13), or through the island in Reach 13 (Appendix 1, Plate 15).

Mitigate flow problems by constructing a spawning channel

The Okanagan Basin Study suggested that more excessive flows could be tolerated if a spawning channel were constructed (Table 6). The idea that existing spawning conditions are replaceable is outdated (Williams et. al., 1999). A channel might improve upon the hydrograph found in the main river, but it should complement rather than replace present spawning grounds. Further discussions on spawning channels are recorded in a later section of the report.

Table 6 - Discharge requirements (m^3/sec) for sockeye salmon in Okanagan River prior to and after construction of a spawning channel (metric version of Table 18.2 from Canada/British Columbia Okanagan Basin Agreement, Tech. Sup. IX, 1974 page 178)

MONTH	Present Salmon Requirements		Requirements with Channel	
	Minimum	Maximum	Minimum	Maximum
August	8.5	12.7	8.5	12.7
September	9.9	15.6	9.9	15.6
October	9.9	14.2	2.8	-
November	5.0	28.3	2.1	-
December	5.0	28.3	2.1	-
January	5.0	28.3	2.1	-
February 1-15	5.0	28.3	2.1	-
February 16-28	5.0	28.3	5.0	-
March	5.0	28.3	5.0	-
April	5.0	28.3	5.0	-

Revise the operating Plan

Since flow problems cannot be fixed by the means just mentioned, it is worthwhile to consider whether the storage operating plan could be improved. The plan has evolved over many years, through a combination of empirical studies, computer modeling, and adaptive management. It appears to work reasonably well given conflicting water demands, the vagaries of climate, and the fact that the Okanagan Basin Agreement gives flood control priority over fishery flows. Under the record high inflows which occurred recently, fishery losses were substantial, but they occurred because the plan could not be followed, not because the plan was inadequate.

The ability to adhere to the plan could be improved if spring inflows could be predicted well ahead of time. For instance, if a large snow pack could be predicted in the fall, excess water could be released prior to kokanee spawning rather than waiting until spring. Some progress in forecasting has recently been made by considering variables such as groundwater levels, and by finding ways to estimate missing data (Summit Environmental Consultants, 1999). Other studies hope to use long term weather cycles to improve forecasting (Ward and Yassien, 1998). Although these studies hold some promise, forecasting cannot yet be relied upon as a means of improving flow releases (B. Symonds, personal communication).

Improve operations

As inflows become more normal fishery losses should diminish. Nevertheless, egg to fry survival could be increased if the water storage and release operations were matched more precisely to the requirements of fish.

In order to accomplish this "fine tuning" of operations, there needs to be a better understanding of exactly how water releases affect kokanee and sockeye. Answers are required to the following questions:

- what levels of egg, alevin and fry losses are normal and tolerable for kokanee shore spawners?
- what is the migratory ability of kokanee after they are hatched but before they emerge?
- what is the correlation between water releases, gravel scouring and sockeye losses?
- what water release schedules provide the best balance between sockeye and kokanee survival?
- how should tradeoffs between kokanee and sockeye be made?
- can annual monitoring of spawning times and temperatures be used to closely predict sockeye and kokanee emergence dates?

Answers could be found by undertaking a 3 year program of applied research. The information would allow water managers to more accurately time flow releases to benefit fish.

Benefits, Costs and Risks

Benefits are likely to be substantial and applicable over a long time period but they are very difficult to quantify in advance.

Costs will vary depending upon the amount of investigative work decided upon. We suggest that $150,000 spent over a 3 year period would be appropriate. Okanagan based universities would probably provide the best product at the least cost.

No risks are anticipated.

Implementation Steps

1. Approval (the approval process is outlined in part 4 of this report)
2. Water Management Branch agreement in principle
3. OBTWG, DCPUD and Water Management refinement of proposal (clear definition of products, cost, roles and responsibilities, and end product)
4. DC PUD commitment to funding
5. Contractual and administrative arrangements
6. Implementation

2. PROCURE WATER LICENSES

Description

The annual inflow to Okanagan Lake is 449,000 cubic decameters (dam^3). Most of it has been licensed and the Water Management Branch recommends that further licensing be limited to 63,000 dam^3 (Obedkoff, 1994). Water managers say "*...the demand for water will grow. There is already competition for the available supply of water ... This competition is going to increase as the demands increase.*" (McKee and Petrie, 1999).

Given this situation, and the fact that the Water Act does not yet recognize fish as legitimate users of water, it would seem prudent to license as much water as possible for fisheries use. In the event of a water shortage, licenses with the earliest dates of application take precedence over later licenses, so it would seem wise to apply as soon as possible.

It is important to note, however, that the competition for water is most intense on tributary streams where gravity saves the cost of pumping (O'Riordan, 1972). Most of these tributaries are now designated as fully recorded, meaning no further licenses are issued other than for domestic use. The situation in the valley bottom is much different. For instance, the storage on Okanagan Lake is 1200 cm but less than 2 cm are used for irrigation and domestic use (Okanagan Basin Water Board, 1998). Water managers are confident that there is ample water available in Okanagan River to meet both off-stream and in-stream uses for the foreseeable future (D. McKee and B. Symonds, personal communication). Continuation of instream flows is assured by the operational plan, international agreements on transboundary flows, and federal/provincial agreements on flows for salmon. That said, in the unlikely event that these assurances prove inaccurate, and a water shortage does arise, a license for fish that takes precedence over some other licenses would be an asset.

The Water Act allows for storage and diversion of water under licenses which are tied to the construction of "works". Any fisheries structure, such as a spawning channel or Newbury Riffle, satisfies the conditions of licensing, where simple retention of instream flow may not. As structures are constructed and opportunities arise water licenses should be applied for. An added benefit is that licenses acquired on this "works" basis would not support the argument that all fish-bearing streams require licensing.

In 1998 the Fish and Wildlife Section of MELP explored the possibility of licensing flows without associated works. They applied for two major water licenses (Symonds, 1998). One application sought 49,320 dam^3 (40,000 acre feet) on Okanagan Lake to manipulate water levels for the conservation of shore-spawning kokanee. The second application was for 61,650 dam^3 (50,000 acre feet) for the protection of downstream flows for resident fish. Water Management has not decided whether to grant these licenses.

Alternatives

A number of ways of maintaining instream flows for fish are being considered (McKee and Petrie, 1999, and BC Ministry of Environment, Lands and Parks). These include:

- a Fish Habitat Protection Amendments Act which would disallow licenses which adversely impact fish
- new regulations under the 1997 "Fish Protection Act"
- reserving relinquished license capacity for fish flows on designated systems
- designation of sensitive streams
- policies and procedures to ensure consideration of fish and fish habitat in water allocation decisions
- water conservation through metering and increased prices

Costs

Annual license fees are waived for the Crown and First Nations, so maintenance of the structures associated with licenses will be the only ongoing cost.

Implementation

The MELP license applications, coupled with water management's assurances that there will be no shortages in the river in the foreseeable future removes any urgency to make additional applications that are not coupled with structures. Licenses tied to structures will be implemented along with those options.

3. INVENTORY WATER DIVERSIONS AND ENCOURAGE SCREENING

Description

Unscreened and ineffectively screened irrigation intakes have been identified as a possible source of fry mortality (Peters et. al., 1998). Shepherd and Inkster (1995) pointed out that only 29% of irrigation intakes on the US Columbia system complied with state screening regulations and they assumed the situation in British Columbia would be no better. Adequate inspection of intakes and enforcement of Fisheries Act requirements in British Columbia is impossible given thousands of intakes on thousands of kilometers of stream, and limited staffing.

In response to growing concerns about screen compliance, Fisheries Renewal BC recently funded the Okanagan Nations Fisheries Commission (ONFC) to undertake an inventory of intakes and determine the degree of compliance with the federal / provincial screening directive (Canada British Columbia Fish Screening Directive for Southern Interior Streams, 1997). The Directive requires that every water intake be screened to the following specifications:

- screen material shall be stainless steel, galvanized steel, aluminum, brass, bronze, or monel metal
- openings shall not exceed 1.5 mm
- screens will be supported and protected from debris
- approach velocity shall not exceed 0.056 m/sec

ONFC located 16 irrigation intakes on the river between McIntyre Dam and Osoyoos Lake. Fourteen of the intakes (88%) conformed with the screening requirements (Chapman, 1999). An attempt will likely be made to advise owners of non-compliant intakes of their legal responsibilities (T. Chapman, personal communication). Moreover, infractions will be brought to the attention of federal and provincial enforcement officials.

Of 23 intakes found in Osoyoos Lake, only 12 (52 %) were compliant. Whether sockeye and kokanee fry frequent the locations where the intakes are situated is not known.

In addition to the irrigation intakes, there are inlets to 6 major oxbows. None of these are screened. Within the oxbows there are many irrigation intakes, but since these were not included in the ONFC study the degree of compliance remains unknown. The oxbows are:

- Jannsen Oxbow (Appendix 1, Plate 2)
- Shippett Oxbow (Appendix 1, Plate 3)
- Black Sage Oxbow (located at VDS 6, Appendix 1 Plate 6)
- Long Oxbow (Appendix 1, Plate 7)
- Thorpe Oxbow (Appendix 1, Plate 7)
- Shuttleworth Oxbow (labeled Oxbow 39 in Appendix 1, Plate 13)

Aerial photos of these oxbows and pictures of the inlets (Figure 9) suggest that if fry enter they have a poor chance of surviving due to predation, disorientation, and prolonged migration times. However, there is no information on whether or not a significant number of fry are entrapped in the oxbows. The Shuttleworth oxbow appears to have the highest potential for entrapment since it is located on an outside corner, adjacent to a good spawning area and with an upstream aspect.

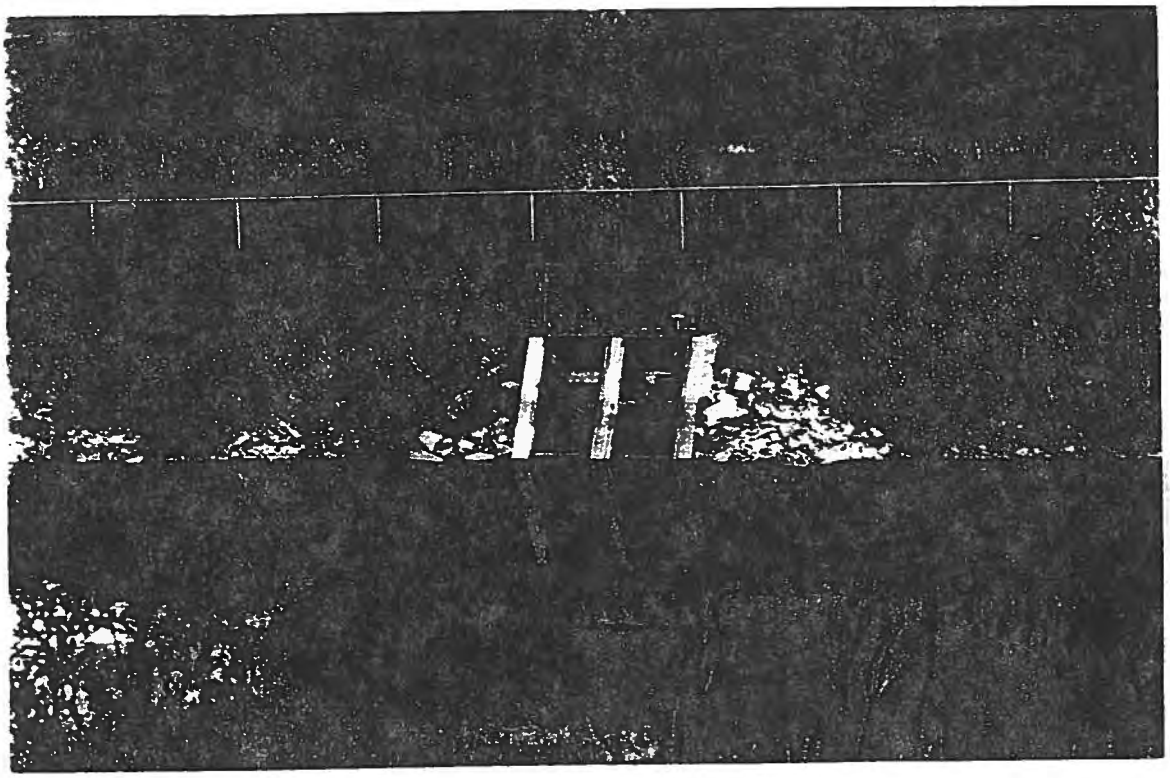
Benefits and Costs

Bringing these major openings into compliance would be difficult and expensive. Shepherd and Inkster (1995) point out that fry entrapment may be less problematic than one would think because *"First, most irrigators do not actually start their pumps until early May; at this time the majority of nerkid fry should have already migrated... Second, nerkid fry tend to migrate mid-river rather than along the margins."*

Furthermore, some of the oxbow inlets are located on inside corners with a downstream aspect. If the OBTWG wishes to explore this option further, it would be logical to determine whether the numbers of fry entering the oxbows would justify the major expense of rectifying the problem. This could be done by running a trapping program similar to that used by Shepherd (1997) just inside the mouth of the 6 oxbows during the sockeye/kokanee emigration period. The cost of such a program would approximate $20,000.

Implementation

1. Approval (the approval process is outlined in part 4 of this report)
2. Water Management agreement in principle
3. Design of trapping (ie feasibility) study
4. Contracted trapping program
5. OBTWG, Water Management and DCPUD review of results
6. Design and costing of screening structures if required
7. Commitment to funding
8. Water license application
9. Notification of interested and affected parties
10. Contractual arrangements
11. Construction of screening
12. Operation, maintenance and adaptive management



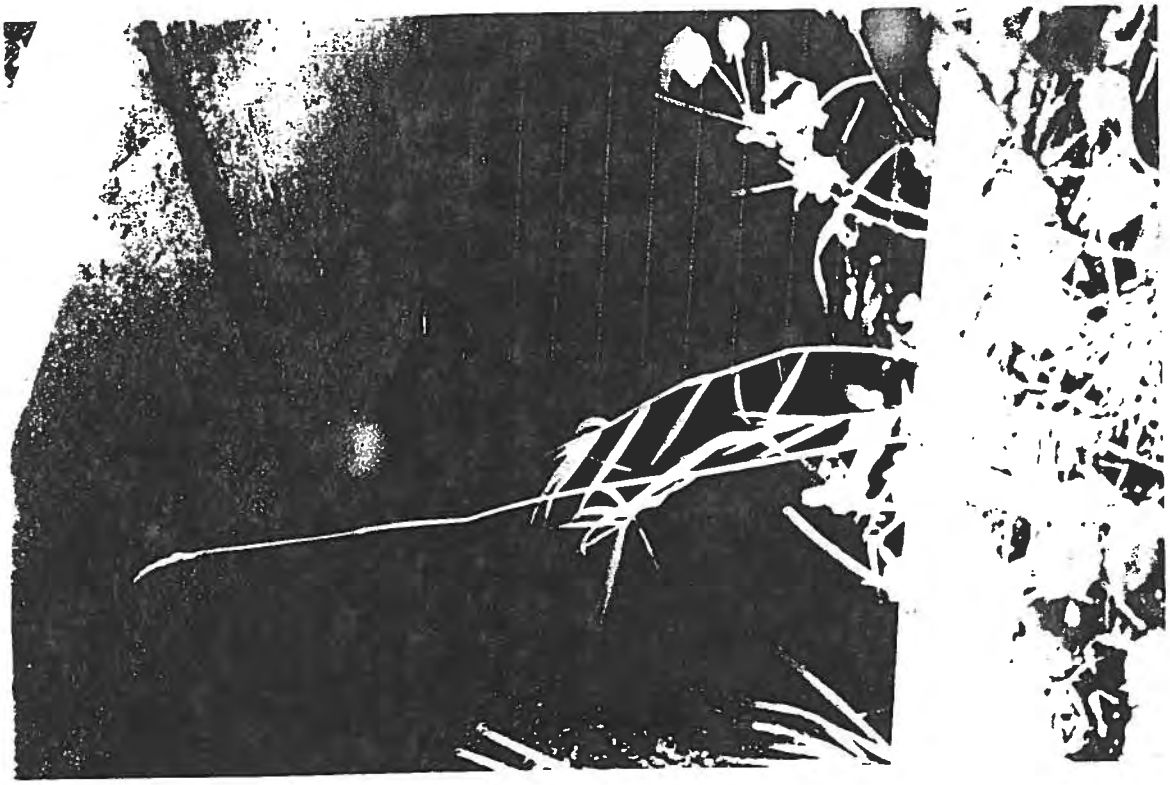


Figure 9 - Unscreened Oxbow Inlets

4. CONSTRUCT A SPAWNING CHANNEL

Concept

The purpose of a spawning channel on the Okanagan River system is not to create additional spawning space, but to increase egg to fry survival. Wilde (in Hilborn, 1990) describes channels as "*...just another piece of river, but with guaranteed flow*". Optimal flow is particularly important in the Okanagan system where a natural hydrograph cannot be assured. A spawning channel would avoid the scouring at high flows and the desiccation and freezing at low flows which takes place in the main river.

For maximum egg to fry survival a channel should be constructed and operated for nerkids (sockeye and kokanee) only (Ewert, personal communication). This should not affect other fish, but a more balanced approach would involve simultaneous restoration of habitat for other species in different locations.

Channel characteristics

Channel characteristics will be determined by the OBTWG in discussion with DCPUD. Nonetheless, a brief summary of the attributes of some existing sockeye channels is presented in Table 7. Figure 10 shows that channels can be aesthetically pleasing as well as productive.

Table 7 - Characteristics of some existing sockeye spawning channels (Sources: SEP Database, 1989; Hilborn, 1990; Cooper et al., 1977).

	Weaver Creek	Fulton No. 1	Gates Creek	Pinkut Creek	Fulton No. 2	Nadina River	Horsefly River
Width (m)	6	9	6	12	15	6	10
Length (m)	2859	1250	1850	2743	4800	2974	1600
Area (m^2)	17,429	11,426	10,995	33,442	73,154	18,131	14,540
Design Capacity	14,000	9,000	9,000	27,000	59,000	15,000	14,000
Slope (%)	0.07	0.09	0.05	0.09	0.20	0.05	0.05
Roughness (n)	0.035	0.035	0.035	0.035	0.035	0.035	0.028
Side Slope	1:1.5	1:1.5	1:2	1:2	1:2	1:1.2	1:2
Water Depth (cm)	24	40	38	30	27	48	30
Velocity (m/s)	0.27	0.44	0.31	0.37	0.52	0.36	0.03
Flow (m^3/s)	0.4	1.7	0.8	1.5	2.3	1.1	1.0
Gravel Size (cm)	1.3-10	1.3-10	1.3-10	1.9-10	1.3-10	1.3-10	1.3-8.9
Survival (%)	64	45	60	56	45	53	50

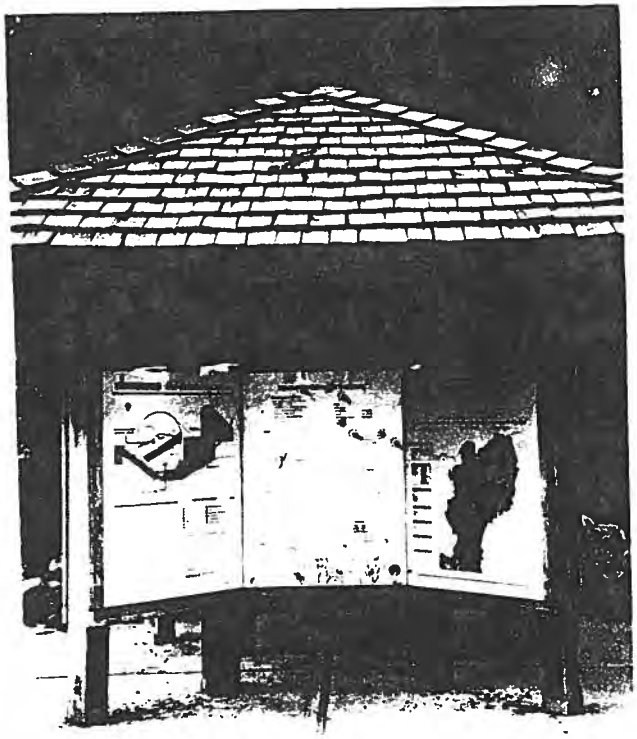


Figure 10 Mission Creek spawning channel

Site

The author examined the entire system from Okanagan Falls to Osoyoos Lake for likely channel sites. Two above Vaseux Lake were dismissed because they would:

- be low gradient (see Appendix Table 1)
- be difficult to colonize
- require extension of the run
- collect heavy fines from Shuttleworth Creek
- subject fry to predation from bass in Vaseux Lake

A number of sites between Oliver and Osoyoos Lake were also rejected due to low gradients which averaged about 0.1% (see Appendix Table 1). Although design grades often average about 0.05%, an overall gradient of at least 0.5% is recommended to allow for head losses, drop structures and weirs within the channel (Lister and Finnigan in Slaney and Zaldokas, 1997). If a channel were built on the lower end of the system it is likely that water velocity would be too slow and the channel would back flood in springtime. This is unfortunate because there appears to be an ample supply of groundwater in the lower reaches.

Another site was eliminated despite the fact that it might have been used previously as a spawning channel by Canada Department of Fisheries and Oceans. Hourston et. al. (1954) report that an experimental channel was built in 1953 on an island near the mouth of Vaseux Creek. They report the island as being downstream from Vaseux Creek but no island is apparent there, and the island immediately upstream has a channel through it which is visible in Aerial Plate 15 (Appendix 1, Reach 13). This site was avoided because of flooding and difficult access. Details of the early experiments are available in Hourston et. al. (1954) and Canada/British Columbia Okanagan Basin Implementation Agreement, Tech. Supp. IX (1974). Further investigation is needed to determine the exact location of the previous channel and whether the site has potential for future development.

Five sites which, in the opinion of the author, had potential included:

- Site A - on the east bank directly downstream of McIntyre Dam (see Appendix 1, Reach 13, Plate 15)
- Site B - bordering the south end of site A (Appendix 1, Reach 13, Plate 15)
- Site C - adjacent to McIntyre Creek (Appendix 1, Reach 12, Plate 14)
- Site D - on Osoyoos Indian Reserve (Appendix 1, Reach 12, Plate 14)
- Site E - on east bank directly above Highway 97 Bridge (Appendix 1, Reach 12, Plate 14)

All five sites were examined by Mike Flynn, Doug Lofthouse, Ken Woo and Vic Ewert of Fisheries and Oceans Canada. Their field report is provided, as written in Appendix 2.

From the sites suggested by the author. Fisheries and Oceans Canada chose Site B as the most suitable for a sockeye production channel. This site was initially suggested by Ian McGregor of MELP and Patrick Slaney of the BC Watershed Restoration Program. It is shown in Figure 11 but the location line is premature and provided for illustration only. The land owner has stated his willingness to discuss the availability of the site should the OBTWG agree to this option and site (B. Kennedy, personal communication).

Fisheries and Oceans Canada favors site D if a multi-species refuge rather than a nerkid channel is to be built. This site is situated within the only remaining natural piece of river and should probably be left untouched (B. Louis, personal communication).

It should be stressed that the Fisheries and Oceans Canada inspection was preliminary only and limited to sites identified by the author. A site selected by Canada/British Columbia Okanagan Basin Agreement, Task 163, (1972) on the west bank beside drop structure 13 (described in the Phase 1 Report, p. 50) was not included in the inspection. A thorough review of all potential sites should take place if this option is chosen.

Operation and Maintenance

A detailed discussion of operation and maintenance is premature. Nevertheless, the need for regular maintenance and monitoring should not be overlooked if maximum rates of production are desired. High egg to fry survival at successful channels is attributable to the prevention of problems like gravel stratification, plugged screens, iced headgates, channel leakages, water shortages and deposition of fines (V. Ewert, personal communication).

Annual assessment will also be required to quantify success and determine the need for modification.

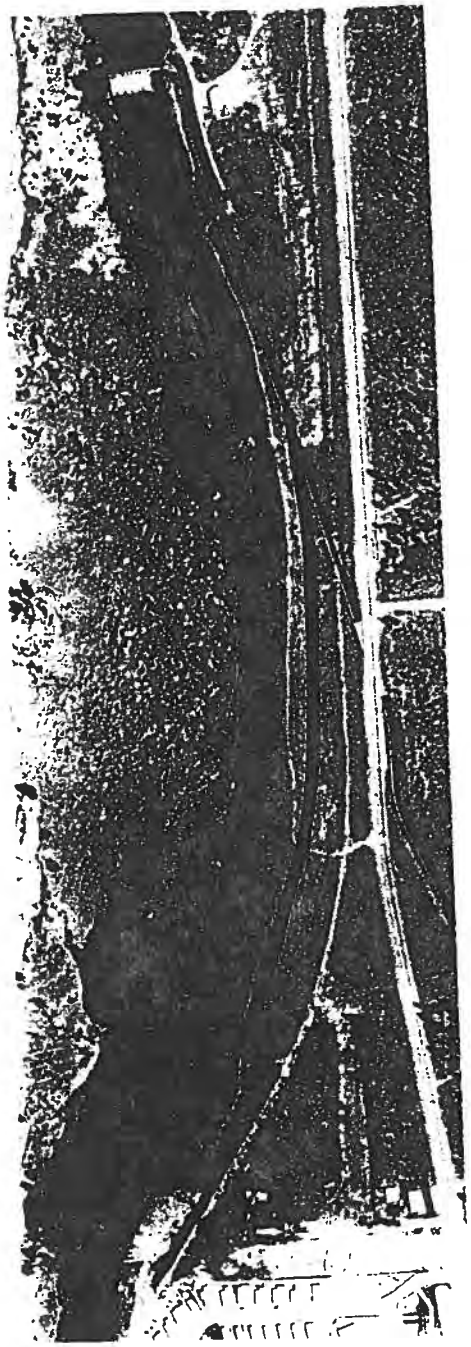
Costs and Benefits

In the present instance, where the stock is not commercially harvested, the calculation of a hypothetical benefit/cost ratio would be pointless. Nevertheless, experience with other sockeye spawning channels indicates that expenditures should be easily justified by the increase in production.

Based upon impressive benefit / cost ratios for the channels they examined, Cooper et. al. (1977) concluded that "*...channels are a practical and economically highly beneficial means of producing sockeye and pink salmon to supplement natural spawning stocks.*"

Risks

The possibility of disease breakouts, which could spread to spawning areas downstream, is mentioned by Williamson in Hilborn (1990). Williamson describes disease "reservoirs" which develop in unnatural voids in the gravel. However, the practical experience that Fisheries and Oceans Canada has had with channels in British Columbia has shown that disease is of minimal concern if channels are properly managed (comment provided through M. Flynn).



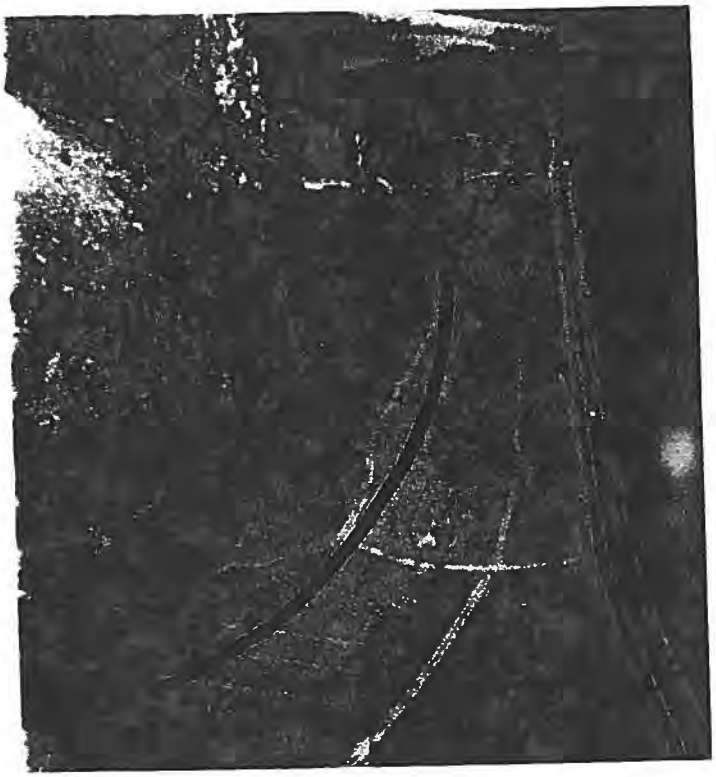


Figure 11 - Proposed spawning channel site B

An additional risk is that the channel could be used as an argument for relaxing the preferred flow regime for sockeye (as suggested in the Okanagan Basin Implementation Agreement). An understanding should be reached with the Water Management Branch prior to constructing a channel.

Implementation Steps

1. Approval (the approval process is outlined in part 4 of this report)
2. OBTWG and DCPUD refinement of proposal
3. Written agreement with Water Management Branch stating that a channel will not affect preferred flow agreements
4. DC PUD commitment to funding (including feasibility studies)
5. Discussions with owner in regard to land availability
6. Land appraisal, review of zoning requirements, and procurement
7. Application for rezoning and subdivision (if required)
8. Preliminary design
9. Site survey
10. Review of water quality and quantity (including groundwater, lake water, river water)
11. Channel and Intake design
12. Commitment to funding
13. Agency approvals
14. Water license application
15. Soil survey and assessment of gravel and rip-rap sources
16. Biological survey (probability of channel colonization)
17. Final design by multi-disciplinary team
18. Notification of interested and affected parties
19. Engineering drawings and plans
20. Contractual arrangements
21. Construction
22. Operation, maintenance and adaptive management

Note - preliminary surveys should begin as soon as possible.

PART 3

RESTORE HABITAT TO A MORE NATURAL CONDITION

1. RESTORE PORTIONS OF THE FLOOD CONTROL CHANNEL TO A MORE NATURAL STATE

Channelization of Okanagan River in the 1950s destroyed essential fish habitat: riffles and pools, streambank vegetation, large woody debris, undercut banks, emergent boulders, back eddies and side channels. It also shortened the river, increasing the gradient and velocity. Seventeen drop structures were installed to compensate for the higher gradient.

This section discusses some alternatives for restoration including:

- channel complexing
- oxbow restoration
- set back dyking
- restoring tributary streams

Channel Complexing

Additional habitat complexity can be introduced into Okanagan River by constructing a series of rock riffles informally known in BC as "Newbury Riffles". These provide cascades, pools, and chutes at locations similar to those which develop naturally in unchannelized streams. The sequence of pools and riffles form a vertical meander in the streambed to compensate for the inability of the stream to meander horizontally. A more complete description of these structures has been written by Newbury, Gaboury and Bates and can be found in chapter 12 of the British Columbia Watershed Restoration Technical Circular No. 9 edited by Slaney and Zaldokas (1997). Additional information can be found in Newbury and Gaboury, 1993 and Gaboury, Newbury and Erickson, 1995.

The complex profile of the riffle/pool system would benefit Okanagan River fish in a number of ways. In the opinion of Pat Slaney, a watershed restoration authority, it may be possible to roughly triple the amount of spawning and rearing habitat in the channelized sections (personal communication). This would benefit sockeye, kokanee, rainbow trout and mountain whitefish. Sockeye and kokanee are known to spawn in the vicinity of present drop structures where there is some complexity of habitat and hydraulic conditions. Even in low gradient reaches spawning will take place at pool tailouts and riffle crests where convex streambed profiles promote downwelling currents (Schuett-Hames and Pleus, 1996).

Pool/riffle sequences would also ease migration over the drop structures where hydraulic conditions are far from ideal. Laminar flow over the crest hampers passage, and unnatural plunge conditions prompt fish to jump prematurely and fall short of the crest. Below the structures, objects become trapped in bank to bank reversals ("drowning curls"). These are thought to disorient fry, making them more vulnerable to predation (Sheng, 1997).

Existing drop structures could be replaced by Newbury Riffles, using the base of the structures as a foundation of the riffle. This would distribute the drop over a long horizontal distance and would eliminate the drowning curl (Figure 12). Pools would provide resting areas and cover particularly in combination with revegetation of adjacent stream banks. The need for natural habitat along migration routes has often been overlooked but it is becoming increasingly recognized (Kees Groot

in Hilborn, 1990; Hourston et. al., 1954; Williams et..al., 1999; and Howard Smith, personal communication).

The idea for riffles was independently suggested by Fisheries and Oceans Canada (Sheng, 1997), and by BC Ministry of Environment Lands and Parks (I. McGregor and P. Slaney, personal communication).

Newbury Riffles also make sense from a water management point of view. Properly engineered riffle/pool sequences would reduce capital expenditures, annual maintenance and public liability.

Fisheries Renewal BC has granted funding to the Okanagan Nation Fisheries Commission to prepare a feasibility plan for installation of riffles. The project team will include Mould Engineering, Newbury Hydraulics, and Glenfir Resources. Direction will be sought from both the OBTWG and MELP Water Management Section prior to producing the final report. The completion deadline is March 31, 2000, so it will fit with an implementation plan for the present project.

Oxbow Restoration

Prior to channelization, the Okanagan River meandered through a series of oxbows which can still be seen in recent aerial photographs (Appendix 1). Greater detail is available in historic maps prepared for the Southern Okanagan Lands Irrigation Project and filed with the Oliver and District Heritage Society. Aerial photographs taken in the 1940s by the Provincial Government, are also available.

In the lower reaches of the system a number of oxbows could be restored by breaching dikes and diverting some or all of the river. However, south of VDS 5 the gradient is flat and the river was formerly shallow and silty (see Appendix 1 and Figure 13). Sockeye salmon seldom used this area, and in all probability neither did other salmonids (Hourston et. al., 1954). Restoration of the lower oxbows would benefit wildlife (Sarell and Scott, 1995), but perhaps not salmonids. It would lengthen the emigration pathway for sockeye, kokanee and lake resident trout and could increase the incidence of bass predation. Furthermore, increased flooding and mosquito problems may affect adjacent landowners.

In the slightly steeper section of the river, between VDS 5 and VDS 11, more confined, gravel based oxbows offer greater potential as rearing habitat (see Figure 13, and Appendix 1, Reaches 5-7, Aerial Plates 5-8). This may be particularly valuable for rainbow trout during the winter (Slaney, personal communication). Three possible prospects identified by MELP are:

1. Thorp Oxbow (Appendix 1, Aerial Plate 7)
2. Blue Sage Oxbow (Appendix 1, Aerial plate 5 and Figure 13)
3. Long Oxbow (Apendix 1, Aerial Plate 7)

MELP also suggests that the Thorp Oxbow could be used as a pilot project to demonstrate the benefits of further work. However before launching a program, land owners must be consulted and there is a need for survey work, test pits, and expert advice. The risk of adding additional silt and fines to the system from any of the restored oxbows will also have to be considered.

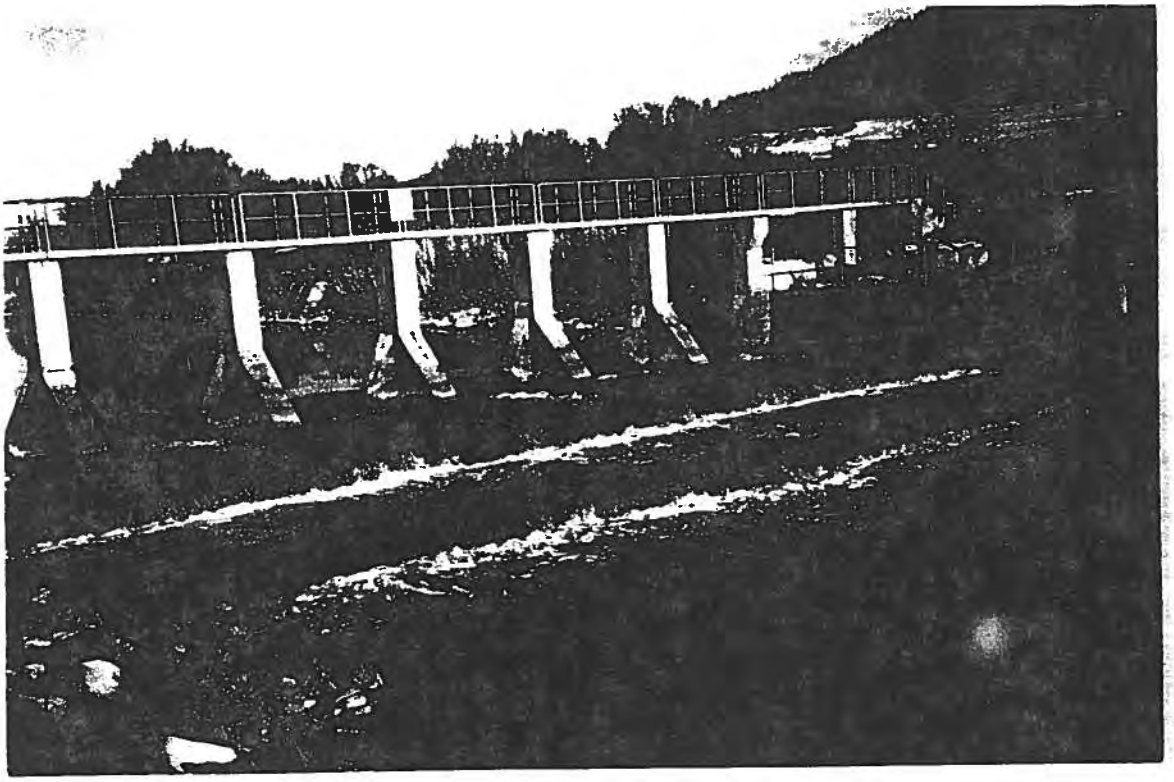
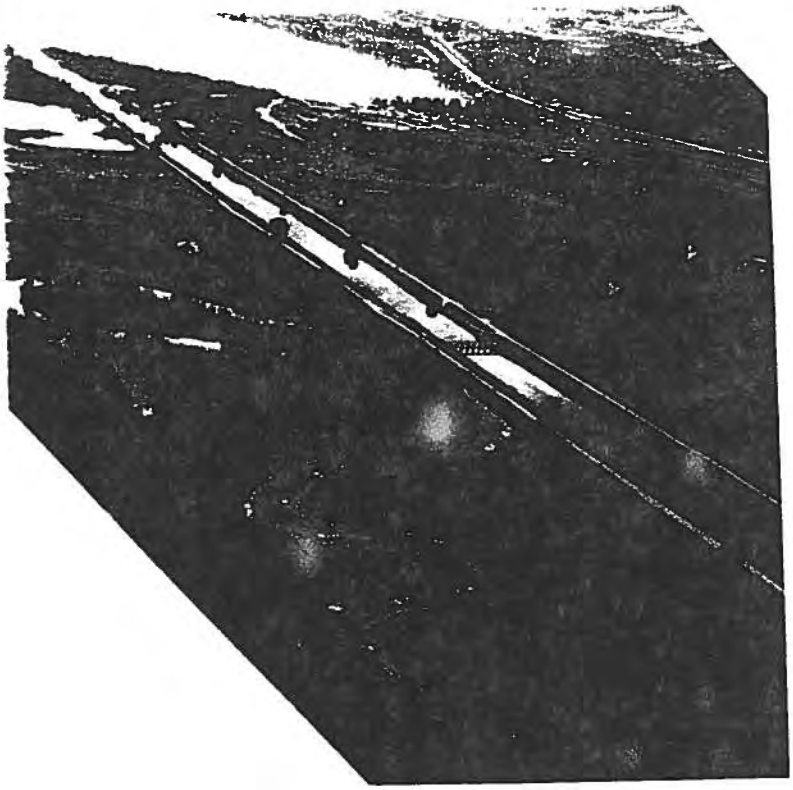


Figure 12 - A vertical drop structure and a pool/riffle sequence



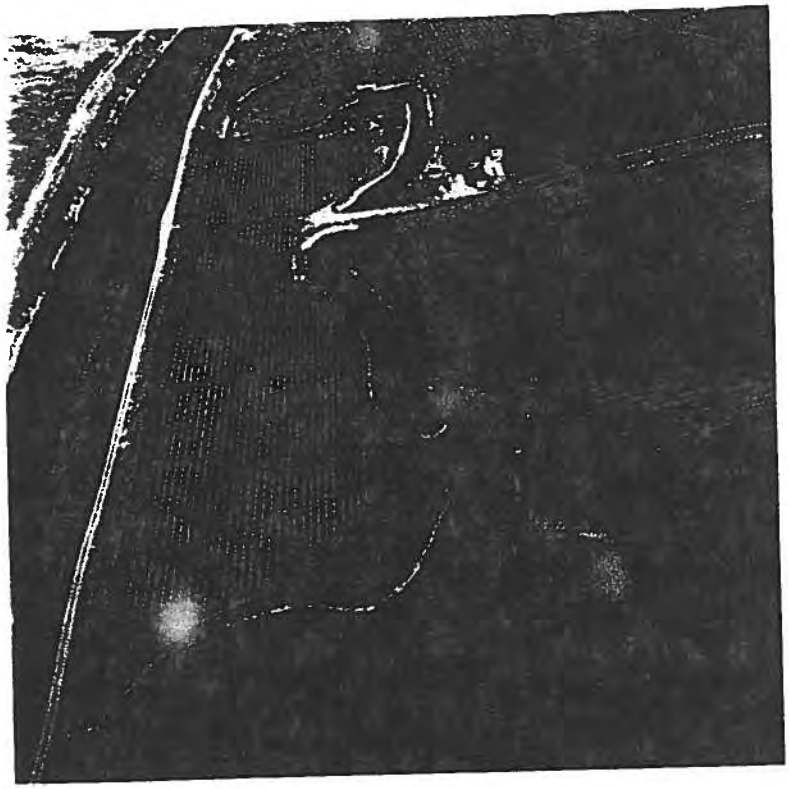


Figure 13 - MacDonald Oxbow in Reach 1 (upper) and Blue Sage Oxbow in Reach 5 (lower)

Set Back Dyking

Moving existing dikes a suitable distance from the main channel could provide space for the river to meander more normally. A sinuous thalweg (line of maximum depth) would develop naturally and would build up point bars on the inside corners, pools on the outside corners, and riffles at the points of crossover between the curves. The process is illustrated in the Phase 1 report.

Recent investigations by MELP and watershed restoration personnel concluded that in most cases, the costs and risks of pursuing this option would outweigh the benefits (I. McGregor and P. Slaney, personal communication). A possible exception might be a portion of the dike located on the northern end of the Inkaneep Park property which could be set back to allow development of an associated riffle and pool. Further information on this possibility will be available upon completion of the Newbury riffle plan mentioned earlier in this section. The decision should consider the fact that this site is located within the high production section of the river and could affect sockeye, kokanee and rainbow trout.

Restoring Tributary Streams

Many of Okanagan River tributaries are small and intermittent. Examples include Testalinden, Hester, Tinhorn, Togo, Reed, Irrigation, and Wolfcub Creeks. Larger tributaries, of interest to fisheries, include Vaseux Creek, Park Rill Creek, and Shuttleworth Creek. While not a tributary of the Okanagan River, Inkaneep Creek is also a very important part of the system. It enters Osoyoos Lake south of Okanagan River.

Pinsent believes that rainbow trout found in Okanagan River are recruited from elsewhere (Canada/British Columbia Okanagan Basin Agreement, Tech. Sup. IX,1974). Slaney (personal communication) thinks tributary streams are a major contributor. If so, Vaseux Creek, which is densely populated with rainbow (Matthews, personal communication), is undoubtedly a very important source. Vaseux Creek is also believed to be the point of origin for most of the spawning gravel in Okanagan River (R. Jubb, personal communication).

For many years a blockage impeded the migration of fish from Okanagan River into Vaseux Creek. A series of back filled weirs constructed in the 1990s rectified the situation but low flows continue to be a major impediment. Sufficient flow is found at the mouth of the canyon some 500 m upstream from Okanagan River but it percolates underground before it reaches the river. Local residents say that the percolation problem began after the creek was bulldozed for flood control in the 1950s (G. Klein, personal communication). If a solution to the percolation problem could be found, flows could be augmented by constructing a storage dam in Venner Meadows near the headwaters (S. Mould and S. Rowe, personal communication).

Shuttleworth Creek enters the Okanagan River at the downstream end of Reach 17 (see Appendix 1). This river reach supports a good fishery for rainbow trout which probably come from the creek (P. Slaney, personal communication). Lakes like Allendale and Clark in the headwaters of this system are known to be well populated with rainbow. Shuttleworth Creek is an unstable system and improvements would likely involve bank stabilization and erosion control. This would be a major undertaking and should be preceded by a watershed assessment program.

Inkaneep Creek has a relatively high degree of habitat complexity and good potential for fish production. The main constraints in the system have been water withdrawal and mass wasting (landslides) in the upper reaches. The Okanagan Nation Fisheries Commission is presently working with Fisheries and Oceans Canada towards a restoration plan (H. Wright, personal communication).

Park Rill Creek is a much smaller and much more stable system (see Appendix 1, Reach 10, Aerial Plate 11). Rainbow trout spawn in the lower end of this system and rear in groundwater fed side channels (Ray Levesque, personal communication). There appears to be a lack of good spawning substrate in the system. This may be due to moderate gradient, low maximum discharges, stable vegetated banks (ie lack of recruitment sources) and the presence of beaver dams. This could be rectified with a modest rehabilitation proposal using a public funding source such as Fisheries Renewal BC, the Habitat Conservation Trust Fund, or Stewardship funding. First, however, an adequate assessment would be needed.

Benefits and Costs

Both the benefits and costs of restoration work are impossible to estimate until the scale of the project is defined and further planning is completed. Work is underway to provide benefits, costs and risks for complexing the flood channel with Newbury riffles. Some watershed assessments have been completed on the tributaries and additional work is underway (Howie Wright, personal communication).

This work is very valuable, but it is fragmented. For a long term ecosystem approach a fish habitat restoration plan is required for the southern Okanagan Basin. These types of plans have been completed for wildlife.

For the present the OBTWG, DCPUD and Wells Coordinating Committee need to decide whether they are prepared to support restoration and at what level of funding. Once this is known the task of designing a restoration plan to meet the level of commitment can begin.

Implementation Steps

1. Approval (the approval process is outlined in part 4 of this report)
2. Consultation with Water Management Branch
3. DC PUD commitment to funding (including feasibility studies)
4. Planning and refinement of proposal
5. Agency approvals
6. Water license application
7. Notification of interested and affected parties
8. Contractual arrangements
9. Construction
10. Operation, maintenance and adaptive management

2. REVEGETATE STREAMBANKS

The benefits of streamside vegetation are well documented (see list of references in Fisheries and Oceans Canada - Streamkeepers Handbook, Module 7,1998). Plants would provide:

- streambank stability
- erosion control
- sediment and pollutant traps
- protective cover for fish
- habitat and travel routes for birds and mammals
- terrestrial insects which enter the drift
- leaf litter and plant detritus which is the base of the aquatic food chain
- woody debris which complexes the channel
- aesthetics
- shade to reduce water temperature

While all these functions are important, the latter one is critical for the Okanagan River system. Sheng (1997) says that in small streams summer temperatures increase 1 - 2 °C as the water travels through 600m of unshaded stream. Conversely temperatures drop 1 - 2 °C as water travels through a shaded stretch of similar length. Beaudry, Hudson, and Hickey, 1999 provide similar arguments for shading.

Okanagan River channel is wide and aligned in a north/south direction so shading will not be so effective. Nevertheless, streamside vegetation would reduce solar heating in the early morning and late afternoon. Furthermore, cool pockets created along the streambanks would be used by fish. Schuett-Hames and Pleus (1996) have observed this with chinook salmon in the Yakima River system. They also report that sockeye use overhead vegetation as escape cover. Revegetation would be especially effective in areas adjacent to Newbury Riffles.

Some areas of the streambank are already adequately vegetated, but others are inadequately planted or completely denuded (Figure 14). The first step in revegetation should be the preparation of a plan of what species to plant, where to plant them, who will do it and how to fund it.

Revegetation could affect the integrity of the flood control system if it is not properly planned (R. Jubb, personal communication). Federal/provincial guidelines should be taken into account (Canada/British Columbia, 1999). Wildlife needs should also be considered since the South Okanagan is one of Canada's most biologically diverse and endangered ecosystems (Sarell and Scott, 1995).

The actual work of planting is neither difficult nor expensive, but it is labor intensive. This is particularly true on the Okanagan System where the hot, dry summers require that the plants are frequently watered until they are able to develop adequate root systems. This type of work lends itself well to partnering and community involvement. For further information in this regard see the Streamkeepers Guide Module 7. A lot of similar work has been done in other areas and assistance in planning should be readily available.

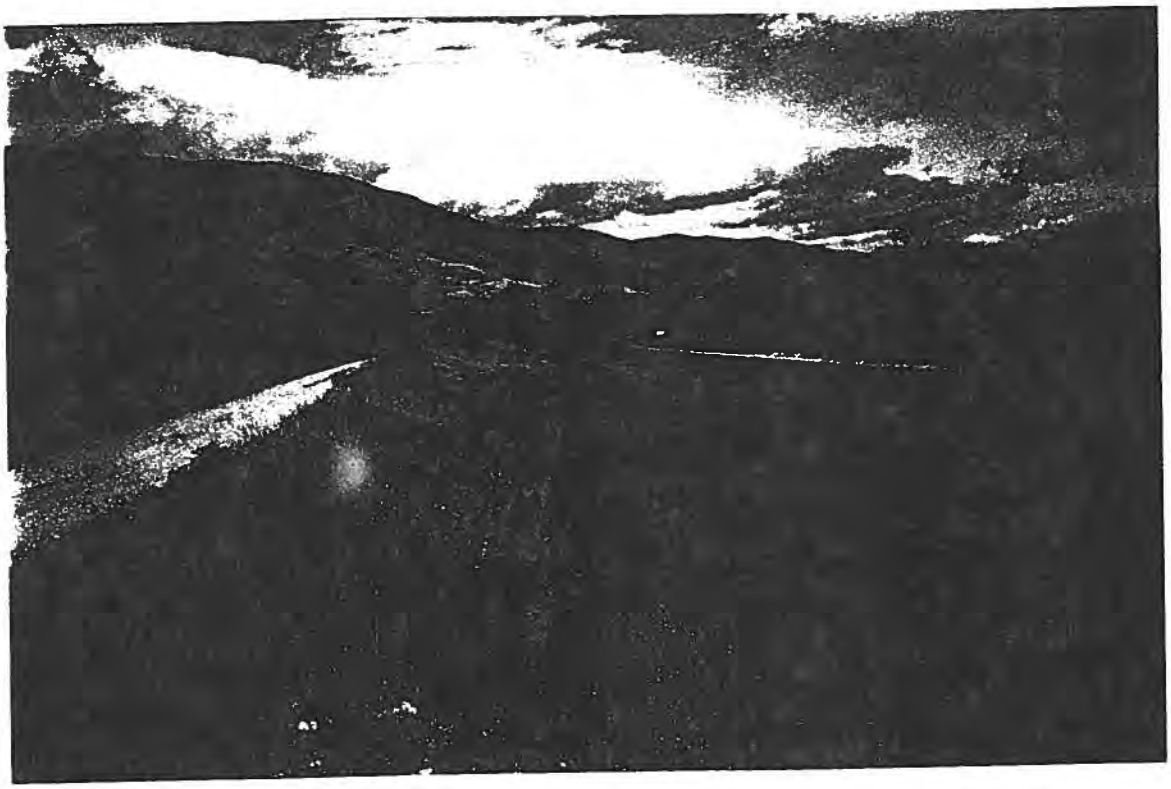


Figure 14 - Vegetated and barren portions of Okanagan River

Implementation Steps

1. Approval (the approval process is outlined in part 4 of this report)
2. Consultation with Water Management Branch
3. Refinement of proposal
4. DC PUD commitment to funding (including feasibility studies)
5. Agency approvals
6. Community involvement
7. Notification of interested and affected parties
8. Contractual arrangements
9. Planting

PART 4

IMPLEMENTATION

Implementation

Implementation Vision

The OBTWG has said that it envisions a natural ecosystem approach. This type of thinking is supported by the Independent Scientific Group (ISG) of the Northwest Power Planning Council which concluded that the Columbia River Basin Fish and Wildlife Program is "*... unlikely to recover declining salmon and steelhead stocks. Adoption of a salmon life history ecosystem concept as a guiding foundation is needed to recover depressed stocks. Increasing natural ecosystem processes and functions should rebuild salmon populations to more abundant productive, and stable levels...*" Williams et. al. (1999).

Members of the OBTWG have stressed the importance of a long range program executed on a large scale (Byron Louis and Ian McGregor - verbal presentations at the October 19, 1999 Wells Committee Meeting). They envision a large number of partners, working with several sources of funding toward an increasingly natural ecosystem.

It is necessary to keep this vision clearly in mind because the benefits of habitat restoration and particularly habitat protection are difficult to quantify in short term fry output. However, benefits are readily apparent when success is measured in long term adult returns.

Approval Process

Before any option can be implemented it must be approved. The first step in the approval process is authorization by the OBTWG. They may reject it, accept it or accept it subject to specific conditions. After they have decided which options to support, they may wish to discuss with the proponent the possibility of combining the acceptable options into a single restoration program.

Once OBTWG has authorized a program or a series of options, this will be forwarded through DCPUD to the Wells Coordinating Committee. The Wells Coordinating Committee will be asked whether the program or list of options meets the terms of the Settlement Agreement. Once again, continued dialogue between the OBTWG, DCPUD and Wells Coordinating Committee will be needed.

When OBTWG, DCPUD and Wells Committee have defined an acceptable program, DCPUD will determine whether they are prepared to commit to funding.

At the completion of this stage, the implementation steps listed under specific options can be pursued.

Partnering

Partnering and multi-sectoral involvement in fisheries management is becoming commonplace. Fisheries Renewal BC, DFO Stewardship program, and the Salmon River Round Table are cases in point. Overlaps, gaps and confusion over roles is reported, but attempts are being made to coordinate efforts and bring together partners and sources of funding (Summit Environmental Consultants Ltd., 1999).

Partnering of the Okanagan River Project with other ventures of a similar nature would provide additional funding and share risks and liabilities. There are a number of agencies and groups which might express an interest in partnering on the Okanagan River Project. Several hundred parties which may have an interest are listed by Summit Environmental Consultants Ltd.(1999) in their recent review of water stewardship in the Okanagan Valley.

Coordination with other initiatives

The South Okanagan has been identified as one of the most endangered habitats in Canada (Klenner & Scudder, 1999; and Olson & Olson, 1998). As a consequence, a large number of initiatives are underway to protect and improve wildlife habitat. Several groups are attempting to focus the work towards common goals and provide long term planning. Examples include:

- Canadian Wildlife Service (see Olson and Olson, 1998)
- RENEW (Recovery of Nationally Endangered Wildlife)
- South Okanagan Conservation Strategy
- Okanagan Basin Water Board (see Summit Environmental Consultants Ltd., 1999).

After the OBTWG, DCPUD, and Wells Coordinating Committee have reached consensus on the general direction of fisheries work, the aforementioned groups should be consulted. This will avoid the chance of working at cross purposes.

Future Direction

The next step is the approval process for the options, or perhaps the roll-up of several options into an implementation package. When this is complete the selected options can go through final design and proceed toward implementation. The need for continued cooperation and frequent consultation will be crucial.

"Coming together is a beginning;
keeping together is progress;
working together is success!"

Henry Ford

PART 5

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DRAFT
ANNUAL BYPASS OPERATION PLAN
FOR THE WELLS DAM, 2000

APPENDIX C

WELLS HYDROELECTRIC PROJECT
JUVENILE BYPASS SYSTEM OPERATIONS PLAN
for the 2000 Bypass Season

The Wells Long Term Settlement Agreement (II.F.1) specifies that Douglas PUD will submit an Annual Operations Plan for the bypass to the Wells Coordinating Committee by December prior to the spring migration. This plan will be reviewed and approved by the Committee by March 1.

The Bypass System
The PUD will install five bypass barriers in spill gates of the Wells Project. The bypass will operate per criteria in the Settlement Agreement (II.C, E).

Operation Criteria
The operation criteria includes operation of the bypass in partnership with adjacent turbine units, the amount of water required for bypass operation and criteria for full bypass system operation.

Bypass Operations Timing Criteria
The bypass will be in place from two weeks before predicted start of the migration until two weeks after the migration is complete.

Projected Hatchery Releases above Wells Dam
Estimated hatchery releases for 2000 above Wells Dam are as follows:

Facility	Species	No. in thousands	Dates
Winthrop (USFWS)	Spr. Chinook	380	4/15
Methow (WDFW)	Spr. Chinook	450	4/15
Carlton (WDFW)	Sum. Chinook	206	4/15
Similkameen (WDFW)	Sum. Chinook	294	4/15
Wells (WDFW)	Sum. Steelhead	655	4/20
Winthrop (USFWS)	Sum. Steelhead	105	5/01
Winthrop (USFWS)	Coho	200	5/15
Cassimer Bar (CCT)	Sockeye	200	10/15

Starting Dates and Ending Dates
Bypass barriers will be in place between March 15 and September 15. Hydroacoustic sampling will start on March 15 and be collected until August 29. Fyke netting will be done between March 15 to either April 10 or the start of the Bypass, which ever occurs first and again from August 15 through 31.

The bypass team will decided the start and end of bypass operation. Hydroacoustics and fyke net information at Wells will be used to show the start and completion of the spring and summer migrations. Preseason dates for bypass operation for spring and summer migration are April 10 through May 30 and July 1 through August 15.

(11/15/99)

c :\Data Files\bypass\bypass00

MEMORANDUM ON SUMMARY OF WELLS BYPASS OPERATIONS IN 1999

APPENDIX D

Memorandum

TO: Brian Cates, USFWS
Jerry Marco, Colville Confederated Tribes
FROM: Rick Klinge, Douglas PUD RK
DATE: September 1, 1999
SUBJECT: Summary of Bypass Operations at Wells Dam, 1999

==========

Flows in the river were above average for the Columbia in 1999. Wells Dam had all ten units available during the most of the bypass operations. This season, highest hourly discharge occurred on June 29 at 0200 hours with 262.3 kcfs.

Based upon the 1997 natural escapement of spring chinook and sockeye, the spring migration of yearlings should have been above average. Sockeye return at Wells in 1997 was over 25,000 adults. Natural escapement of summer / fall chinook in 1998 was lower than average. This should have been reflective in the summer migration. Compared to the 1998 hydroacoustics, the amplitude of the combined day and night index was much higher in 1999 for both the spring and summer migrations.

The bypass team used a combination of 1999 fyke net catch ratios of salmonids and historical fyke net data to adjust the hydroacoustic index for non-salmonids. From March 15 through April 10 and after August 15, actual fyke net data were used to adjust the index. Between the initiation of the bypass through May 30, it was assumed the index represented 100% salmonids. A ten-year average correction for salmonids was applied to the index from June 1 until August 15.

Hydroacoustic sampling started at Wells on March 15 to collect background data prior to the start of the spring migration. Initial levels were low and climbed after April until the bypass was initiated on April 8. The spring bypass operated until June 25 for a total of 79 days and with a total discharge of 1.84 MAF, or 7.7% of total project discharge. During the spring bypass operation there were 168 hours (8.9%) that had forced spill.

When the hydroacoustics indicate a pause between the spring and summer migrations, the bypass is suspended temporarily. The bypass team could not discern this phenomena in 1999.

Summer bypass started on June 26 at 0000h and ran until August 26, for a total of 62 days for a total bypass discharge of 1.43 MAF or 6.7 % of the total discharge. During the summer bypass operation, there were 134 hours (9.1%) that had forced spill.

There were six occasions for fyke netting this year to aid in adjustment of the raw index. Fyke netting was done on March 24, 31, April 7, and August 16, 18 and 25. The ratios of salmonids from the catch and the composition of the catch are shown in Table 1.

Figure 1. Daily hydroacoustic index values at Wells Dam, 1999

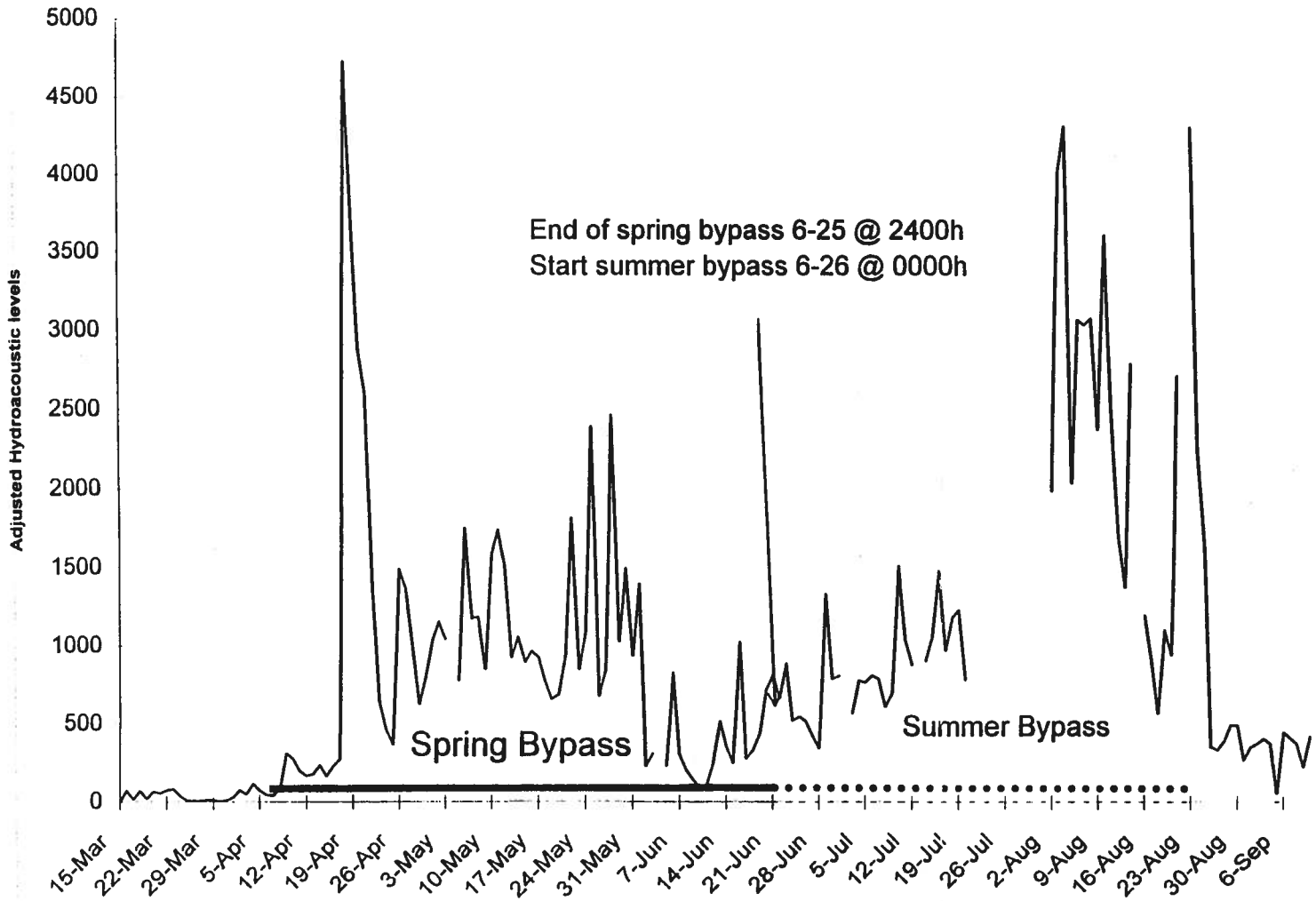


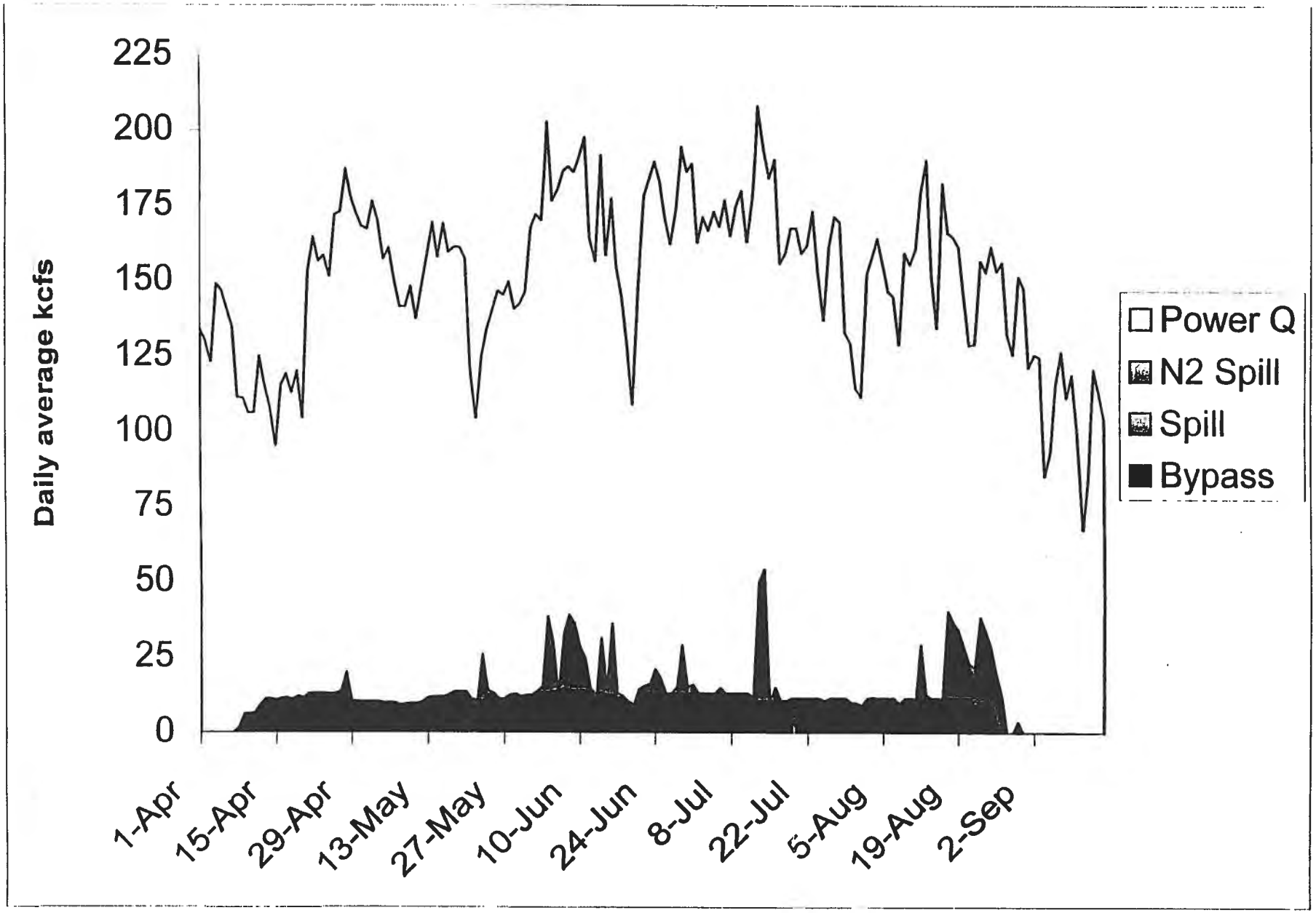
Table 1. Fyke net catches at Wells Dam, 1999.

Date	Chinook 1+	Chinook 0's	Sockeye	Steelhead	Coho	Black Bullhead	Bluegill	Burbot	Carp	Chiselmouth	Chub	Lamprey	Peamouth	Pumpkinseed	Redside Shiner	Sculpin	Small Mouth Bass	Squawfish	Sucker spp.	Walleye	whitefish	% Salmonid	Comments
24-Mar	2											6							11			15%	
31-Mar	3											10							3			50%	
7-Apr	6	0		1								6							2			78%	
16-Aug		3										6				1	1		3		1	33%	
18-Aug		16									1	5				4			4			64%	
25-Aug		1								3		1							4	1		11%	
TOTAL	11	20	0	1	0	0	0	0	0	3	1	34	0	0	0	5	1	0	27	1	1		

Note: Night fyke netting was between 2200 - 0700 hours

% salmonids is percent of chinook, sockeye and steelhead of total sample. Lamprey are excluded from total.

Figure 2. Daily average bypass flow, discharge and spill at Wells Dam 1999.



Appendix 1. Hydroacoustic values for day and night hours from Wells Dam, 1999.

WELLS BYPASS OPERATION FOR 1999
Hydroacoustic Index Values & fyke net summary
(Day value 1300 - 1700 Night value 2200 - 0200)

data from R. Klinge
9/10/99 14:51

DATE	Hydroacoustic Index DAY	NIGHT	Total	Adjust	Fyke %	Bypass Status	Comments
15-Mar	0	71	71	71	100%	OFF	First day of pinging
16-Mar	16	0	16	16	100%	OFF	
17-Mar	69	0	69	69	100%	OFF	
18-Mar	20	0	20	20	100%	OFF	
19-Mar	61	6	67	67	100%	OFF	
20-Mar	26	29	55	55	100%	OFF	
21-Mar	41	32	73	73	100%	OFF	
22-Mar	77	5	82	82	100%	OFF	
23-Mar	30	9	39	39	100%	OFF	
24-Mar	23	52	75	11	15%	OFF	Fyke net 2 Chin 1+ and 7 suckers (15% salmonids)
25-Mar	25	23	48	7	15%	OFF	
26-Mar	35	29	64	10	15%	OFF	
27-Mar	61	30	91	14	15%	OFF	
28-Mar	74	13	87	13	15%	OFF	
29-Mar	18	5	23	3	15%	OFF	
30-Mar	65	4	69	10	15%	OFF	
31-Mar	10	46	56	28	50%	OFF	Fyke net 3 Chin 1+ and 3 suckers (50% salmonids)
1-Apr	115	34	149	75	50%	OFF	
2-Apr	38	56	94	47	50%	OFF	
3-Apr	205	25	230	115	50%	OFF	
4-Apr	53	93	146	73	50%	OFF	System down 0100 - 1600; Day value for 1 hr only
5-Apr	28	59	87	44	50%	OFF	Similk Sum Chin 1+ 590K
6-Apr	49	33	82	41	50%	OFF	
7-Apr	50	52	102	80	78%	OFF	Cassimer Bar Sockeye 1+ 15K ; Fyke netting (78%
8-Apr	120	191	311	311	100%	ON*	Bypass initiated at 1800 h; *Assumed 100% salmo
9-Apr	127	148	275	275	100%	ON	
10-Apr	136	63	199	199	100%	ON	
11-Apr	105	60	165	165	100%	ON	
12-Apr	109	68	177	177	100%	ON	
13-Apr	116	118	234	234	100%	ON	
14-Apr	78	85	163	163	100%	ON	
15-Apr	156	71	227	227	100%	ON	Methow Spr Chin 1+ 494K
16-Apr	186	88	274	274	100%	ON	Winthrop release 545K Spr Ch. (4-15)
17-Apr	276	4453	4729	4729	100%	ON	Carlton Sum Chin 1+ 390K; volit. on 4-15
18-Apr	244	3502	3746	3746	100%	ON	
19-Apr	456	2425	2881	2881	100%	ON	First Day of survival study
20-Apr	478	2125	2603	2603	100%	ON	
21-Apr	266	1104	1370	1370	100%	ON	
22-Apr	169	472	641	641	100%	ON	
23-Apr	168	300	468	468	100%	ON	
24-Apr	226	143	369	369	100%	ON	
25-Apr	332	1159	1491	1491	100%	ON	
26-Apr	489	876	1365	1365	100%	ON	
27-Apr	395	602	997	997	100%	ON	

Appendix 1. Hydroacoustic values for day and night hours from Wells Dam, 1999.

DATE	Hydroacoustic Index DAY	NIGHT	Total	Adjust	Fyke %	Bypass Status	Comments
28-Apr	418	211	629	629	100%	ON	
29-Apr	374	428	802	802	100%	ON	
30-Apr	277	759	1036	1036	100%	ON	
1-May	475	679	1154	1154	100%	ON	
2-May	349	696	1045	1045	100%	ON	
3-May					100%	ON	problem with system from 2000 - 1030 on 5-4-99
4-May	125	656	781	781	100%	ON	
5-May	511	1241	1752	1752	100%	ON	
6-May	367	809	1176	1176	100%	ON	
7-May	325	859	1184	1184	100%	ON	
8-May	373	480	853	853	100%	ON	
9-May	531	1052	1583	1583	100%	ON	
10-May	435	1305	1740	1740	100%	ON	
11-May	646	866	1512	1512	100%	ON	
12-May	454	474	928	928	100%	ON	
13-May	376	682	1058	1058	100%	ON	
14-May	540	355	895	895	100%	ON	
15-May	443	524	967	967	100%	ON	
16-May	480	447	927	927	100%	ON	
17-May	553	221	774	774	100%	ON	
18-May	439	219	658	658	100%	ON	Night index 2200 - 0000. Problem after 0000 hrs
19-May	399	289	688	688	100%	ON	
20-May	357	583	940	940	100%	ON	
21-May	1323	492	1815	1815	100%	ON	
22-May	259	594	853	853	100%	ON	
23-May	268	820	1088	1088	100%	ON	
24-May	379	2015	2394	2394	100%	ON	
25-May	382	298	680	680	100%	ON	
26-May	329	523	852	852	100%	ON	
27-May	1714	751	2465	2465	100%	ON	
28-May	314	718	1032	1032	100%	ON	
29-May	893	602	1495	1495	100%	ON	
30-May	301	639	940	940	100%	ON	
31-May	763	632	1395	1395	100%	ON	
1-Jun	276	161	437	232	53%	ON	Starting June 1, will use historical fyke net ratio.
2-Jun	405	221	626	311	50%	ON	
3-Jun					47%	ON	problem with system
4-Jun	317	204	521	231	44%	ON	T-4 (east side) out. Adjust for 3 ducers.
5-Jun	1297	335	1632	825	51%	ON	
6-Jun	599	183	782	305	39%	ON	
7-Jun	279	243	522	203	39%	ON	T-4 back working
8-Jun	241	158	399	141	35%	ON	
9-Jun	213	76	289	91	32%	ON	
10-Jun	174	147	321	107	33%	ON	
11-Jun	329	392	721	240	33%	ON	
12-Jun	435	1073	1508	517	34%	ON	

Appendix 1. Hydroacoustic values for day and night hours from Wells Dam, 1999.

DATE	Hydroacoustic Index DAY	NIGHT	Total	Adjust	Fyke %	Bypass Status	Comments
13-Jun	648	629	1277	358	28%	ON	
14-Jun	414	224	638	251	39%	ON	
15-Jun	228	2322	2550	1023	40%	ON	
16-Jun	492	184	676	277	41%	ON	
17-Jun	543	272	815	328	40%	ON	
18-Jun	628	452	1080	440	41%	ON	
19-Jun	1270	446	1716	717	42%	ON	
20-Jun	1354	758	2112	811	38%	ON	
21-Jun	806	1341	2147	666	31%	ON	
22-Jun	1082	1337	2419	886	37%	ON	
23-Jun	692	814	1506	521	35%	ON	
24-Jun	514	946	1460	545	37%	ON	
25-Jun	919	391	1310	514	39%	ON	Spring Bypass ends at 2400h
26-Jun	626	511	1137	425	37%	ON	Summer Bypass starts at 0000h
27-Jun	496	325	821	345	42%	ON	
28-Jun	662	2137	2799	1331	48%	ON	
29-Jun	639	1027	1666	788	47%	ON	
30-Jun	770	739	1509	806	53%	ON	
1-Jul	nd	nd			50%	ON	problem with system @ 0200h
2-Jul	617	480	1097	570	52%	ON	
3-Jul	1153	397	1550	775	50%	ON	
4-Jul	1234	295	1529	765	50%	ON	
5-Jul	1056	337	1393	808	58%	ON	
6-Jul	981	424	1405	787	56%	ON	
7-Jul	834	298	1132	611	54%	ON	
8-Jul	995	293	1288	696	54%	ON	
9-Jul	1604	871	2475	1510	61%	ON	
10-Jul	1099	606	1705	1040	61%	ON	
11-Jul	842	488	1330	878	66%	ON	
12-Jul					66%	ON	No data.
13-Jul	161	1210	1371	905	66%	ON	
14-Jul	1164	442	1606	1060	66%	ON	
15-Jul	1436	806	2242	1480	66%	ON	
16-Jul	983	615	1598	975	61%	ON	
17-Jul	1478	398	1876	1182	63%	ON	
18-Jul	927	965	1892	1230	65%	ON	
19-Jul	623	644	1267	786	62%	ON	
20-Jul					68%	ON	No data. Problem with system
21-Jul					72%	ON	No data. Problem with system
22-Jul					69%	ON	No data. Problem with system
23-Jul					69%	ON	No data. Problem with system
24-Jul					69%	ON	No data. Problem with system
25-Jul					70%	ON	No data. Problem with system
26-Jul					79%	ON	No data. Problem with system
27-Jul					74%	ON	No data. Problem with system
28-Jul					74%	ON	No data. Problem with system

Appendix 1. Hydroacoustic values for day and night hours from Wells Dam, 1999.

DATE	Hydroacoustic Index DAY	NIGHT	Total	Adjust	Fyke %	Bypass Status	Comments
29-Jul					74%	ON	No data. Problem with system
30-Jul					71%	ON	No data. Problem with system
31-Jul					72%	ON	No data. Problem with system
1-Aug	1635	1053	2688	1989	74%	ON	System fixed @ 1500h
2-Aug	2435	3007	5442	4027	74%	ON	
3-Aug	1775	3973	5748	4311	75%	ON	
4-Aug	2383	572	2955	2039	69%	ON	
5-Aug	2304	2143	4447	3068	69%	ON	
6-Aug	2303	2226	4529	3034	67%	ON	
7-Aug	2734	1926	4660	3076	66%	ON	
8-Aug	2902	936	3838	2380	62%	ON	
9-Aug	5474	857	6331	3609	57%	ON	
10-Aug	5027	565	5592	2516	45%	ON	
11-Aug	3016	1030	4046	1699	42%	ON	
12-Aug	1952	1775	3727	1379	37%	ON	
13-Aug	3456	4088	7544	2791	37%	ON	
14-Aug	3341				34%	ON	Computer locked up on night index
15-Aug	1090	2060	3150	1197	38%	ON	
16-Aug	718	2063	2781	918	33%	ON	Fyke net 3 chin 0's, 6 resident fish 33.3% salmonid
17-Aug	1148	577	1725	569	33%	ON	
18-Aug	1148	577	1725	1104	64%	ON	Fyke net 16 chin 0's, 9 resident fish 64% salmonid
19-Aug	1043	434	1477	945	64%	ON	
20-Aug	2203	2037	4240	2714	64%	ON	
21-Aug	3145	nd			64%	ON	Computer locked up on night index
22-Aug	3990	2738	6728	4306	64%	ON	
23-Aug	2600	944	3544	2268	64%	ON	
24-Aug	1404	1172	2576	1649	64%	ON	
25-Aug	2048	1147	3195	355	11%	ON	Fyke net 1 chin 0's, 8 resident fish 11% salmonids
26-Aug	2408	566	2974	330	11%	OFF	Summer Bypass ends @ 0900.
27-Aug	2738	766	3504	389	11%	OFF	
28-Aug	3321	1113	4434	492	11%	OFF	
29-Aug	3027	1380	4407	489	11%	OFF	
30-Aug	1473	948	2421	269	11%	OFF	
31-Aug	2848	305	3153	350	11%	OFF	
1-Sep	1482	1880	3362	373	11%	OFF	
2-Sep	1192	2457	3649	405	11%	OFF	
3-Sep	2124	1221	3345	371	11%	OFF	
4-Sep	373	163	536	59	11%	OFF	
5-Sep	3067	965	4032	448	11%	OFF	
6-Sep	2142	1541	3683	409	11%	OFF	
7-Sep	2583	758	3341	371	11%	OFF	
8-Sep	1302	729	2031	225	11%	OFF	
9-Sep	3132	636	3768	418	11%	OFF	last day of pinging
10-Sep							
11-Sep							

DISSOLVED GAS MONITORING AT WELLS DAM FOREBAY AND TAILRACE, 1999

APPENDIX E

Dissolved Gas Monitoring at Wells Dam Forebay and Tailrace, 1999

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April 2000

Dissolved Gas Monitoring at Wells Dam Forebay and Tailrace, 1999

Introduction

Total dissolved gas (TDG) levels at mid-Columbia dams have been monitored during the spring and summer months since the early 1980's. These data provide information on how projects either contribute or reduce TDG in the Columbia River. Spill at hydroelectric dams can increase TDG during months when adult and juvenile salmonids are migrating in the river. It has been well documented that fish can be injured or die from sustained exposure to elevated dissolved gas. Today, TDG in the Columbia River is monitored at the forebay of all hydroprojects and at least one point in the tailrace.

Initial review in 1996 of TDG generation at Wells Dam compared forebay to forebay data between Wells and Rocky Reach Dam. This initial comparison showed a reduction of gas levels. In 1997, the third highest flow year on record, tailrace measurements at Wells were collected from a boat at least once a week. Readings showed an increase in forebay to tailrace TDG over an eight week period of forced spill (Klinge, 1998). A fixed monitor in the tailrace in 1998 also showed a slight increase in TDG when spill events occurred (Klinge, 1999).

Wells Dam was built as a hydrocombine; that is the spillway is situated directly above the powerhouse. The eleven spill gates at Wells have vertical lift gates with bottom discharge. The water level of the tailrace is within five feet of the spill ogee elevation under most spring flow conditions. Thus there is little to no vertical plunge of spill. The juvenile bypass system modified five spillway entrances to improve attraction velocity for guidance of salmon and steelhead smolts. The even numbered gates (2,4,6,8,and 10) are dedicated for bypass operation. Two of the five modified spillways have top spill trash sluice ways. Bypass flow through top gates (less than 2,000 cfs) drops approximately 70 feet. All forced spill and nitrogen replacement spill, is passed through the remaining odd numbered gates.

In 1999, TDG was recorded at 15 minute intervals from the forebay and tailrace at Wells. This report describes methods and results of TDG data collection along with river discharge and spillway volumes.

Methods

Two Hydrolab MiniSonde sensors equipped with a dissolved gas and temperature probe collected data every fifteen minutes from April 1 to September 15. The forebay sensor was located midway across the face of the dam at Unit 5 and the tailrace sensor was located on the left bank approximately 2 miles below the dam (Figure 2). Both sensors were placed at 15 feet below normal forebay and tailwater levels. Data from both stations were automatically transmitted by radio and stored in a file on a personal computer. Data on the hour were sent via the Internet to the Army Corps of Engineers for posting at various Web pages. The manufacturer calibrated the sensors at the beginning of the season. Service to each probe during the season was limited to an inspection of the probe membrane and removal of silt and algae. Barometric data were recorded from a Capricorn 2000 weather station with an electronic barometer located on the deck of the dam at approximately elevation 807. These data were used in both forebay and tailwater calculations of TDG. The Douglas PUD Power Operations provided hydraulic data for discharge and spill.

Figure 1. Location of Wells Dam on the Columbia River.

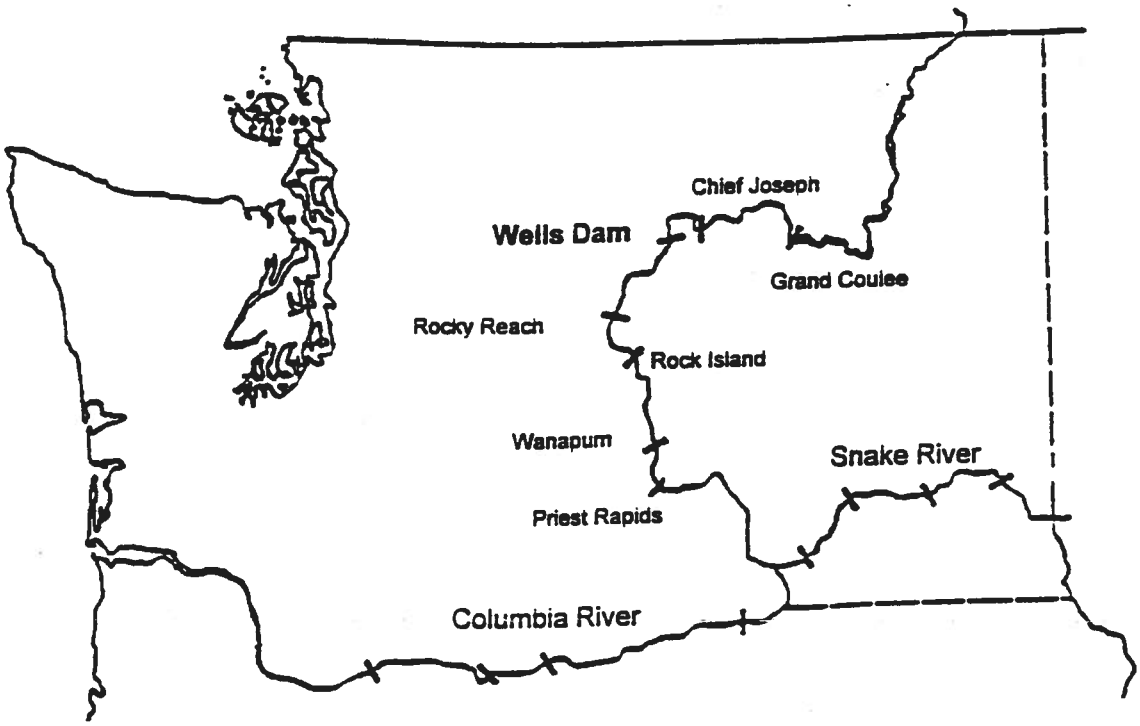
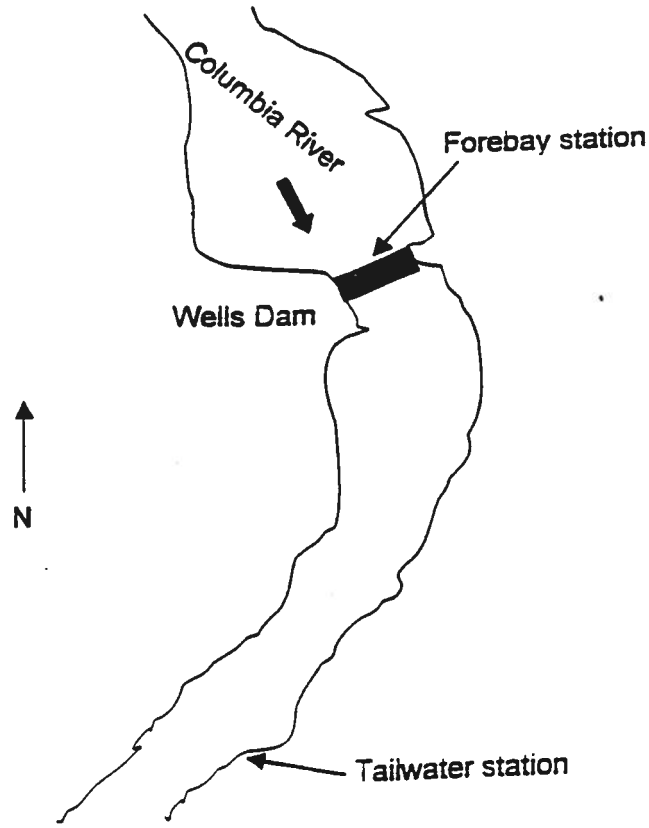


Figure 2. Wells Dam and the TDG sampling locations.



Results

There were just under 16,000 fifteen minute intervals of records collected between April 1 and September 15. The systems for transmitting and logging data had intermittent problems as records either were not logged or were stuck (repeated values). I removed records if water temperature data changed more than 0.2°F in fifteen minutes or less than 0.05° F in 60 minutes. Barometric pressure and forebay gas pressure data was removed if it changed more than 2.0 mmHg in fifteen minutes or if it showed less than a 0.5 mmHg change in 60 minutes. Tailwater gas pressure data were eliminated only if there were no changes over four consecutive records. After quality control was applied, there were 12,699 records of water temperature (80%), 11,385 records of barometric pressure (71%), 12,126 records of gas pressure from the forebay (76%) and 12,698 records of gas pressure in the tailwater (80%).

Forebay TDG

TDG levels between April 1 and September 15 are shown in Figure 3. The range of values from the 15 minute records were low at 103.7% on May 5 at 0929 hours and high at 115.6% on June 11 at 0114 hours. The daily 12 hour average from the forebay at Wells exceeded 110% on 80 days, the longest continuous stretch being from June 27 until August 12. The highest 12 hour average for the forebay was 113.9% on July 28 (Figure 4; Appendix A).

Tailrace TDG

Tailrace TDG values ranged between 102.2% on September 11, at 0559 hours to 131.6% on July 13 at 0744 hours (Figure 3). The 12 hour average exceeded 110% for 103 days; the longest continuous period being from June 7 until August 30. The 12 hour average exceeded 115% for twenty one days and

Figure 3. Forebay and tailwater TDG levels at Wells Dam, 1999.

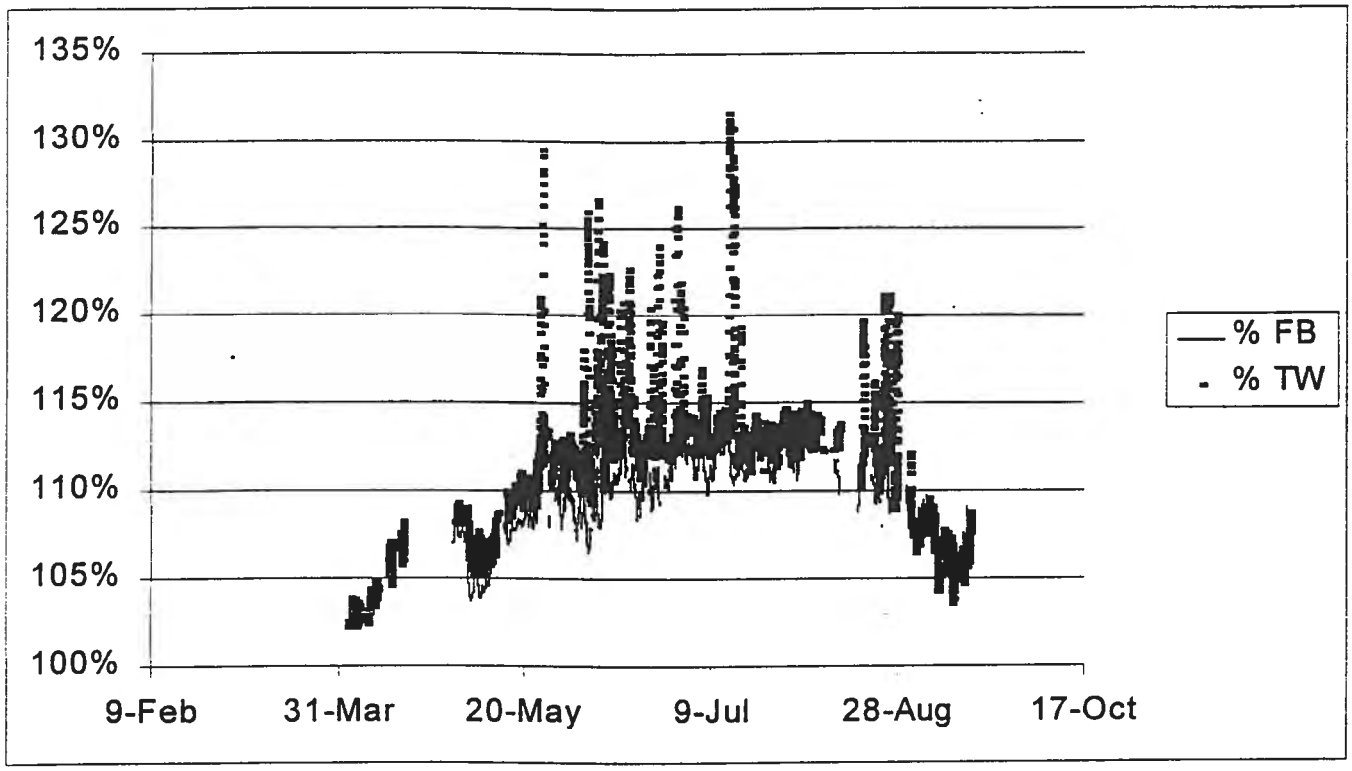
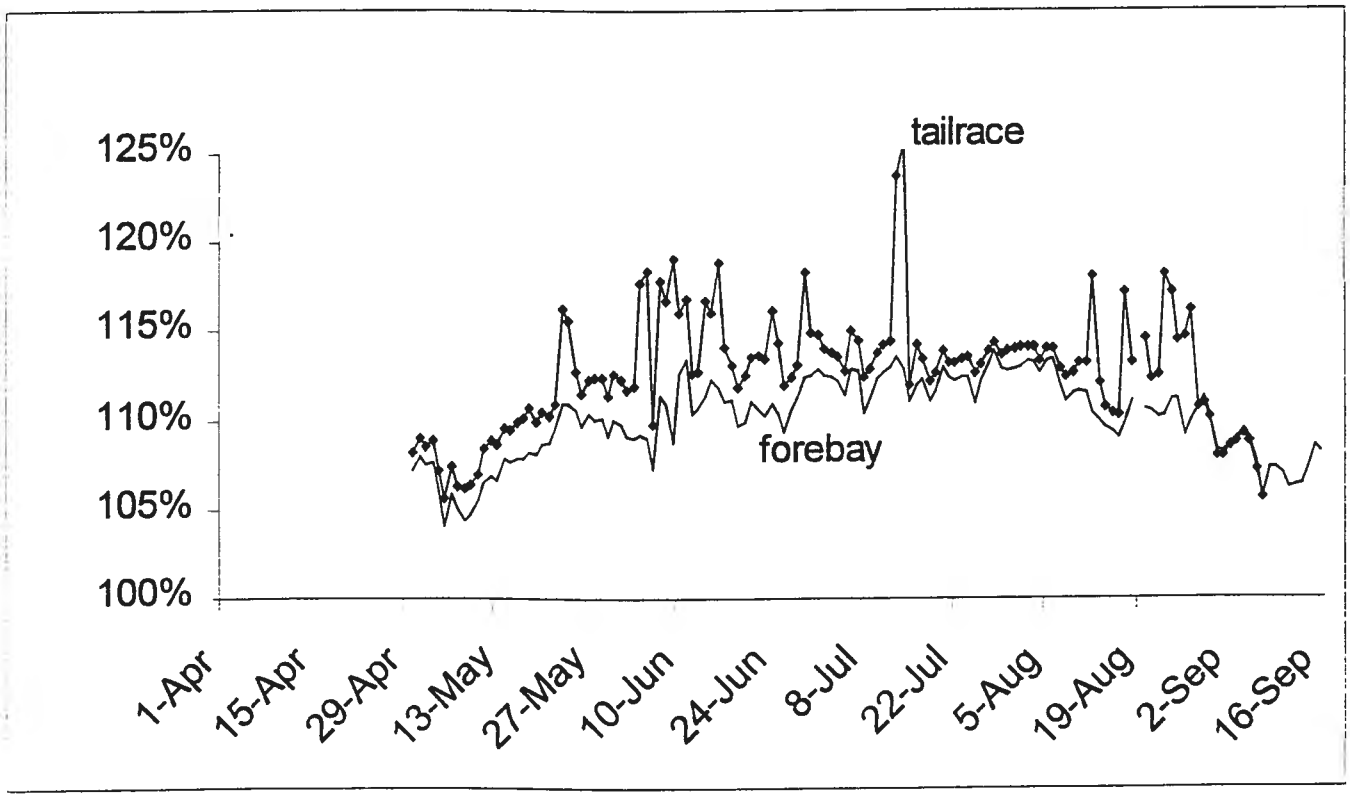


Figure 4. 12 Hour average forebay and tailwater TDG levels at Wells Dam, 1999



exceeded 120% on two days, July 13 and 14 (see Figure 4; Appendix A). The peak 12 hour average TDG from the tailrace was 126% on July 14.

Flows at Wells Dam were above average during the spring and summer of 1999. The flow at Grand Coulee between January and July was 69.7 million acre feet or 113% normal (Roger Ross, Corps of Engineers, personal communication). Daily average discharge and all spills are shown in Figure 5. Peak discharge occurred on June 29 at 0200 hours at 262 thousand cubic feet per second (kcfs). Daily average flow (24 hour average) between April 1 and September 15 ranged from 68 to 208 kcfs (Appendix B).

Spill at Wells was a combination of juvenile bypass flow, forced spill and nitrogen replacement spill. There was no spill until the bypass system was operated to protect migrating juvenile salmon and steelhead. The bypass operated for the spring migration from April 8 to June 25 and for the summer migration from June 26 to August 26. Bypass operation used approximately 6% to 10% of the project flow. Forced spill occurred over 46 days with a peak hourly spill volume of 113.4 kcfs on July 13 at 0700 hour. Nitrogen replacement spill was received on June 4 and 5 at a volume of 25 kcfs over a total of 14 hours. Combined spill was analyzed with regards to how it changed TDG between forebay to tailrace sensors. Percent spill verses the change in forebay to tailrace TDG suggests that every 4% of river spilled, TDG would increase by 1% ($R^2 = 0.65$, $p<0.001$; Figure 6).

Of the 12,837 readings collected in 1999, 20% of the records occurred with no spill. On the average, there was no difference in TDG from forebay to tailrace for non-spill hours.

There was a delay once spill was initiated before the tailwater sensor located two miles below the project, showed an increase in dissolved gas pressure. Isolated spill events were reviewed to track response time of TDG to the tailwater sensor (Table 1). The response time generally dropped as total discharge increased.

Table 1. Lag response in minutes at the tailwater sensor from isolated spill event

Date	Time	Spill Q (kcfs)	Percent Spill	Total Q (kcfs)	Lag response minutes
July 6	0145	34.2	22.8%	149.9	135
June 4	1940	94.7	55.1%	171.8	120
August 26	1715	44.3	25.3%	175.0	120
June 16	0200	67.7	36.4%	186.1	120
May 23	2244	117.6	60.7%	193.7	90
June 24	0200	84.0	43.3%	194.2	75
June 7	1940	115.0	46.4%	247.7	75
June 29	0030	120.8	53.5%	255.8	75

Table 2. Percent spill and percent change TDG from tailwater to forebay for data on the hour.

% spill	Occurrences	TDG Change	Min Change	Max Change
0 – 5%	473	-0.3%	-1.6%	7.9%
5 – 10%	2252	1.6%	-0.5%	18.6%
10 – 15%	318	2.0%	0.1%	14.8%
15 – 20%	79	4.7%	0.1%	12.2%
20 – 30%	112	6.2%	-0.2%	17.8%
30 – 40%	45	10.3%	0.2%	16.7%
>40%	28	12.5%	0.4%	17.9%

Other hydraulic conditions

The spring and summer in 1999 produced below average temperatures in the Columbia River at Wells Dam. Water temperatures were as much as 2°F lower than average and up to 6°F lower than 1998 for the same day. Figure 6 shows the Columbia River temperatures in 1999 compared to the 14 year average at Wells Dam. Cooler temperatures were seen through out the Columbia basin in 1999 compared to 1998 (Technical Management Team, 1999)

Figure 5. Daily averages of power, forced spill bypass and nitrogen replacement spill discharges at Wells Dam, 1999

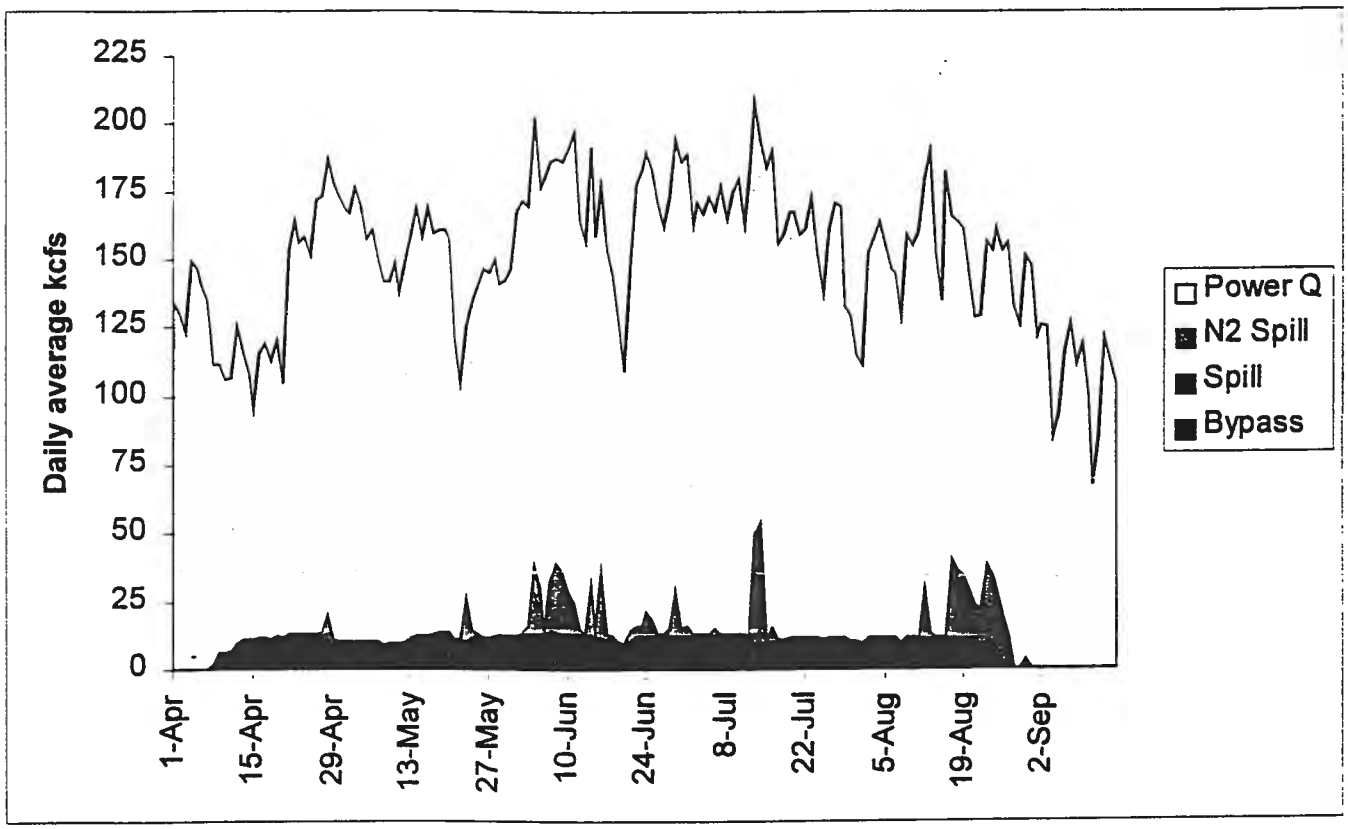


Figure 6. Relation of percent spill to percent change in TDG between tailrace and forebay TDG, Wells Dam, 1999.

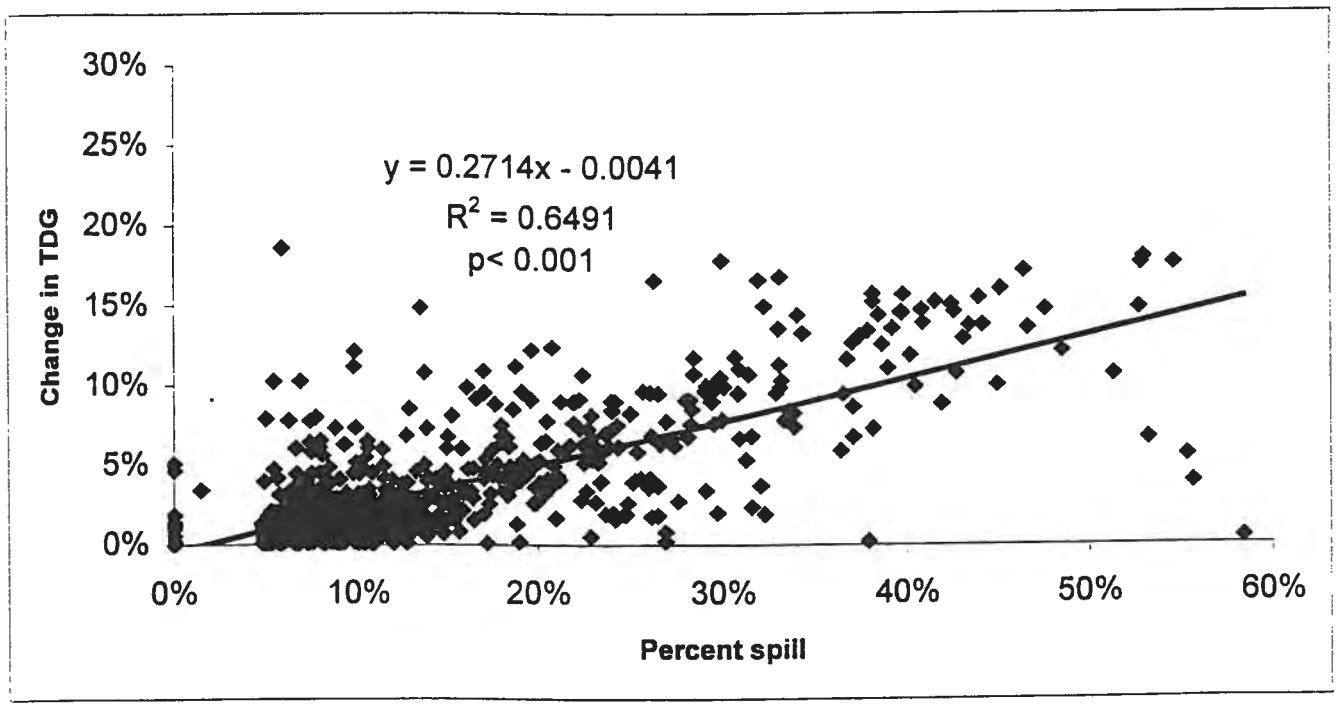


Figure 7. Columbia River temperatures, 1999 and 13 year average, Wells Dam.

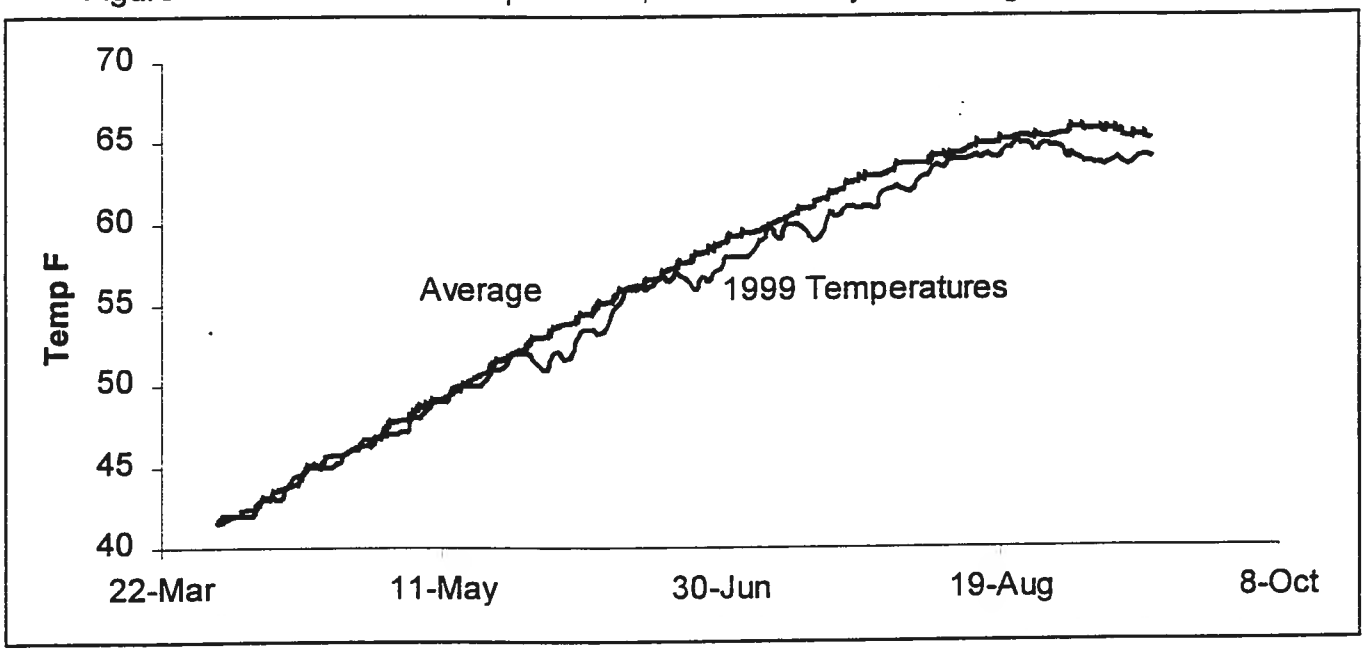
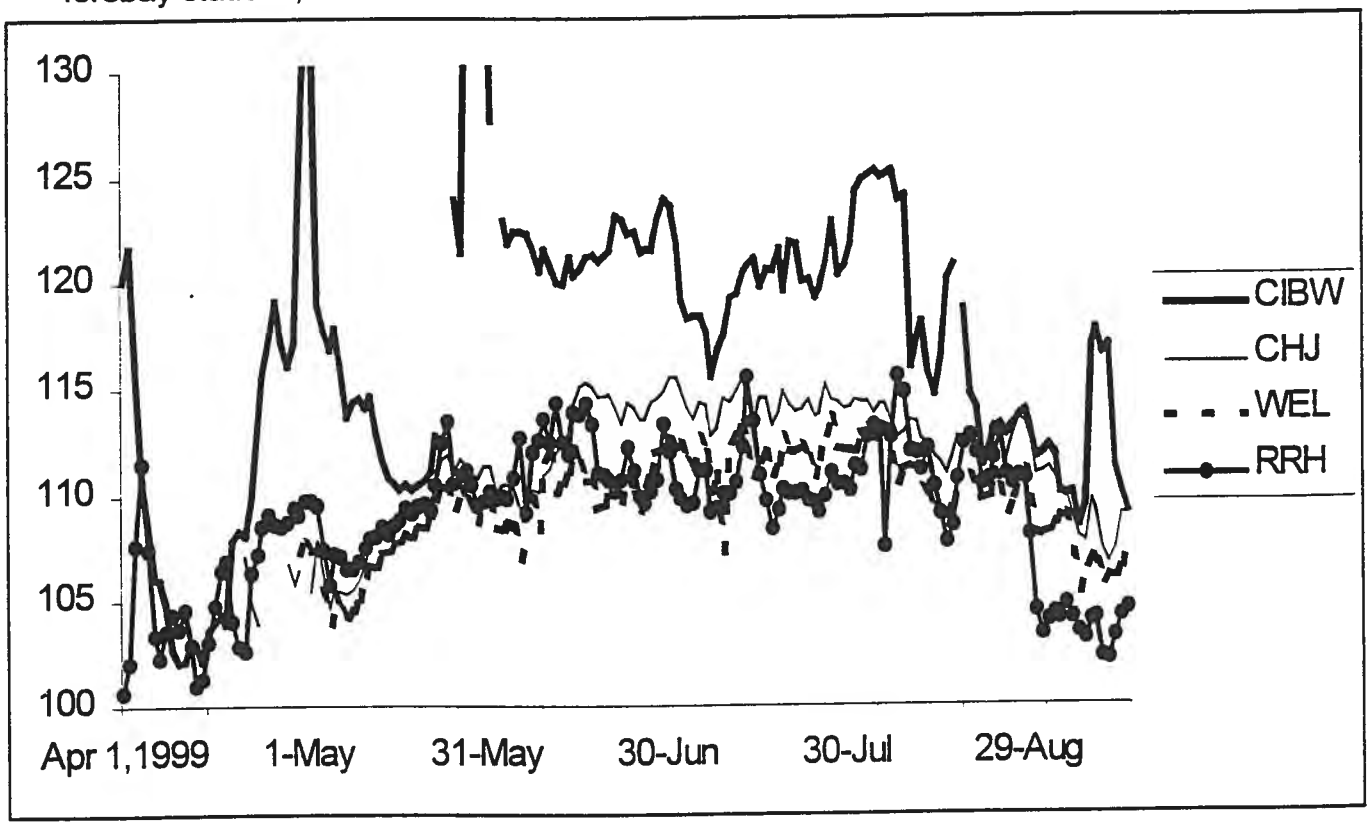


Figure 8. Receiving TDG at Boundary, Chief Joseph, Wells and Rocky Reach forebay stations, 1999.



Discussion

Forebay TDG levels at Wells appear to be driven by operations upstream, namely from Chief Joseph Dam, Grand Coulee Dam or projects in Canada. Figure 7 shows records of receiving TDG for 1998 as posted on the DART Page[1] as water reached the Boundary station (RM 745), Grand Coulee Dam (RM 597) Chief Joseph Dam (RM 545), Wells Dam (RM 515) and Rocky Reach Dam (RM 474). Data generally show a drop in TDG levels from station to station moving downstream (Figure 8). The operators at both Grand Coulee and Chief Joseph have been addressing this to minimize addition of TDG to the river.

Power peaking and load following caused changes in hourly discharge volumes. This change in volume affected the travel time of water from the dam to the tailwater sensor. The arrival of water at the tailwater sensor from a 30% spill event is slower with flows at 80 kcfs compared to 240 kcfs. This makes the development of a cause and effect model of spill to changes in TDG difficult and is largely responsible for a modest regression coefficient of percent spill to percent change in tailwater to forebay TDG (see Figure 5). There was no attempt to model response time under a range of flows. Difference in TDG between forebay to tailrace during non-spill hours ranged from -2.1% to +9.4% with an average of 0%. The +9.4% difference of TDG for a non-spill hour was recorded on August 11 at 2100 h. There was spill the hour before (2000 hours) of 25% and the hour after (2200 hours) of 15%.

In 1999, operations at Wells in from late April through May appeared to add 1.4% TDG to the receiving levels at Rocky Reach Dam. Between June 4 and June 5, high spill (> 30%) was observed during the late night and early morning hours at Wells. While this caused some hours of elevated TDG at the Rocky Reach forebay monitor, the average change from forebay to forebay for June was only 1.4% (Appendix C). In 1998, a comparison of 12 hour forebay TDG levels between Wells and Rocky Reach for the same dates shows a build of around 8% (Koehler and McDonald, 1998). This was consistent that same

[1]University of Washington DART page (http://www.cbr.washington.edu/dart/river.html).

year to the response seen at the Wells tailrace sensor of a build of 1% to every 4% spill. Though from early July to late August this relationship disappears since there was no change in TDG recorded at the forebays of Wells and Rocky Reach as Wells was dedicating 9% of the river to bypass flow.

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Koehler, Valerie A., Robert D. McDonald. 1998. Total Dissolved Gas Monitoring at Rocky Reach and Rock Island Hydroelectric Projects in 1998. Fish and Wildlife Operations, Chelan Public Utility District No. 1; Wenatchee, WA,1999

Technical Management Team 1999 Meeting Draft Minutes Nov. 3, 1999

Appendix A. TDG Sampling at Wells Dam, 1999.

Wells Dam 1999 Forebay

Total Disovled Gas Saturation (%) - Average of 12 highest, 24 h average and 24 h High

Date	24 h Avg	12 h Avg	High	# Hr	Date	24 h Avg	12 h Avg	High	# Hr	Date	24 h Avg	12 h Avg	High	# Hr	Date	24 h Avg	12 h Avg	High	# Hr
1-Apr					1-May	107.8%	108.0%	108.1%	24	1-Jun	109.6%	109.8%	110.1%	24	1-Jul	112.5%	112.9%	113.3%	24
2-Apr					2-May	107.5%	107.5%	107.7%	24	2-Jun	108.6%	109.2%	109.6%	24	2-Jul	112.2%	112.6%	113.1%	23
3-Apr					3-May	107.5%	107.7%	107.8%	24	3-Jun	108.4%	109.0%	109.5%	24	3-Jul	112.3%	112.4%	112.7%	19
4-Apr					4-May	105.4%	106.1%	106.7%	23	4-Jun	108.8%	109.3%	109.7%	24	4-Jul	111.6%	112.2%	112.6%	23
5-Apr					5-May	103.9%	104.0%	104.2%	24	5-Jun	108.5%	109.1%	109.6%	24	5-Jul	111.2%	111.5%	112.4%	23
6-Apr					6-May	105.2%	105.9%	106.2%	24	6-Jun	107.1%	107.4%	107.9%	24	6-Jul	112.7%	113.0%	113.7%	18
7-Apr					7-May	104.7%	105.1%	105.9%	24	7-Jun	110.0%	111.4%	113.4%	24	7-Jul	111.9%	112.8%	113.9%	21
8-Apr					8-May	104.3%	104.4%	104.6%	24	8-Jun	109.9%	111.0%	112.6%	24	8-Jul	110.2%	110.5%	111.0%	23
9-Apr					9-May	104.6%	104.7%	104.9%	24	9-Jun	108.5%	108.8%	110.1%	24	9-Jul	111.0%	111.2%	111.5%	23
10-Apr					10-May	105.1%	105.6%	105.8%	23	10-Jun	111.8%	112.7%	114.3%	23	10-Jul	111.9%	112.4%	113.0%	24
11-Apr					11-May	106.2%	106.5%	106.7%	24	11-Jun	112.1%	113.5%	115.5%	24	11-Jul	112.5%	112.7%	113.1%	23
12-Apr					12-May	106.8%	106.9%	107.1%	23	12-Jun	110.2%	110.4%	110.6%	24	12-Jul	112.8%	113.0%	113.3%	22
13-Apr					13-May	106.6%	106.7%	106.8%	24	13-Jun	110.6%	110.7%	110.9%	23	13-Jul	113.2%	113.6%	113.8%	24
14-Apr					14-May	107.4%	107.9%	108.0%	24	14-Jun	111.2%	111.5%	112.2%	24	14-Jul	112.1%	112.9%	114.0%	21
15-Apr					15-May	107.4%	107.7%	108.0%	24	15-Jun	112.2%	112.3%	112.7%	22	15-Jul	110.8%	111.1%	112.0%	24
16-Apr					16-May	107.7%	107.9%	108.0%	24	16-Jun	111.5%	111.9%	112.6%	24	16-Jul	111.6%	112.0%	112.3%	24
17-Apr					17-May	107.9%	107.9%	108.1%	24	17-Jun	110.7%	111.1%	111.5%	24	17-Jul	112.0%	112.3%	112.5%	24
18-Apr					18-May	108.2%	108.3%	108.4%	24	18-Jun	110.7%	111.2%	111.5%	24	18-Jul	111.0%	111.1%	111.3%	24
19-Apr					19-May	108.1%	108.2%	108.3%	24	19-Jun	109.4%	109.7%	110.4%	24	19-Jul	111.5%	111.7%	111.8%	24
20-Apr					20-May	108.6%	108.7%	108.8%	24	20-Jun	109.7%	109.9%	110.1%	24	20-Jul	112.7%	113.0%	113.1%	24
21-Apr					21-May	108.5%	108.8%	109.4%	23	21-Jun	110.7%	111.1%	111.6%	24	21-Jul	112.2%	112.4%	112.7%	24
22-Apr					22-May	109.0%	109.6%	110.8%	20	22-Jun	110.3%	110.7%	111.4%	24	22-Jul	112.1%	112.2%	112.4%	24
23-Apr					23-May	109.9%	111.0%	111.5%	24	23-Jun	109.8%	110.3%	111.0%	24	23-Jul	112.3%	112.5%	112.8%	24
24-Apr					24-May	110.6%	111.0%	111.7%	23	24-Jun	110.7%	111.0%	111.4%	24	24-Jul	111.8%	112.4%	112.8%	24
25-Apr					25-May	110.4%	110.7%	111.0%	21	25-Jun	110.0%	110.4%	111.4%	19	25-Jul	110.8%	111.0%	111.2%	24
26-Apr					26-May	109.4%	109.8%	110.4%	15	26-Jun	109.3%	109.4%	110.2%	22	26-Jul	111.7%	112.2%	112.4%	24
27-Apr					27-May	110.3%	110.4%	110.8%	23	27-Jun	110.5%	110.7%	110.8%	24	27-Jul	112.8%	113.1%	114.1%	24
28-Apr					28-May	109.9%	110.0%	110.2%	24	28-Jun	111.1%	111.3%	111.9%	21	28-Jul	113.6%	113.9%	114.5%	24
29-Apr					29-May	109.7%	110.2%	111.1%	24	29-Jun	112.0%	112.4%	112.8%	24	29-Jul	112.2%	112.9%	113.1%	29
30-Apr	107.3%	107.3%	107.6%	9	30-May	108.8%	109.1%	109.6%	24	30-Jun	112.3%	112.6%	113.1%	24	30-Jul	112.2%	112.8%	113.3%	24
					31-May	109.9%	110.1%	110.4%	24						31-Jul	112.2%	112.9%	113.6%	24
Avg					Avg	107.7%	108.0%	108.3%	23	Avg	110.2%	110.7%	111.3%	24	Average	112.0%	112.4%	112.8%	23

Appendix A. TDG Sampling at Wells Dam, 1999.

Wells Dam 1999 Forebay

Total Disovled Gas Saturation (%) - Average of 12 highest, 24 h average and 24 h High

Date	24 h Avg	12 h Avg	High	# Hr	Date	24 h Avg	12 h Avg	High	# Hr
1-Aug	113.4%	114.1%	114.5%	24	1-Sep	108.1%	108.3%	108.6%	24
2-Aug	113.7%	114.1%	114.5%	24	2-Sep	108.3%	108.7%	109.0%	24
3-Aug	113.8%	114.1%	114.3%	24	3-Sep	108.6%	109.0%	109.4%	24
4-Aug	113.1%	113.4%	113.6%	24	4-Sep	109.0%	109.3%	109.6%	24
5-Aug	113.8%	114.1%	114.2%	24	5-Sep	108.9%	109.1%	109.2%	24
6-Aug	113.7%	114.0%	114.2%	24	6-Sep	107.1%	107.7%	108.6%	24
7-Aug	112.6%	112.9%	113.3%	24	7-Sep	105.3%	105.7%	105.8%	24
8-Aug	111.9%	112.5%	113.1%	24	8-Sep	106.5%	107.3%	107.6%	25
9-Aug	112.2%	112.7%	113.2%	24	9-Sep	106.9%	107.3%	107.8%	24
10-Aug	112.9%	113.3%	113.6%	24	10-Sep	106.7%	107.1%	107.4%	24
11-Aug	112.9%	113.2%	113.4%	24	11-Sep	105.9%	106.3%	106.5%	24
12-Aug	114.7%	118.1%	126.9%	24	12-Sep	106.1%	106.4%	106.5%	24
13-Aug	109.9%	110.0%	110.1%	22	13-Sep	106.1%	106.5%	106.7%	24
14-Aug	109.4%	109.6%	110.0%	24	14-Sep	106.5%	107.2%	107.5%	24
15-Aug	109.0%	109.4%	109.5%	24	15-Sep	107.7%	108.6%	109.0%	25
16-Aug	109.0%	109.0%	109.1%	13	16-Sep	107.9%	108.3%	108.7%	24
17-Aug	109.5%	109.8%	110.4%	24					
18-Aug	110.9%	111.1%	111.3%	19					
19-Aug				0					
20-Aug	110.7%	110.7%	110.8%	7					
21-Aug	110.2%	110.5%	110.7%	24					
22-Aug	109.7%	110.1%	110.5%	23					
23-Aug	109.9%	110.3%	110.6%	24					
24-Aug	111.0%	111.2%	111.3%	24					
25-Aug	110.2%	111.2%	111.6%	24					
26-Aug	109.0%	109.2%	109.5%	24					
27-Aug	109.9%	109.9%	110.1%	24					
28-Aug	110.6%	110.7%	110.8%	24					
29-Aug	111.0%	111.3%	111.4%	24					
30-Aug	109.7%	110.3%	110.4%	24					
31-Aug	108.3%	108.4%	108.5%	24					
Avg	#####	#####	#####	22	Avg	107.2%	107.7%	108.0%	24

Appendix A. TDG Sampling at Wells Dam, 1999.

Wells Dam 1999 Tailwater

Total Disovled Gas Saturation (%) - Average of 12 highest, 24 h average and 24 h High

Date	24 h Avg	12 h Avg	High	# Hr
1-Apr				
2-Apr				
3-Apr				
4-Apr				
5-Apr				
6-Apr				
7-Apr				
8-Apr				
9-Apr				
10-Apr				
11-Apr				
12-Apr				
13-Apr				
14-Apr				
15-Apr				
16-Apr				
17-Apr				
18-Apr				
19-Apr				
20-Apr				
21-Apr				
22-Apr				
23-Apr				
24-Apr				
25-Apr				
26-Apr				
27-Apr				
28-Apr				
29-Apr				
30-Apr	108.3%	108.3%	108.6%	9
Avg				

Date	24 h Avg	12 h Avg	High	# Hr
1-May	108.8%	109.1%	109.2%	24
2-May	108.5%	108.6%	108.7%	24
3-May	108.6%	108.9%	109.0%	24
4-May	106.6%	107.2%	107.9%	23
5-May	105.5%	105.6%	105.7%	24
6-May	106.8%	107.4%	107.6%	24
7-May	106.0%	106.4%	107.3%	24
8-May	105.9%	106.2%	106.7%	24
9-May	106.2%	106.5%	107.1%	24
10-May	106.6%	107.0%	107.3%	23
11-May	107.8%	108.5%	108.7%	24
12-May	108.8%	109.0%	109.1%	23
13-May	108.7%	108.7%	108.8%	24
14-May	109.1%	109.6%	109.9%	24
15-May	109.1%	109.5%	109.9%	24
16-May	109.7%	109.9%	110.2%	24
17-May	110.0%	110.2%	110.5%	24
18-May	110.4%	110.7%	110.9%	24
19-May	109.9%	110.0%	110.2%	24
20-May	110.3%	110.6%	110.7%	24
21-May	110.0%	110.3%	110.5%	23
22-May	110.4%	110.9%	111.6%	20
23-May	113.9%	116.3%	128.3%	24
24-May	114.0%	115.6%	126.9%	23
25-May	112.4%	112.8%	113.6%	21
26-May	111.3%	111.5%	112.2%	15
27-May	111.9%	112.3%	112.7%	23
28-May	112.3%	112.5%	112.7%	24
29-May	112.1%	112.5%	112.9%	24
30-May	111.0%	111.4%	111.6%	24
31-May	112.2%	112.6%	113.0%	24
Avg	109.5%	110.0%	111.0%	23

Date	24 h Avg	Avg	High	# Hr
1-Jun	112.0%	112.3%	112.5%	24
2-Jun	111.2%	111.7%	112.1%	24
3-Jun	111.1%	111.9%	118.0%	24
4-Jun	114.4%	117.7%	123.8%	24
5-Jun	114.4%	118.4%	125.6%	24
6-Jun	109.6%	109.8%	110.3%	24
7-Jun	114.7%	117.9%	125.5%	24
8-Jun	115.1%	116.7%	120.0%	24
9-Jun	114.9%	119.1%	123.7%	24
10-Jun	114.4%	116.1%	121.6%	23
11-Jun	115.0%	116.8%	121.7%	24
12-Jun	112.4%	112.7%	115.1%	24
13-Jun	112.5%	112.7%	113.0%	23
14-Jun	114.9%	116.8%	120.3%	24
15-Jun	114.8%	116.0%	123.3%	22
16-Jun	116.9%	118.9%	122.6%	24
17-Jun	113.3%	114.1%	117.2%	24
18-Jun	112.6%	113.1%	113.6%	24
19-Jun	111.5%	111.9%	112.1%	24
20-Jun	112.3%	112.6%	112.7%	24
21-Jun	113.0%	113.6%	118.3%	24
22-Jun	113.0%	113.7%	120.4%	24
23-Jun	112.8%	113.5%	116.9%	24
24-Jun	114.6%	116.2%	123.1%	24
25-Jun	113.5%	114.4%	118.3%	19
26-Jun	112.0%	112.0%	112.0%	22
27-Jun	112.2%	112.4%	112.6%	24
28-Jun	112.9%	113.1%	115.8%	21
29-Jun	115.7%	118.3%	126.2%	24
30-Jun	114.2%	114.9%	121.9%	24
Avg	113.4%	114.7%	118.3%	24

Date	24 h Avg	12 h Avg	High	# Hr
1-Jul	114.2%	114.8%	120.0%	24
2-Jul	113.8%	114.1%	114.2%	23
3-Jul	113.7%	113.8%	114.2%	19
4-Jul	113.1%	113.6%	113.8%	22
5-Jul	112.6%	112.8%	113.0%	23
6-Jul	114.6%	115.0%	116.9%	18
7-Jul	113.6%	114.5%	115.3%	21
8-Jul	112.2%	112.4%	112.7%	23
9-Jul	112.7%	112.9%	113.1%	23
10-Jul	113.5%	113.8%	114.2%	24
11-Jul	114.0%	114.3%	114.4%	23
12-Jul	114.0%	114.4%	114.6%	22
13-Jul	118.7%	123.8%	131.2%	24
14-Jul	121.3%	125.7%	129.1%	21
15-Jul	111.8%	112.0%	112.7%	24
16-Jul	113.2%	114.2%	119.0%	24
17-Jul	113.0%	113.4%	113.6%	24
18-Jul	112.0%	112.3%	112.6%	24
19-Jul	112.6%	112.7%	112.8%	24
20-Jul	113.7%	113.9%	114.3%	24
21-Jul	113.0%	113.2%	113.5%	24
22-Jul	113.0%	113.2%	113.4%	25
23-Jul	113.3%	113.4%	113.6%	24
24-Jul	113.0%	113.6%	113.7%	24
25-Jul	112.3%	112.7%	113.2%	24
26-Jul	112.8%	113.1%	113.6%	24
27-Jul	113.6%	113.9%	114.2%	24
28-Jul	114.2%	114.4%	114.7%	24
29-Jul	113.2%	113.7%	114.1%	29
30-Jul	113.1%	113.9%	114.4%	24
31-Jul	113.3%	114.1%	114.4%	24
Avg	113.6%	114.3%	115.3%	23

Appendix A. TDG Sampling at Wells Dam, 1999.

Wells Dam 1999 Tailwater

Total Disovled Gas Saturation (%) - Average of 12 highest, 24 h average and 24 h High

Date	24 h Avg	12 h Avg	High	# Hr	Date	24 h Avg	12 h Avg	High	# Hr
1-Aug	113.4%	114.1%	114.5%	24	1-Sep	107.6%	108.0%	108.3%	24
2-Aug	113.6%	114.1%	114.5%	24	2-Sep	108.0%	108.5%	108.8%	24
3-Aug	113.8%	114.1%	114.3%	24	3-Sep	108.4%	108.8%	109.1%	24
4-Aug	113.1%	113.4%	113.6%	24	4-Sep	108.7%	109.2%	109.5%	24
5-Aug	113.8%	114.1%	114.2%	24	5-Sep	108.6%	108.8%	109.0%	24
6-Aug	113.7%	114.0%	114.2%	24	6-Sep	106.7%	107.2%	108.0%	24
7-Aug	112.6%	112.9%	113.3%	24	7-Sep	105.2%	105.6%	105.9%	24
8-Aug	111.9%	112.5%	113.1%	24	8-Sep	106.3%	107.2%	107.8%	25
9-Aug	112.2%	112.2%	113.1%	24	9-Sep	106.6%	107.2%	107.7%	24
10-Aug	112.9%	113.3%	113.6%	24	10-Sep	106.3%	106.9%	107.3%	24
11-Aug	112.9%	113.2%	113.4%	24	11-Sep	105.2%	105.9%	106.2%	24
12-Aug	114.7%	118.1%	126.9%	24	12-Sep	105.7%	106.0%	106.4%	24
13-Aug	111.7%	112.6%	114.2%	24	13-Sep	105.8%	106.3%	106.7%	24
14-Aug	110.5%	110.8%	111.1%	24	14-Sep	106.1%	107.0%	107.3%	24
15-Aug	110.1%	110.4%	110.7%	24	15-Sep	107.2%	108.2%	108.7%	25
16-Aug	110.3%	110.3%	110.9%	13	16-Sep	107.6%	108.0%	108.5%	24
17-Aug	113.9%	117.2%	119.7%	24					
18-Aug	112.8%	113.2%	115.1%	19					
19-Aug				0					
20-Aug	114.6%	114.6%	115.8%	7					
21-Aug	111.9%	112.3%	113.7%	24					
22-Aug	111.5%	112.5%	115.1%	23					
23-Aug	115.0%	118.2%	121.1%	24					
24-Aug	115.1%	117.2%	121.1%	24					
25-Aug	113.4%	114.5%	117.9%	24					
26-Aug	112.2%	114.7%	120.0%	24					
27-Aug	113.0%	116.2%	118.9%	24					
28-Aug	110.4%	110.7%	111.7%	24					
29-Aug	110.6%	111.0%	111.4%	24					
30-Aug	109.5%	110.1%	112.1%	24					
31-Aug	107.8%	108.0%	108.2%	24					
Avg	#####	#####	#####	22	Avg	106.9%	107.4%	107.8%	24

Appendix B. Daily average flows at Wells Dam, 1999.

all values in kcfs

Date	Total Q	Bypass	Spill Q	N2 Spill	Date	Total Q	Bypass	Spill Q	N2 Spill	Date	Total Q	Bypass	Spill Q	N2 Spill	Date	Total Q	Bypass	Spill Q	N2 Spill
1-Apr	134.0	0.0	0.0	0.0	1-May	168.2	167.7	0.0	0.0	1-Jun	167.7	12.6	0.0	0.0	1-Jul	189.1	13.2	2.8	0.0
2-Apr	130.2	0.0	0.0	0.0	2-May	167.3	172.2	0.0	0.0	2-Jun	172.2	13.8	0.0	0.0	2-Jul	163.0	13.2	0.0	0.0
3-Apr	123.3	0.0	0.0	0.0	3-May	176.7	170.3	0.0	0.0	3-Jun	170.3	13.5	2.0	0.0	3-Jul	171.5	13.2	0.0	0.0
4-Apr	149.0	0.0	0.0	0.0	4-May	170.0	202.8	0.0	0.0	4-Jun	202.8	13.5	16.8	8.3	4-Jul	167.0	13.2	0.0	0.0
5-Apr	146.8	0.0	0.0	0.0	5-May	157.4	176.8	0.0	0.0	5-Jun	176.8	13.8	10.4	6.3	5-Jul	173.3	13.2	0.0	0.0
6-Apr	140.7	0.0	0.0	0.0	6-May	161.0	180.4	0.0	0.0	6-Jun	180.4	14.0	0.0	0.0	6-Jul	168.3	13.2	1.8	0.0
7-Apr	134.8	0.0	0.0	0.0	7-May	150.1	186.6	0.0	0.0	7-Jun	186.6	14.9	18.5	0.0	7-Jul	177.2	13.2	0.0	0.0
8-Apr	111.5	1.7	0.0	0.0	8-May	141.6	188.1	0.0	0.0	8-Jun	188.1	14.4	24.8	0.0	8-Jul	165.2	13.2	0.0	0.0
9-Apr	111.1	6.3	0.0	0.0	9-May	141.5	186.3	0.0	0.0	9-Jun	186.3	13.8	22.5	0.0	9-Jul	175.3	13.2	0.0	0.0
10-Apr	106.2	6.3	0.0	0.0	10-May	148.3	191.6	0.0	0.0	10-Jun	191.6	14.0	14.8	0.0	10-Jul	180.3	13.2	0.0	0.0
11-Apr	106.4	6.8	0.0	0.0	11-May	137.6	197.8	0.0	0.0	11-Jun	197.8	14.0	10.8	0.0	11-Jul	163.2	13.2	0.0	0.0
12-Apr	125.2	9.3	0.0	0.0	12-May	148.3	164.6	0.0	0.0	12-Jun	164.6	13.8	1.1	0.0	12-Jul	178.3	12.2	0.0	0.0
13-Apr	115.6	11.3	0.0	0.0	13-May	158.6	156.6	0.0	0.0	13-Jun	156.6	12.9	0.0	0.0	13-Jul	208.3	10.5	39.6	0.0
14-Apr	108.2	11.3	0.0	0.0	14-May	169.6	191.8	0.0	0.0	14-Jun	191.8	13.5	17.9	0.0	14-Jul	194.0	10.7	43.7	0.0
15-Apr	95.6	11.0	0.0	0.0	15-May	157.9	158.6	0.0	0.0	15-Jun	158.6	12.7	3.3	0.0	15-Jul	184.5	10.7	0.2	0.0
16-Apr	115.5	11.6	0.0	0.0	16-May	169.2	177.6	0.0	0.0	16-Jun	177.6	12.6	23.6	0.0	16-Jul	190.6	10.7	4.4	0.0
17-Apr	119.3	11.6	0.0	0.0	17-May	159.5	154.5	0.0	0.0	17-Jun	154.5	11.6	1.6	0.0	17-Jul	156.0	10.7	0.0	0.0
18-Apr	113.0	11.1	0.0	0.0	18-May	161.1	144.7	0.0	0.0	18-Jun	144.7	12.2	0.0	0.0	18-Jul	159.3	10.7	0.0	0.0
19-Apr	120.4	12.2	0.0	0.0	19-May	161.2	128.2	0.0	0.0	19-Jun	128.2	10.4	0.0	0.0	19-Jul	167.6	11.6	0.0	0.0
20-Apr	104.6	11.6	0.0	0.0	20-May	157.4	109.3	0.0	0.0	20-Jun	109.3	9.6	0.0	0.0	20-Jul	167.7	11.6	0.0	0.0
21-Apr	153.5	13.1	0.0	0.0	21-May	121.4	147.9	0.0	0.0	21-Jun	147.9	11.5	3.0	0.0	21-Jul	159.4	11.6	0.0	0.0
22-Apr	164.6	13.2	0.0	0.0	22-May	104.6	178.2	0.0	0.0	22-Jun	178.2	13.2	2.5	0.0	22-Jul	161.9	11.6	0.0	0.0
23-Apr	156.5	13.2	0.0	0.0	23-May	125.0	184.0	15.6	0.0	23-Jun	184.0	13.2	3.1	0.0	23-Jul	173.5	11.6	0.0	0.0
24-Apr	158.5	13.2	0.0	0.0	24-May	134.2	189.7	1.5	0.0	24-Jun	189.7	13.2	7.9	0.0	24-Jul	153.0	11.6	0.0	0.0
25-Apr	151.6	13.1	0.0	0.0	25-May	140.5	183.5	0.0	0.0	25-Jun	183.5	13.2	5.1	0.0	25-Jul	137.4	10.7	0.0	0.0
26-Apr	172.0	13.2	0.0	0.0	26-May	146.7	171.3	0.0	0.0	26-Jun	171.3	13.2	0.0	0.0	26-Jul	161.8	11.6	0.0	0.0
27-Apr	173.1	13.2	0.8	0.0	27-May	145.4	162.4	0.0	0.0	27-Jun	162.4	13.2	0.0	0.0	27-Jul	171.6	11.6	0.0	0.0
28-Apr	187.4	12.4	7.8	0.0	28-May	149.8	173.7	0.0	0.0	28-Jun	173.7	13.2	2.2	0.0	28-Jul	169.8	11.6	0.0	0.0
29-Apr	178.3	10.4	0.5	0.0	29-May	140.8	194.7	0.0	0.0	29-Jun	194.7	13.2	16.0	0.0	29-Jul	133.1	11.6	0.0	0.0
30-Apr	172.7	10.4	0.0	0.0	30-May	142.5	186.6	0.0	0.0	30-Jun	186.6	13.2	2.2	0.0	30-Jul	129.5	10.2	0.0	0.0
					31-May	146.3	146.3	0.0	0.0					0.0	31-Jul	114.7	10.1	0.0	0.0
Avg	136.0	8.2	0.3	0.0	Avg	150.3	171.8	0.6	0.0	Avg	172.6	13.1	7.0	0.5	Avg	166.6	11.9	3.0	0.0

Appendix B. Daily average flows at Wells Dam, 1999.

all values in kcfs

Date	Total Q	Bypass	Spill Q	N2 Spill	Date	Total Q	Bypass	Spill Q	N2 Spill
1-Aug	111.8	9.3	0.0	0.0	1-Sep	121.7	0.0	0.0	0.0
2-Aug	152.6	11.6	0.0	0.0	2-Sep	125.9	0.0	0.0	0.0
3-Aug	158.3	11.6	0.3	0.0	3-Sep	125.0	0.0	0.0	0.0
4-Aug	164.4	11.6	0.0	0.0	4-Sep	85.5	0.0	0.0	0.0
5-Aug	155.6	11.6	0.0	0.0	5-Sep	93.5	0.0	0.0	0.0
6-Aug	146.8	11.6	0.0	0.0	6-Sep	116.0	0.0	0.0	0.0
7-Aug	145.0	11.6	0.0	0.0	7-Sep	126.8	0.0	0.0	0.0
8-Aug	129.4	9.9	0.0	0.0	8-Sep	111.6	0.0	0.0	0.0
9-Aug	159.5	11.6	0.0	0.0	9-Sep	119.3	0.0	0.0	0.0
10-Aug	155.7	11.6	0.0	0.0	10-Sep	100.2	0.0	0.0	0.0
11-Aug	160.7	11.6	0.0	0.0	11-Sep	67.6	0.0	0.0	0.0
12-Aug	180.5	11.6	17.8	0.0	12-Sep	84.9	0.0	0.0	0.0
13-Aug	190.4	11.6	1.3	0.0	13-Sep	121.1	0.0	0.0	0.0
14-Aug	152.0	11.6	0.0	0.0	14-Sep	112.9	0.0	0.0	0.0
15-Aug	134.8	11.6	0.0	0.0	15-Sep	104.1	0.0	0.0	0.0
16-Aug	182.8	11.6	0.0	0.0	16-Sep				
17-Aug	166.2	11.6	17.4	0.0	17-Sep				
18-Aug	164.7	11.6	13.6	0.0	18-Sep				
19-Aug	161.5	11.6	11.0	0.0	19-Sep				
20-Aug	144.4	11.6	5.4	0.0	20-Sep				
21-Aug	128.9	11.6	0.0	0.0	21-Sep				
22-Aug	129.3	9.4	3.1	0.0	22-Sep				
23-Aug	156.9	10.1	18.2	0.0	23-Sep				
24-Aug	153.3	10.7	12.7	0.0	24-Sep				
25-Aug	161.6	10.7	7.6	0.0	25-Sep				
26-Aug	153.5	4.0	11.8	0.0	26-Sep				
27-Aug	156.4	0.0	12.7	0.0	27-Sep				
28-Aug	132.7	0.0	0.0	0.0	28-Sep				
29-Aug	125.9	0.0	0.0	0.0	29-Sep				
30-Aug	151.6	0.0	3.7	0.0	30-Sep				
31-Aug	147.7	0.0	0.0	0.0					
Avg	152.1	9.2	4.4	0.0	Avg	107.7	0.0	0.0	0.0

Appendix C. 1999 Daily average TDG data for Boundary, Grand Coulee, Chief Joseph, Wells and Rocky Reach.

Date	CIBW	GCL	CHJ	WEL	RRH	Date	CIBW	GCL	CHJ	WEL	RRH	Date	CIBW	GCL	CHJ	WEL	RRH
1-Apr	120.1	103.9			100.7	1-May	132.9	109.5		107.8	109.7	1-Jun	127.7	112.4	111.4	109.6	110.2
2-Apr	121.7	105.0			102.1	2-May	133.6	108.9	105.5	107.5	109.8	2-Jun		111.9	110.1	108.6	109.8
3-Apr	115.8	105.5			107.7	3-May	118.9	109.4	107.9	107.5	109.6	3-Jun	123.0	112.2	110.5	108.4	109.9
4-Apr	110.7	105.2			111.5	4-May	117.7	107.6	106.2	105.4	107.4	4-Jun	121.9	112.1	110.6	108.8	109.8
5-Apr	108.3	105.2			107.5	5-May	116.9	106.8	104.7	103.9	105.9	5-Jun	122.5	113.2	110.4	108.5	110.9
6-Apr	106.1	105.2			103.4	6-May	117.8	108.0	105.6	105.2	107.2	6-Jun	122.5	112.5	109.5	107.1	112.7
7-Apr	106.0	105.3			102.3	7-May	116.0	107.5	105.4	104.7	107.2	7-Jun	122.3	112.3	109.6	110.0	109.2
8-Apr	104.9	105.6			103.7	8-May	113.7	107.9	105.3	104.3	106.6	8-Jun	121.5	113.0	110.3	109.9	112.0
9-Apr	102.7	104.7			104.4	9-May	114.4	108.1	105.6	104.6	106.5	9-Jun	120.6	113.3	110.2	108.5	112.6
10-Apr	102.1	104.6			103.8	10-May	114.5	108.9	106.0	105.1	106.9	10-Jun	121.6	119.8	110.9	111.8	113.5
11-Apr	102.2	105.3			104.6	11-May	114.2	109.7	106.8	106.2	107.6	11-Jun	120.8	116.4	111.3	112.1	112.4
12-Apr	103.1	105.2			103.0	12-May	114.6	110.7	107.9	106.8	108.0	12-Jun	120.1	112.8	112.0	110.2	114.3
13-Apr	103.0	103.4			101.0	13-May	112.9	110.9	108.3	106.6	108.1	13-Jun	119.9	116.9	112.4	110.6	112.4
14-Apr	102.2	102.8			101.3	14-May	111.6	111.1	108.3	107.4	108.6	14-Jun	121.2	120.4	113.0	111.2	111.9
15-Apr	103.6	104.0			103.1	15-May	110.9	110.7	108.5	107.4	108.2	15-Jun	120.4	125.7	114.3	112.2	113.9
16-Apr	104.0	106.4			104.9	16-May	110.5	110.6	108.8	107.7	108.6	16-Jun	120.7	115.7	115.2	111.5	113.8
17-Apr	104.4	107.5			106.4	17-May	110.3	110.9	109.0	107.9	108.9	17-Jun	121.3	115.3	115.3	110.7	114.4
18-Apr	103.9	107.8			106.9	18-May	110.6	111.0	109.2	108.2	109.4	18-Jun	121.4	115.4	115.1	110.7	113.3
19-Apr	107.9	107.9			104.0	19-May	110.3	111.1	109.1	108.1	109.2	19-Jun	121.0	114.9	114.6	109.4	111.1
20-Apr	108.3	107.4			102.8	20-May	110.5	112.1	109.4	108.6	109.6	20-Jun	121.3	115.2	114.7	109.7	111.0
21-Apr	108.1	107.6	107.1		102.7	21-May	110.8	111.5	109.6	108.5	109.6	21-Jun	121.6	115.4	114.8	110.7	110.8
22-Apr	109.9	107.2	104.9		106.3	22-May	111.1	111.1	109.3	109.0	109.4	22-Jun	123.2	114.9	114.2	110.3	110.2
23-Apr	113.4	108.6	103.9		107.2	23-May	112.8	112.1	110.4	109.9	110.5	23-Jun	123.0	114.3	113.4	109.8	110.7
24-Apr	115.6	110.3			108.6	24-May		113.1	111.7	110.6	112.5	24-Jun	122.4	117.1	114.4	110.7	112.2
25-Apr	117.3	110.9			109.1	25-May		113.5	112.0	110.4	113.5	25-Jun	122.4	116.9	114.1	110.0	111.2
26-Apr	119.1	109.4			108.7	26-May	123.9	111.7	111.1	109.4	110.6	26-Jun	121.5	116.7	113.6	109.3	109.9
27-Apr	117.2	109.1			108.5	27-May	121.5	113.7	111.7	110.3	110.9	27-Jun	121.6	116.6	113.6	110.5	109.6
28-Apr	116.1	108.1	106.8		108.8	28-May	140.4	113.0	111.4	109.9	111.1	28-Jun	121.6	116.5	114.3	111.1	110.2
29-Apr	117.2	107.9	105.9		109.4	29-May	145.2	112.2	111.1	109.7	110.6	29-Jun	123.1	116.8	114.5	112.0	110.7
30-Apr	124.0	108.6	106.5	107.3	109.1	30-May	148.6	111.4	110.8	108.8	109.5	30-Jun	124.0	117.2	114.9	112.3	113.4
						31-May	143.6	112.4	111.4	109.9	109.7						
Average	110.0	106.5	105.8	107.3	105.4	Average	119.7	110.5	108.6	107.7	109.1	Average	121.9	115.5	112.8	110.2	111.6

Appendix C. 1999 Daily average TDG data for Boundary, Grand Coulee, Chief Joseph, Wells and Rocky Reach.

Date	CIBW	GCL	CHJ	WEL	RRH
1-Jul	123.7	118.0	115.5	112.5	112.0
2-Jul	121.9	117.9	115.5	112.2	110.3
3-Jul	119.2	117.6	115.0	112.3	109.9
4-Jul	118.3	116.7	114.1	111.6	109.5
5-Jul	118.4	115.9	113.5	111.2	109.6
6-Jul	118.4	116.8	114.3	112.7	111.2
7-Jul	117.6	116.8	114.2	111.9	111.2
8-Jul	115.6	116.0	112.8	110.2	109.2
9-Jul	116.7	115.9	113.1	111.0	109.5
10-Jul	117.5	116.2	114.5	111.9	110.1
11-Jul	119.2	116.3	114.4	112.5	110.1
12-Jul	119.5	116.6	114.8	112.8	110.6
13-Jul	120.5	117.1	115.4	113.2	112.3
14-Jul	120.8	116.6	114.7	112.1	115.5
15-Jul	121.2	117.0	113.2	110.8	113.5
16-Jul	119.8	117.1	114.5	111.6	111.0
17-Jul	120.6	117.5	114.6	112.0	109.8
18-Jul	120.6	117.1	113.2	111.0	108.5
19-Jul	121.6	117.5	113.9	111.5	109.3
20-Jul	119.6	118.3	114.9	112.7	110.3
21-Jul	121.9	117.8	114.3	112.2	110.1
22-Jul	121.7	117.3	113.9	112.1	110.1
23-Jul	120.0	117.1	114.0	112.3	110.1
24-Jul	120.2	117.4	114.4	111.8	109.8
25-Jul	119.2	116.5	113.7	110.8	109.7
26-Jul	119.7	116.8	113.8	111.7	109.3
27-Jul	120.9	117.3	115.2	112.8	110.0
28-Jul	122.9	117.3	114.5	113.6	111.1
29-Jul	120.4	117.2	114.3	112.2	110.5
30-Jul	120.8	116.7	114.0	112.2	110.5
31-Jul	121.8	116.9	114.2	112.2	110.2
Average	120.0	117.0	114.3	112.0	110.5

Date	CIBW	GCL	CHJ	WEL	RRH
1-Aug	124.3	116.8	114.5	112.1	111.4
2-Aug	124.9	116.3	114.4	112.9	111.2
3-Aug	125.1	116.1	114.3	113.0	112.8
4-Aug	125.3	116.0	113.8	112.5	113.3
5-Aug	125.0	116.6	114.3	113.2	113.0
6-Aug	125.1	116.9	114.2	113.0	107.6
7-Aug	125.3	115.9	113.5	111.7	112.7
8-Aug	123.9	115.4	112.7	110.5	115.5
9-Aug	124.1	115.6	113.0	111.1	114.8
10-Aug	116.0	116.5	113.5	111.4	112.0
11-Aug	117.4	116.4	113.3	111.3	111.9
12-Aug	118.1	115.6	112.6	110.1	111.2
13-Aug	115.7	115.9	112.3	109.9	112.1
14-Aug	114.7	115.9	111.8	109.4	110.4
15-Aug	116.5	116.1	111.5	109.0	109.1
16-Aug	120.1	115.3	110.9	109.0	107.7
17-Aug	120.8	115.1	111.9	109.5	108.5
18-Aug		115.9	112.7	110.9	110.7
19-Aug	118.8	115.9	112.5		112.4
20-Aug	114.7	115.4	112.7	110.7	112.7
21-Aug	114.0	115.1	112.4	110.2	111.9
22-Aug	111.4	114.1	111.7	109.7	110.5
23-Aug	111.9	115.0	112.5	109.9	110.8
24-Aug	113.0	115.4	113.2	111.0	111.7
25-Aug	113.3	115.4	112.4	110.2	112.9
26-Aug	112.9	116.4	111.7	109.0	110.9
27-Aug	113.2	116.4	112.8	109.9	110.5
28-Aug	113.7	116.4	113.6	110.6	110.8
29-Aug	113.9	116.8	113.4	111.0	110.7
30-Aug	113.2	116.4	112.6	109.7	108.1
31-Aug	111.8	115.0	110.9	108.3	104.5
Average	117.9	115.9	112.8	110.7	111.1

Date	CIBW	GCL	CHJ	WEL	RRH
1-Sep	112.0	114.3	111.0	108.1	103.4
2-Sep	112.3	114.4	111.3	108.3	104.0
3-Sep	111.8	113.7	110.7	108.6	104.3
4-Sep	110.1	113.8	110.3	109.0	104.2
5-Sep	110.0	114.2	110.1	108.9	104.9
6-Sep	110.1	113.4	109.0	107.1	104.2
7-Sep	108.5	112.1	108.0	105.3	103.5
8-Sep	109.6	111.8	107.8	106.5	103.1
9-Sep	117.0	112.3	109.7	106.9	104.0
10-Sep	117.8	112.3	109.2	106.7	104.1
11-Sep	116.6	111.7	107.5	105.9	102.3
12-Sep	117.0	110.8	106.8	106.1	102.2
13-Sep	111.3	110.8	107.4	106.1	103.2
14-Sep	110.2	112.0	109.1	106.5	104.3
15-Sep	109.2	112.2	109.1	107.7	104.6
Average	112.2	112.7	109.1	107.2	103.8

METHOW BASIN SPRING CHINOOK SPAWNER GROUND SURVEY REPORT FOR 1999

APPENDIX F

Methow Basin Spring Chinook Spawner Ground Survey Report For 1999

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April 2000

Prepared for

Public Utility District No. 1 of Douglas County
East Wenatchee, WA

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ABSTRACT

The estimated 1999 spring chinook run to Wells Dam was 422 adults and 368 jacks. Of these 239 adults and 138 jacks were taken for broodstock. The estimated spawner escapement was 183 adults and 230 jacks.

A total of 36 spring chinook redds were located in the Methow Basin in 1999. The number of redds by major subbasin were as follows: Methow- 17 (47.2%), Lost- 3 (8.3%), Early Winters- 0 (0%), Chewuch- 6 (16.7%) and Twisp- 10 (27.8%).

A total of three CWT'ed carcasses were recovered all of which were recovered in the Methow River. Two of the carcasses originated from the 1995 brood year and the other from the 1994 brood year, and were released as smolts from either the Winthrop National Fish Hatchery (WNFH) or the Methow Fish Hatchery (MFH).

The fish per redd ratio, exclusive of the jacks, was 5.1.

INTRODUCTION

The Methow Basin Spring Chinook Salmon Supplementation Plan (MBSCSP) (June 20, 1995) is a compensation program directed towards the enhancement of the wild spring chinook (*Oncorhynchus tshawytscha*) stocks in the Methow Basin. The MBSCSP is the result of the Wells Settlement Agreement between the fishery agencies, tribes, Douglas PUD and the power purchasers of the Wells Project. The goal of this agreement is to compensate for unavoidable losses of juvenile anadromous fishes at Wells Dam. The stated purpose of the MBSCSP "...is to increase natural propagation of salmon in the Methow, Chewuch, and Twisp rivers in a manner that minimizes or eliminates ecological and genetic risks to the natural population.", through a monitored hatchery supplementation plan. The settlement agreement requires that the MBSCSP be operated according to procedures outlined by the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program (NPPC, 1987). A specific outcome is that the MBSCSP "be capable of collecting, rearing, and releasing three potentially discrete stocks of salmon"(Methow, Chewuch and Twisp), which is part of the Phase I compensation requirements under the settlement agreement.

Spring chinook spawner surveys in the Methow Basin is a monitoring and evaluation task, which is a component of the MBSCSP. Under Objective 2, Task 2.9 (Natural Production section) of the MBSCSP spawner surveys are conducted to evaluate various attributes (i.e., spawning behavior and geographic distribution) between natural and hatchery spawners. The entire monitoring and evaluation plan is presented in Appendix D of the MBSCSP document, which will provide the reader context for where spawner surveys mesh with other tasks of the evaluation program. Basin wide spring chinook spawning ground surveys have been conducted since 1987. In 1996 and 1998 no spawner surveys were conducted since nearly all spring chinook were collected at Wells Dam for broodstock.

STUDY AREA

The Methow River Basin is located in north-central Washington on the eastern slope of the Cascade Mountains (Figure 1). The Methow River and its tributaries lie in Okanogan County and drain an area of nearly 1,800 square miles. The headwaters of the Methow River are located near the Cascade Crest at an elevation of 6,000 feet and drops to 779 feet where it joins the Columbia River at Pateros, WA. The upper portion of the Methow River is heavily forested, predominantly with ponderosa pine. This area is used extensively for recreation and is experiencing a considerable amount of growth especially residential and commercial development. The lower Methow valley is a fertile agricultural area that experiences heavy irrigation demands. Water quality in the lower Methow Basin nonetheless remains high, with an AA rating from the Washington Department of Ecology. Spring chinook spawning in the Methow River extends from about Trout Creek (river mile 78) downstream below the Chewuch River confluence about two river miles (river mile 48).

The Chewuch River joins the Methow River at river mile (rm) 50 at an elevation of 1,745 feet. These two rivers join in the city of Winthrop. The Chewuch basin covers 530 square miles and drains in a southern direction into the Methow River. The upper portion of the Chewuch River is located in the Pasayten Wilderness (above RM 32.4) and is heavily forested. Spring chinook spawn downstream from river mile 31.5, which is also used extensively for recreation and residential development.

The Twisp basin encompasses about 250 square miles of watershed and enters the Methow River at near rm 40. The elevation descends from 8,500 ft to 1,600 ft and drains in a southeast direction. The headwater and upslope areas lay within the Lake Chelan-Sawtooth Wilderness. Spring chinook spawning has extended upstream to South Creek (rm ~ 28).

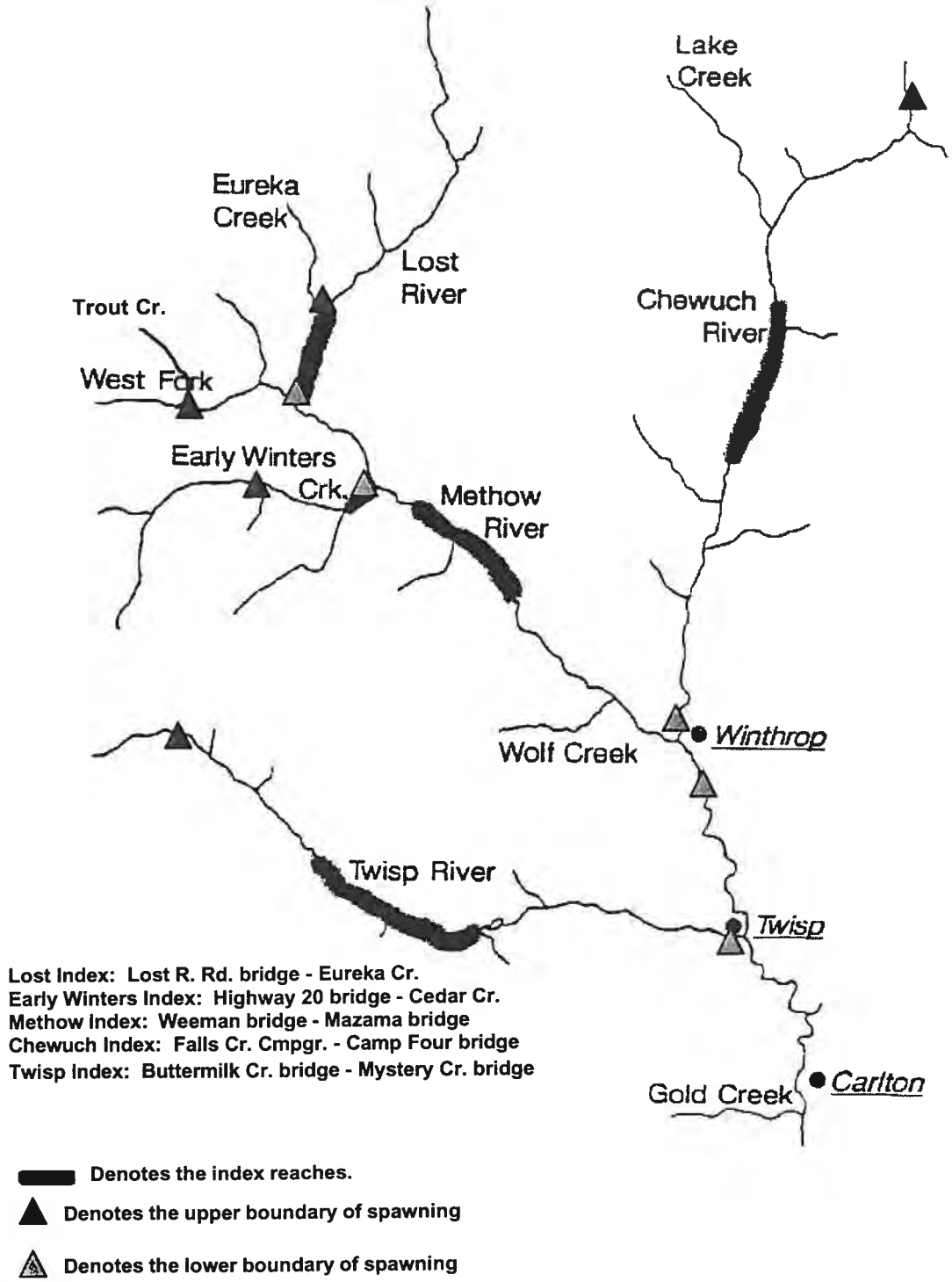

Figure 1. Spring chinook spawning distribution in the Methow Basin.

METHOD AND MATERIALS

Spawner surveys were conducted in the Methow, Lost, Chewuch and Twisp rivers, and in Early Winters Creek. The historical index reaches were normally surveyed weekly, while those reaches where nominal spawning occurs were surveyed less frequently. However, all spawning reaches where redds normally are located were surveyed at least once during or after the historic peak spawning period. The historic index reaches are the following: Methow- Weeman bridge to Mazama bridge (6.2 river miles); Lost- Lost River Bridge to the Eureka Creek (4.2 river miles); Early Winters- Highway 20 Bridge to Cedar Cr. (1.9 river miles); Chewuch- Falls Creek Campground to Camp Four Bridge (6.8 river miles); and Twisp- Buttermilk Creek Bridge to the Mystery Creek Bridge (10.1 river miles).

Surveys began August 17th and continued through September 30th . Appendix Tables 1, 2, 3 and 4 present the complete week-by-week survey schedule and redd counts.

Foot surveys were conducted in the upper Methow, Lost, Chewuch and Twisp rivers, and in Early Winters Creek. Sufficient flows allowed raft surveys in the Methow River downstream from Mazama bridge. To ensure survey consistency, the same survey crew was normally assigned to the same spawning reach. However, for QC purposes a different crew occasionally surveyed another crew's survey reach. To avoid recounting or missing a previously counted redd, each redd was marked with surveyor's tape on the riverbank adjacent to the redd. Written on each posted tape were the consecutive redd number and survey date.

All live spawners were counted during each survey. Carcasses were recovered and checked for sex, tags, fin clips, and spawning success. Scales were collected when possible from each carcass and post eye-to-hypural plate length was recorded.

The estimated spring chinook spawner escapement to the Methow Basin was derived from the Wells Dam count plus the various broodstock collection sources (Wells Dam, WNFH and MFH), minus the number of spring chinook broodstock subsequently released from the

Methow Fish Hatchery. Since there is no precise method to estimate pre-spawning mortality after passing Wells Dam, no adjustments are made to the natural escapement value.

RESULTS AND DISCUSSION

Spring Chinook Run Size

A summary of the Methow Basin spring chinook run size and spawner escapement for years 1967-99 is presented in Table 1 and Figure 1. The estimated 1999 spring chinook run size to Wells Dam was 790 (422 adults, 368 jacks) (Memo L. Brown, January 19, 2000).

Broodstock Collection

A total of 377 (239 adults, 138 jacks) spring chinook broodstock were transferred to the Methow Fish Hatchery. The total broodstock collection was derived as follows: 445 (283 adults, 162 jacks) spring chinook were collected at Wells Dam and transferred to Methow FH[1]; 12 (6 adults, 6 jacks) volunteers to the WNFH and 56 fish (14 adults, 42 jacks) volunteered to the Methow FH (Table 1).

Estimated Spawner Escapement and Redd Count in the Basin

The estimated natural escapement in the Methow Basin was 413 fish (183 adults, 230 jacks). This spawner escapement value assumes no pre-spawning mortality (Table 1). A total of 36 redds were counted for the entire Methow Basin.

Spawning Ground Surveys

Methow River

A total of 17 redds were found in the Methow River which comprised 47.2% of the Methow Basin's total redd count. Two redds were located within the index reach (Mazama Bridge to Weeman Bridge), which accounted for 11.8% of total Methow River redd count. The

1 Subsequently, 136 fish (64 adults, 72 jacks) were later released from the Methow FH, because of potential over collection of broodstock.

Table 1. Summary of spring chinook adult counts at Wells Dam, broodstock collection and releases, and spawner escapement in the Methow Basin, 1967-99.

Year	Total arrival to Wells Dam			Wells Dam		Wells Dam		Tributaries		WNFH		MFH		Wells Dam	
	Adults	Jacks	Total	adutls counted past dam	jacks counted past dam	adult broodstock	jack broodstock	adult broodstock	jack broodstock	adult broodstock	jack broodstock	adult broodstock	jack broodstock	adult released above Wells Dam	jack released above Wells Dam
1967	541	616	1,157	541	616	0	0	–	–	0	0	–	–	0	0
1968	4,086	845	4,931	4,086	845	0	0	–	–	0	0	–	–	0	0
1969	3,048	551	3,599	3,048	551	0	0	–	–	0	0	–	–	0	0
1970	2,092	578	2,670	2,092	578	0	0	–	–	0	0	–	–	0	0
1971	2,535	633	3,168	2,535	633	0	0	–	–	0	0	–	–	0	0
1972	3,368	248	3,616	3,368	248	0	0	–	–	0	0	–	–	0	0
1973	2,505	507	3,012	2,505	507	0	0	–	–	0	0	–	–	0	0
1974	3,199	221	3,420	3,199	221	0	0	–	–	0	0	–	–	0	0
1975	2,096	129	2,225	2,096	129	0	0	–	–	0	0	–	–	0	0
1976	1,510	1,249	2,759	1,510	1,249	0	0	–	–	0	0	–	–	0	0
1977	3,976	235	4,211	3,976	235	0	0	–	–	0	0	–	–	0	0
1978	3,532	83	3,615	3,532	83	0	0	–	–	38	0	–	–	0	0
1979	971	132	1,103	971	132	0	0	–	–	102	0	–	–	0	0
1980	941	241	1,182	941	241	0	0	–	–	155	0	–	–	0	0
1981	1,367	98	1,465	1,367	98	0	0	–	–	399	0	–	–	0	0
1982	2,270	131	2,401	2,270	131	0	0	–	–	601	0	–	–	0	0
1983	2,726	143	2,869	2,726	143	0	0	–	–	755	0	–	–	0	0
1984	3,066	214	3,280	3,066	214	0	0	–	–	510	0	–	–	0	0
1985	5,151	116	5,267	5,151	116	0	0	–	–	1201	0	–	–	0	0
1986	2,896	65	2,961	2,896	65	0	0	–	–	836	0	–	–	0	0
1987	2,272	74	2,346	2,272	74	0	0	–	–	594	0	–	–	0	0
1988	2,844	96	2,940	2,844	96	0	0	–	–	1327	0	–	–	0	0
1989	1,633	87	1,720	1,633	87	0	0	–	–	195	0	–	–	0	0
1990	927	12	939	927	12	0	0	–	–	121	0	–	–	0	0
1991	682	100	782	682	100	0	0	–	–	92	0	–	–	0	0
1992	1,542	31	1,573	1,542	31	0	0	54	0	332	0	0	0	0	0
1993	2,601	25	2,626	2,601	25	0	0	152	0	646	0	99	0	0	0
1994	243	15	258	243	15	0	0	15	2	28	1	17	0	0	0
1995	72	41	113	66	41	6	0	0	0	7	0	5	2	6	0
1996	393	68	461	0	0	393	68	0	0	0	0	0	0	0	0
1997	1,134	29	1,163	942	29	192	0	0	0	230	1	131	0	0	0
1998	401	18	419	6	4	395	14	0	0	0	0	0	0	0	0
1999	422	368	790	139	206	283	162	0	0	6	6	14	42	64	72

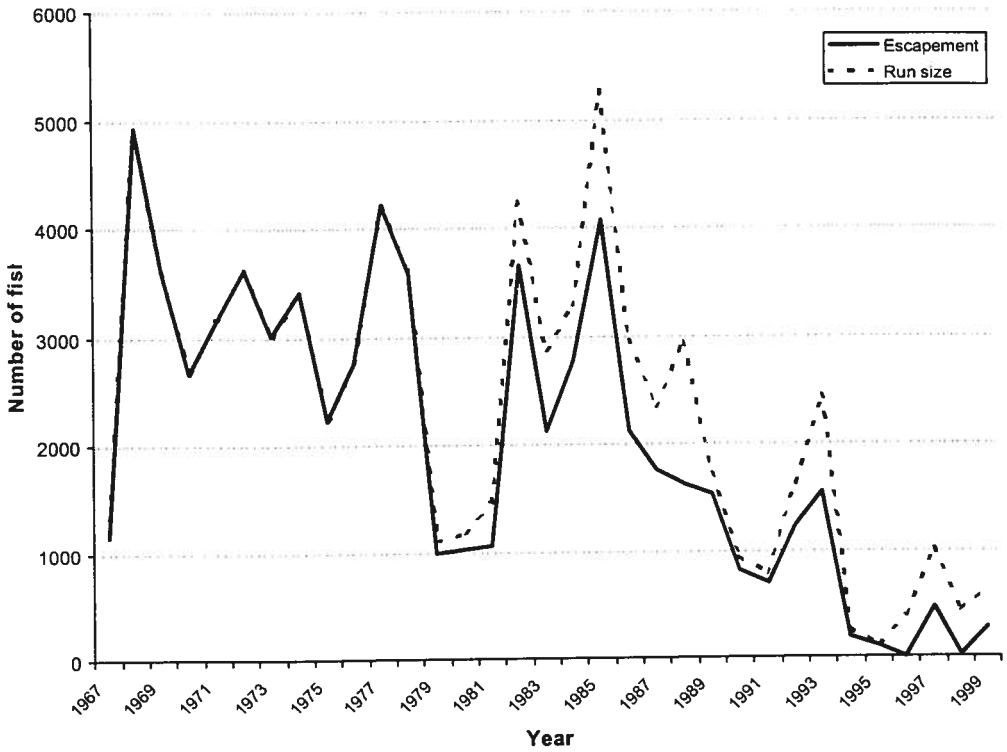

Figure 2. Estimated run size and spawner escapement in the Methow Basin,

percentage of redds located above and below the index reach was 17.6% (3 redds) and 70.6% (12 redds), respectively. This was the second lowest percentage of redds located within the index reach since 1987 when records were first kept. For the 1987-99 period the mean percent of redds located in the index reach is 33.8%, and has ranged from 6.7% (4 redds) to 54.9% (73 redds) (Table 2). Two of the 12 redds located below the index reach were deposited in the outfall channel to the Methow Fish Hatchery. The peak week of spawning was September 7-10, with six redds, accounting for 35.3% of the total redds deposited in the Methow River mainstem. The highest number of redds (8) occurred in the Weeman Bridge to along Highway 20 (section 7), which is the first section downstream of the index reach.

Lost River

Three redds were located in Lost River. All were outside the index reach (Eureka Cr. to Lost River Bridge) and in immediate proximity to one another, between the Lost River

Table 2. The number and percent of redds located above, within and below the index reaches in the Methow, Chewuch and Twisp basins, 1987-1999.

Year	Methow							Chewuch							Twisp						
	Above		Within		Below		Total	Above		Within		Below		Total	Above		Within		Below		Total
	# of redds	% of redds	# of redds	% of redds	# of redds	% of redds	# of redds	# of redds	% of redds	# of redds	% of redds	# of redds	% of redds	# of redds	# of redds	% of redds	# of redds	% of redds	# of redds	% of redds	# of redds
1987	32	12.5%	75	29.3%	149	58.2%	256	38	19.9%	77	40.3%	76	39.8%	191	44	26.8%	79	48.2%	41	25.0%	164
1988	52	19.8%	82	31.3%	128	48.9%	262	51	25.2%	55	27.2%	96	47.5%	202	45	22.6%	111	55.8%	43	21.6%	199
1989	9	8.2%	60	54.5%	41	37.3%	110	22	13.8%	44	27.5%	94	58.8%	160	28	15.6%	100	55.9%	51	28.5%	179
1990	26	13.4%	80	41.2%	88	45.4%	194	34	21.5%	61	38.6%	63	39.9%	158	12	10.7%	77	68.8%	23	20.5%	112
1991	18	24.3%	31	41.9%	25	33.8%	74	17	18.7%	30	33.0%	44	48.4%	91	12	17.4%	40	58.0%	17	24.6%	69
1992	45	13.4%	90	26.8%	201	59.8%	336	38	20.5%	77	41.6%	70	37.8%	185	12	8.5%	73	51.8%	56	39.7%	141
1993	59	20.3%	92	31.7%	139	47.9%	290	23	27.7%	35	42.2%	25	30.1%	83	40	20.8%	108	56.3%	44	22.9%	192
1994	15	23.4%	8	12.5%	41	64.1%	64	5	18.5%	11	40.7%	11	40.7%	27	13	40.6%	13	40.6%	6	18.8%	32
1995	0	0.0%	7	77.8%	2	22.2%	9	2	100.0%	0	0.0%	0	0.0%	2	0	0.0%	2	50.0%	2	50.0%	4
1996 /a	0	0.0%	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%	0	0.0%	0
1997	25	41.7%	4	6.7%	31	51.7%	60	2	3.6%	27	49.1%	26	47.3%	55	1	3.1%	12	37.5%	19	59.4%	32
1998 /a	0	0.0%	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%	0	0.0%	0
1999	3	17.6%	2	11.8%	12	70.6%	17	0	0.0%	0	0.0%	6	100.0%	6	9	90.0%	1	10.0%	0	0.0%	10
Average	**26**	**17.7%**	**48**	**33.2%**	**78**	**49.1%**		**21**	**24.5%**	**38**	**30.9%**	**46**	**44.6%**		**20**	**23.3%**	**56**	**48.4%**	**27**	**28.3%**	

/a All fish were collected at Wells Dam for broodstock.

Bridge and the confluence with the Methow River. The Lost River accounted for 8.3% of the Methow Basin total redd count, which is comparable to the annual mean of 6.8%. There was no peak week of spawning since each of the three redds was deposited in separate weeks.

Chewuch River

A total of six redds were deposited in the Chewuch basin. Redds deposited in the Chewuch basin comprised 16.7% of the Basin total, which compares to the annual mean of 25.5%. There were no redds located within the index reach (Camp Four Bridge to Fall Creek Cmp. Gr.). The percentage of redds located above and below the index reach was 0% and 100% (6 redds), respectively (Table 2).

The peak spawn week in the Chewuch was September 27 through October 1, with a total of four redds. However, it was evident from redd appearance that these redds counted during this week had been deposited previously. The section in which these redds were identified (Eight-Mile Ranch to Memorial Piers) had been surveyed earlier in the season, but was not a section that was regularly surveyed each week. Due to the timing cycle of section surveys, these previously deposited redds were recorded during the last week of the spawning surveys.

Twisp River

A total of ten redds were located in the Twisp basin. This accounted for 27.8% of the Methow Basin total redd count. This is slightly higher than the annual mean of 26.0%. Spawning within the index reach (Mystery Bridge to Buttermilk Bridge) accounted for 10.0% (1 redd) of the total redd count, which was the lowest percentage recorded since 1987. The previous lowest percent of redds within the index reach was 37.5% (12 redds) in 1997. Since 1987 a mean of 48.4% redds have occurred within the index area. The percentage of redds located upstream and downstream to the index reach was 90.0% (9 redds) and 0%, respectively (Table 2). The percentage of redds located above the index reach was substantially higher than the mean of 23.3%.

Most of the redds were located in river sections 2 (road end cmp. gr. to South Creek Bridge) and 4 (Poplar Flats Cmp. Gr. to Mystery Bridge), with three redds located in the uppermost section and 6 redds in the lower section.

The peak week for spawning was September 27-October 1 (7 redds), accounting for 70% of the total redds.

Other Tributaries

No redds were found in Early Winters or Wolf creeks, although early in the spawning season four adult spring chinook were observed in Early Winters Creek by WDFW personnel.

Carcass Length Data

For the entire Methow Basin 14 carcasses were recovered- 13 in the Methow River and one in the Chewuch River (Table 3). The low number of carcasses recovered corresponds to the low number of redds observed throughout the Basin. All but one carcass recovered were females, and six of the 14 carcasses were adipose clipped. Three of the six adipose clipped carcasses had CWTs. All three CWT'ed fish were released as smolts from either the WNFH or the MFH, and all three carcasses were recovered in the Methow River upstream to the KOA Campground (rm 49.6). On carcass was from the 1994 WNFH brood year, while the other two were from the 1995 brood year[2].

The fork length frequency is presented in Figure 3. The mean fork length was 75.2 cm (29.6 in) (n=14) and fish size ranged from 56.5 cm (22.2 in) to 94.5 cm (37.5 in). The majority (10 fish) were between 67.5 (26.6 in) to 77.5 (30.5 in) cm in fork length.

Fish Per Redd

Based only on an adult spawner escapement of 183 fish, the fish per redd ratio is 5.1. Jacks were purposely excluded from this calculation as they comprised 55.7% of the estimated natural escapement, and thus, would have skewed the ratio high. This unusually high fish

[2] Smolts released from the 1995 brood year were divided in half and reared and released at both the WNFH and the MFH. The CWT groups (based on the brood year 1995 family study) were equally split between the two hatchery facilities, thus the exact release location can not be determined.

Table 3. Summary of spring chinook carcass data from the Methow Basin, 1999.

River	Section	Date	PEHP length	Fork length	Sex	Type	Age
Chewuch	8-mile ranch - Memorial Br.	9/14	59.5	72.5	female	–	4.2
Methow	Mazama Br. to Foghorn Dam	9/8	73.5	56.5	male	wild	4.2
Methow	Mazama Br. to Foghorn Dam	9/1	–	67	female	hatchery	
Methow	Mazama Br. to Foghorn Dam	9/21	57	69	female	wild	4.2
Methow	Lost R. to Gate Cr.	9/7	61	71	female	wild	4.2
Methow	Lost R. to Gate Cr.	9/13	58	72.5	female	wild	—
Methow	Mazama Br. to Foghorn Dam	9/14	61	74	female	wild	4.2
Methow	Mazama Br. to Foghorn Dam	9/21	63	76	female	wild	4.2
Methow	Foghorn Dam to diversion dam	9/9	62	76	female	hatchery	4.2
Methow	Mazama Br. to Foghorn Dam	9/14	66	76.5	female	hatchery	4.2
Methow	Weeman Br. - along Highway 20	8/24	59.7	77.5	female	wild	4.2
Methow	Mazama Br. to Foghorn Dam	9/8	65	82.5	female	wild	4.2
Methow	Mazama Br. to Foghorn Dam	9/1	69.5	87	female	hatchery	5.2
Methow	Mazama Br. to Foghorn Dam	9/14	73.5	94.5	female	hatchery	5.2

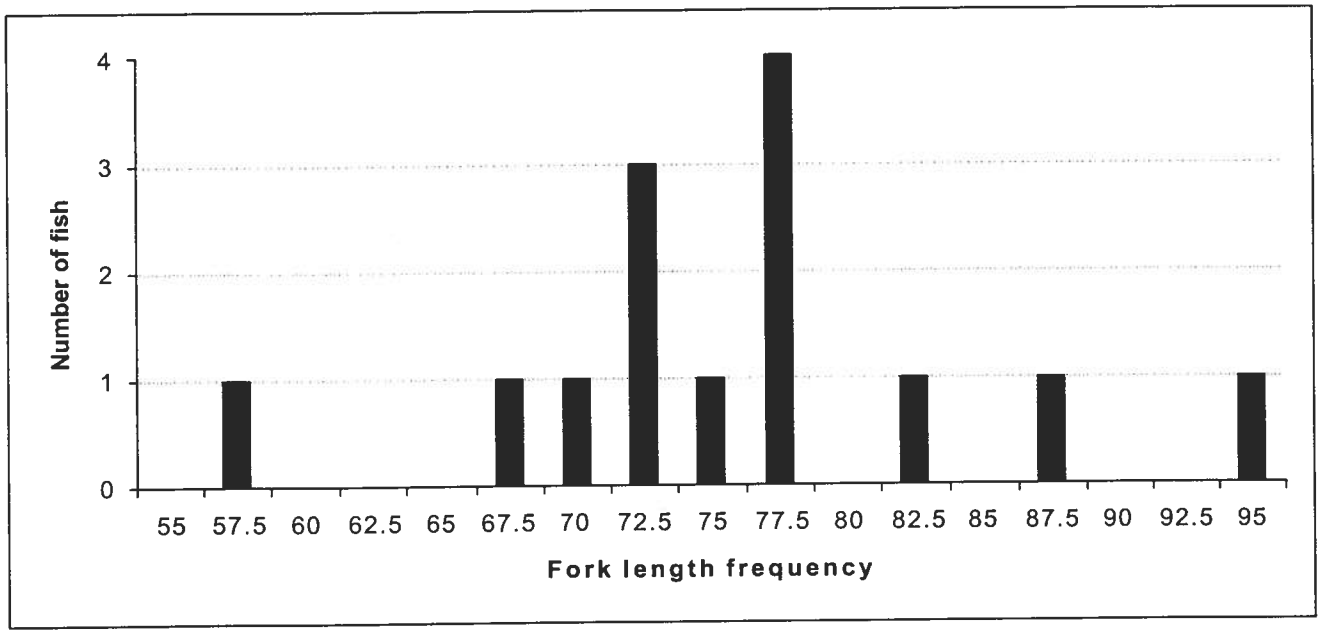

Figure 3. Fork length frequency of carcasses recovered in the Methow Basin, 1999.

per redd ratio is comparable to, and somewhat higher, than the 1995 run which had a ratio of 4.8 exclusive of jacks. The number of adults of the natural escapement portion of the 1995 run was similarly low- 63 fish. This suggests an unusually high inriver mortality after passing Wells Dam. Excluding the 1995 and 1999 runs, the mean fish per redd ratio has been 2.7 fish for the period of 1987-99.

Redd Distribution Analysis

There was no relationship between the annual number of redds in the Methow, Chewuch and Twisp basins to the percent of redds located within each respective index reach. Figure 4 depicts the total number of redds located in the Methow, Chewuch and Twisp basins to the percentage of redds located within each respective index reach, since 1987. One might expect an increase in the percent of redds within the index reaches as total redd counts decline. The underlying assumption is that the index reaches represent the best spawning habitat, therefore, as the run size decreases spawning in the lesser quality habitat reaches would correspondingly decrease. However, in both the Twisp and Chewuch basins there was much variation in the percent of redds within the index reach relative to total redds in the subbasin. This suggests there is no tendency for spawning to occur more or less frequently in the index reach of a subbasin as redd counts increase or decrease. Similarly, in the Methow basin there was no clear relationship between the percent of redds in the index reach and the total redd count in the basin. The three outlier years of 1994, 1997 and 1999 call into question the apparent trend of a higher portion of redds occurring within the index reach as the total basin redd count decreases. Closer examination was given to these three outlier years, thinking that perhaps river discharge influenced redd distribution. However, this does not appear to be the case. For example, in the Methow for the river discharge period of August 1 – September 30 (gauged at Pateros) the mean flow (1987-99) was 38% of normal in 1994, and 148% and 175% of normal in 1997 and 1999, respectively. In addition, there was no relationship between the percent of redds located either above or below the index reach with respect to the mean annual August 1 – September 30 river flow. For example, in 1994 the percent of redds located above and below the index reach was 23.4% and 64.1%, respectively. In 1997 the percent of redds located above and below the index reach were, respectively, 41.7% and 45.0%, and in 1999 they were, respectively, 17.6% and 70.6%.

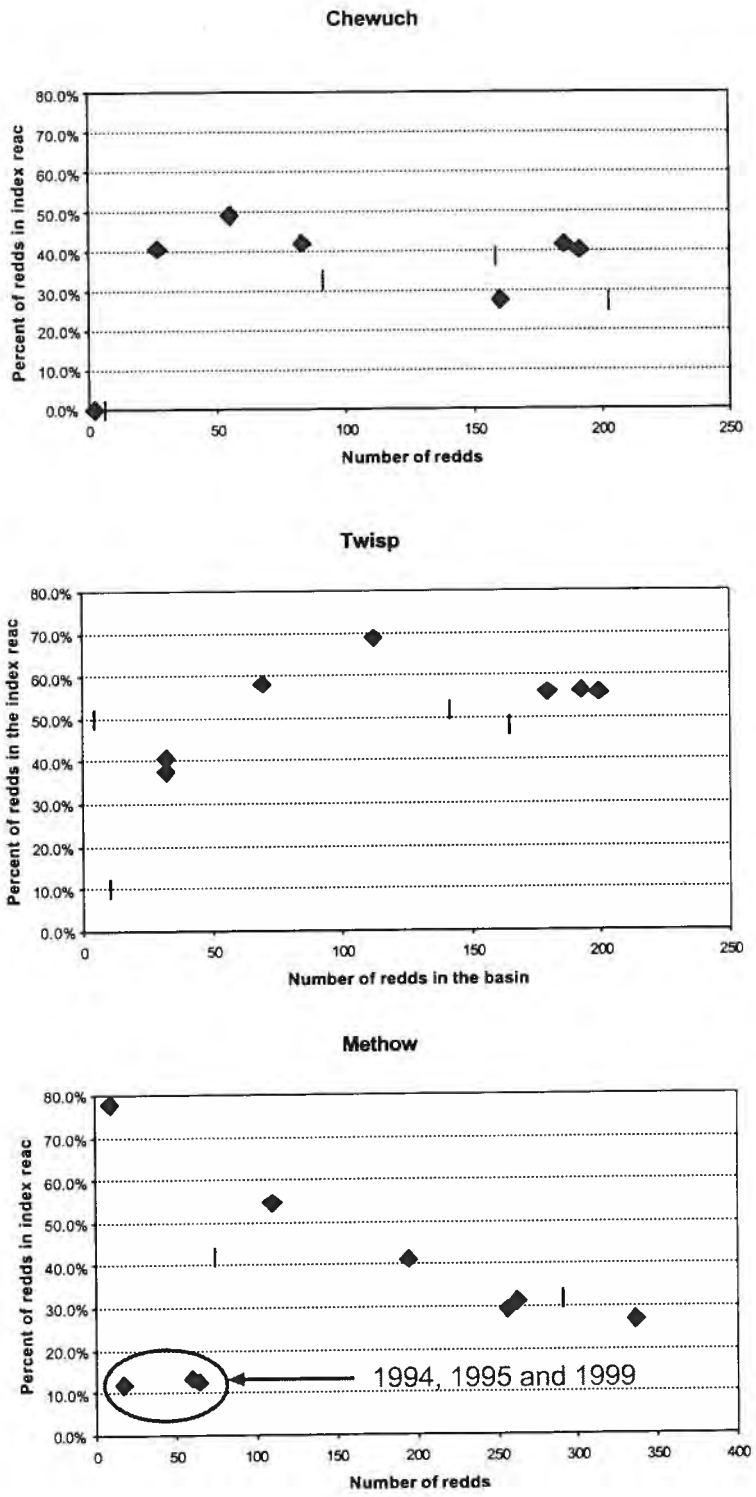

Figure 4. Relationship between the percent of redds within the index reach and the number of redds located in the Chewuch, Twisp and Methow basins.

Part of the long term monitoring effort will be to look for correlation's between the redd distribution in each of the three basins with respect to physical attributes such as stream flow, and potential influences caused by the hatchery supplementation program.

LITERATURE CITED

Wells Project Coordinating Committee. 1995. Methow basin spring chinook salmon supplementation plan.

Brown, Larry. 2000. A WDFW memorandum summary of the 1999 spring chinook broodstock collection and natural escapement

APPENDIX TABLES

Appendix Table 1. Methow basin survey schedule and redd counts, 1999.

Appendix Table 2. Lost River and Early Winters Creek survey schedules and redd counts, 1999.

Appendix Table 3. Chewuch basin survey schedule and redd counts, 1999.

Appendix Table 4. Twisp basin redd survey schedule and redd counts, 1999.

Appendix Table 1. Methow basin survey schedule and redd counts, 1999.

River Section	Section number	Week 1	Week 2			Week 3		Week 4			Week 5			Week 6			Week 7		
		8/17	8/23	8/24	8/25	8/31	9/1	9/7	9/8	9/9	9/13	9/14	9/15	9/20	9/21	9/22	9/28	9/29	9/30
Trout Cr. - Ballard cmp. gr.	--																	0	
Ballard cmp. gr. - Lost R.	1									0									
Lost R. - Gate Cr.	2		0			0		1			1			0					
Gate Cr. - Early Winters Cr.	3				1	0		0			0			0					
Early Winters Cr. - Mazama Br.	4				0	0		0			0			0					
Mazama Br. - Rd. barrier	**5**	**0**		**1**			**0**		**0**			**0**			**0**			**0**	
Rd. barrier - Weeman Br.	**6**	**0**		**0**			**0**		**0**			**1**			**0**			**0**	
Weeman Br. - along Highway 20	7	0		2			1		4			0			0			1	
along Highway 20 - Wolf Cr.	8	0		0			0		0			0			0			0	
Wolf Cr. - Foghorn Dam	9	1		0			0		0			0			0			0	
Foghorn Dam - Winthrop Br.	10									1			0			0	0		
Winthrop Br. - diversion dam	11																0		
diversion dam - Twisp Br.	12																		
Twisp Br. - Carlton Br.	13																		
Methow hatchery outlet	----																		2

Appendix Table 2. Lost River and Early Winters Creek survey schedules and redd counts, 1999.

River Section	Section number	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6
Lost River		8/25	8/26	8/31	9/3	9/7	9/10	9/13	9/16	9/20	9/23	9/30
Sunset Cr. - Eureka Cr.	1											
Eureka Cr. - Lost R. Rd. Br.	**2**		**0**		**0**		**0**		**0**		**0**	**0**
Lost R. Rd. Br. - conflence	3			1		1		1		0		
Early Winters Creek												
Klipchuch cmp. gr. - Early Winters Br.	1	0										
Early Winters Br. - Highway 20 Br.	2				0							
Highway 20 Br. - diversion dam	3				0							
diversion dam - Highway 20 Br.	4	0			0							
Highway 20 Br. - confluence	5											

Appendix Table 3. Chewuch basin survey schedule and redd counts, 1999.

River Section	Section number	Week 1	Week 2	Week 3	Week 4		Week 5			Week 6	Week 7	
		8/18	8/23	9/1	9/8	9/9	9/14	9/15	9/16	9/21	9/27	9/30
falls - 30 mi. Br.	1											
30 mi. Br. - road-side cmp.	2				0							
Rd. side cmp. - Andrews Cr.	3				0							
Andrews Cr. - Lake Cr.	4											
Lake Cr. - Buck Cr.	5				0							
Buck Cr. - camp 4	**6**						**0**					
camp 4 - road-side cmp.	**7**	**0**		**0**	**0**		**0**				**0**	
road-side cmp. - Chewuch cmp. g	**8**	**0**		**0**	**0**		**0**				**0**	
Chewuch cmp. gr. - mile 6 cmp.	**9**	**0**		**0**	**0**		**0**				**0**	
mile 6 cmp. - Falls Cr. cmp. gr.	**10**	**0**		**0**	**0**		**0**				**0**	
Falls Cr. cmp. gr. - 8 mile ranch	11				0					0		
8 mile ranch - Memorial Br.	12			0				0			4	
Memorial Br. - Chewuch Br.	13							0				
Chewuch Br. - halfway pt.	14			0						0		0
halfway pt. - confluence	15					1			1	0		0

Appendix Table 4. Twisp basin survey schedule and redd counts, 1999.

River Section	Section number	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
		8/18	8/25	9/2	9/9	9/15	9/22	9/28	9/30
Rd. end cmp. gr. - up 2 mi.	1								
Rd. end cmp. gr. - South Cr. Br.	2							3	0
South Cr. Br. - Popular Flats cmp. gr.	3		0						
Popular Flats cmp. gr. - Mystery Br.	4		0			1	1	0	4
Mystery Br. - War Cr. Br.	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
War Cr. Br. - cabin	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
cabin - Buttermilk Br.	**7**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**
Buttermilk Br. - green Br.	8			0					
green Br. - Little Cr. Br.	9			0				0	
Little Cr. Br. - Newby Cr. Br.	10			0					
Newby Cr. Br. - fish weir	11			0					
fish weir - wooden Br.	12			0					
wooden Br. - Poorman's Br.	13			0					
Poorman's Br. - Twisp R. Br.	14			0				0	
Twisp R. Br. - confluence	15			0					

PROJECT SURVIVAL ESTIMATE FOR YEARLING SUMMER STEELHEAD MIGRATING THROUGH THE WELLS HYDROELECTRIC FACILITY, 1999

APPENDIX G

PROJECT SURVIVAL ESTIMATES FOR YEARLING SUMMER STEELHEAD MIGRATING THROUGH THE WELLS HYDROELECTRIC FACILITY, 1999

PROJECT SURVIVAL ESTIMATES FOR YEARLING SUMMER STEELHEAD MIGRATING THROUGH THE WELLS HYDROELECTRIC FACILITY, 1999

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EXECUTIVE SUMMARY

In the spring of 1999, the Public Utility District No. 1 of Douglas County conducted a PIT-tag survival study at the Wells Hydroelectric Project. Yearling hatchery summer steelhead smolts were collected, PIT-tagged and released above and below the project on fifteen different occasions. The primary goal of the study was to precisely estimate the survival of PIT-tagged steelhead migrating from the mouth of the Methow River through and to the tailrace of the Wells Hydroelectric Project. Specific objectives toward accomplishing the primary goal included 1) testing the assumptions of the single (SRR) and paired (PRR) release-recapture models, 2) estimating capture and reach specific survival probabilities and 3) developing component estimates of reach survival for steelhead passing from the mouth of the Methow River to the tailrace of the Wells Hydroelectric Project.

Steelhead smolt survival from the mouth of the Methow River to the tailrace of Wells Dam was assessed through the release of 30,072 steelhead at Pateros and 30,049 steelhead into the tailrace of Wells Dam. The Methow River release site was located 13 km upstream of Wells Dam at river km 843. The tailrace or control release site was located 300 meters downstream of Wells Dam at river km 829.6. Fifteen replicate releases of steelhead were completed at both the Methow and tailrace release sites. Each replicate release at each release site contained approximately 2,000 yearling steelhead.

To minimize differences between replicate release groups, fish destined for the Methow and tailrace release sites were treated identically throughout the collection, tagging, recovery and transportation phases of the study. Toward this goal, the PIT-tagging crews were continually rotated between the Methow and tailrace release groups. Holding containers and tagging equipment were randomly assigned to release groups. Columbia River water was utilized throughout the collection, tagging, recovery and release phases of the study to provide consistent pre-release conditions between replicate release pairings. Water chemistry was monitored and recorded hourly to ensure consistency between the two release sites and within each of the fifteen replicate release pairs.

Fish physiology for the Methow and tailrace release groups were monitored throughout the study. Eight of the fifteen Methow/tailrace release replicates were sampled to provide pre-release comparisons of fish physiology between replicate release pairs. Physiological data amassed included indices of steelhead smoltification (ATPase and silvering), handling stress (plasma cortisol, plasma glucose and liver HSP70), morphology (length, weight and mesenteric fat), fish condition (fin erosion, descale, and injury rates) and fish health (organ tissue color, size and texture). In addition to sampling tagged fish, a control group of untagged fish was sampled. Information from the control groups was used to develop baseline indices of fish stress, fish condition and smoltification prior to the tagging procedure.

The information on fish physiology was used to detect subtle differences in fish handling (handling stress and fish condition) within and between the Methow and tailrace release groups. Physiological information was also used to detect differences in fish condition between replicate release pairs (smoltification, morphology and fish health). It was hypothesized that subtle differences in handling, stress, or fish condition might increase the variability and uncertainty surrounding reach survival estimates.

In general, few significant differences were found either within or between the replicate release pairs sampled. No significant differences in fish morphology were detectable either within or between the replicate release pairs sampled. Differences in smolt readiness, as measured by ATPase levels, were not significant within an individual release pairing. Overall, fish appeared to be healthy with little descaling, fin erosion or injuries noted. Percent mesenteric fat and average condition factor were high indicating fish were well fed and had substantial fat reserves. Subtle trends over time included a slight decline in fat coverage and ATPase levels as the study progressed.

The collection of short-term, intermediate and long-term stress indices were informative and indicated that collection, handling, tagging and transportation techniques were not different either within or between replicate release pairs sampled. In general, short-term and long-term indices of stress were low and typical of fish at rest. This included the comparison between tagged and untagged steelhead.

Recapture and passive interrogation of study fish took place at Rocky Reach, McNary, John Day and Bonneville dams. Additional study fish were detected at the Columbia River estuary by a boat towed PIT-tag trawl. The majority of the Methow and tailrace release replicates (Methow/tailrace) migrated downstream together. All fifteen Methow/tailrace release pairings exhibited homogeneous arrival distributions at McNary, John Day and Bonneville dams. Arrival timing at Rocky Reach Dam was not synchronized with fifteen out of fifteen replicate release pairs exhibiting heterogeneous arrival distributions.

Detection probabilities for the Methow/tailrace release replicates were not significantly different at McNary and John Day dams. However, seven out of fifteen Methow/tailrace release pairings had significantly different detection probabilities at Rocky Reach Dam. Detection rates for Douglas PUD released steelhead smolts averaged 0.250 ($S\hat{E} = 0.009$), 0.198 ($S\hat{E} = 0.005$) and 0.358 ($S\hat{E} = 0.013$) at Rocky Reach, McNary and John Day dams, respectively.

Survival through Wells Dam was estimated based upon the relative survival of Methow and tailrace release groups. Survival from the Methow release site through to the tailrace of Wells Dam ranged from 0.859 to 1.110. To remain consistent with survival estimates derived for Snake and Columbia river dams, all reported point estimates of survival were based upon the weighted average of the replicate survival estimates. The weighted average survival for yearling steelhead passing from the mouth of the Methow River to 300 m downstream of Wells Dam was 0.943 ($S\hat{E} = 0.016$) (n = 15) during 1999. The survival estimate generated for steelhead in 1999 is the product of survival through the reservoir, forebay, dam and tailrace for ESA listed summer steelhead smolts.

Estimates of reach specific survival were derived from release sites to immediately downstream of Rocky Reach, McNary and John Day dams. Survival from the Rocky Reach tailrace to the McNary tailrace was not significantly different between the paired Douglas PUD release groups. Survival from the Rocky Reach tailrace to the McNary tailrace averaged (weighted) 0.686 ($S\hat{E} = 0.010$). Survival from the McNary tailrace to the John Day Dam tailrace averaged 1.012 ($S\hat{E} = 0.020$).

In addition to Douglas PUD tagged steelhead, the Fish Passage Center release three groups of PIT-tagged yearling spring chinook from the Winthrop National Fish Hatchery. Estimates of detection and survival from this group of fish provided an interesting contrast between spring chinook and summer steelhead survival between the Rocky Reach and McNary tailraces.

Detection rates for Winthrop spring chinook averaged 0.172 ($S\hat{E} = 0.010$), 0.306 ($S\hat{E} = 0.017$) and 0.210 ($S\hat{E} = 0.008$) at Rocky Reach, McNary and John Day dams. Estimated reach survival for Winthrop fish migrating from the Rocky Reach tailrace to the McNary tailrace averaged 0.727 ($S\hat{E} = 0.053$) during 1999.

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1.0 INTRODUCTION

In the spring of 1998, the Public Utility District No. 1 of Douglas County conducted a pilot survival study at the Wells Hydroelectric Project. This study was designed to assess the adequacy of several key assumptions related to the design and implementation of the paired release-recapture (PRR) survival model specifically at the Wells Hydroelectric Project. Issues related to the feasibility of PIT-tag survival studies included: 1) testing the critical assumptions of the single release-recapture (SRR) and PRR recapture models, 2) acquiring direct estimates of detection, median arrival time and project specific survival from fish released above and below Wells Dam, and 3) estimating survival through Wells Dam.

Results from the 1998 study indicated that the critical assumptions of the SRR and PRR models can be satisfied during PIT-tag survival studies at Wells Dam. Mean detection probabilities averaged 0.098, 0.111, and 0.118 at Rocky Reach, McNary and John Day dams in 1998. In general, the majority of the release pairings of Wells Fish Hatchery (WFH) chinook migrated downstream together. Chinook survival through the Wells Project was estimated based upon the relative survival of chinook released at Pateros and chinook released below Wells Dam. Estimated chinook survival from the mouth of the Methow River to the tailrace of Wells Dam averaged 99.7% ($S\hat{E} = 0.015$) in 1998 (Bickford et al. 1999).

Estimated survival from the Rocky Reach tailrace to the McNary tailrace during 1998 averaged 0.659 ($S\hat{E} = 0.040$) for yearling Wells summer chinook, 0.720 ($S\hat{E}$ =0.091) for yearling Winthrop spring chinook and 0.720 ($S\hat{E} = 0.084$) for yearling Methow run-of-river chinook (Bickford et al., 1999). Estimated reach survival from Rocky Reach to McNary were not significantly different (p=0.5390) between Winthrop spring and Wells Fish Hatchery summer chinook. Likewise, estimated survival for summer chinook and Methow collected run-of-river chinook were not significantly different (p=0.2040).

In the spring of 1999, Douglas County PUD proposed a second year of PIT-tag survival studies at Wells Dam. The 1999 survival study was designed to accurately estimate the survival of PIT-tagged steelhead smolts migrating through the Wells Hydroelectric Project. The primary goal of the study was to estimate smolt survival from the mouth of the Methow River to the tailrace of Wells Dam.

2.0 STUDY AREA

The Wells Hydrocombine generating facility is located at river km (R km) 830 on the upper Columbia River (Figure 1). The Wells Hydrocombine, unlike typical Columbia River hydroelectric projects, efficiently combines generation, spill and fish passage facilities into one structure. The generation facilities at Wells Dam contain ten Kaplan turbines capable of producing 840,000 kilowatts of electricity. Juvenile fish are bypassed away from turbines via a highly effective surface collection system. The Wells bypass system provides a safe, non-turbine passage route through the dam for over 92% of the spring and summer migrants (Johnsen et al., 1992; Skalski et al., 1996). Wells is the uppermost generating project on the Columbia River which anadromous chinook (*Oncorhynchus tshawytscha*), steelhead (*O. mykiss*) and sockeye salmon (*O. nerka*) migrate through. Adult fish passage is provided by two fish ladders located at either end of the powerhouse.

The reservoir formed by Wells Dam is called Lake Pateros. The Methow River enters Lake Pateros at R km 843 (Figure 2). The Methow is the most important production area for Upper Columbia River salmon and steelhead upstream of Wells Dam. Both natural and hatchery produced steelhead smolts originate from this system. The Okanogan River enters Lake Pateros at R km 870. Steelhead smolts migrating out of the Okanogan River are planted into this system each spring by staff from the Wells Fish Hatchery.

Figure 1. Mainstem Columbia and Snake rivers depicting important hydroelectric projects.

3.0 METHODS AND MATERIALS

3.1 Fish Collection

The collection of yearling hatchery summer steelhead (study animals) took place at the Wells Fish Hatchery. Steelhead smolts ready to migrate were allowed to volitionally exit Pond #2 via an overflow weir. Fish passing over the weir were washed downstream through an outfall pipe and deposited into a 23,000 L collection trap.

Two to three days prior to each tagging session, sufficient numbers of steelhead smolts were collected from the trap. Fish were pumped from the trap into a 2,000 L transportation container with a 20 cm Aqualite Harvester hydraulic fish pump (Magic Valley Harvest, Hagerman, Idaho). The transportation container was outfitted with a displacement meter, water re-circulation pump and metered compressed oxygen. The displacement meter ensured that the density of fish inside the transport container never exceeded 0.16 Kg fish/L. Once inside the transport container, the fish were transported less than 0.5 km to one of two concrete pre-tagging holding raceways. Transport times from the collection site to the holding raceways was less than 15 minutes per load.

The Wells pre-tagging raceways contained a minimum of 70,000 L of single pass river water. Pond #2 and Raceway #1 and #2 all received a continuous supply of gravity fed river water from the Wells Hatchery water distribution system.

3.2 Tagging and Holding Procedures

On tagging days, small groups of untagged steelhead, being held in either of the two pre-tagging raceways, were crowded toward a pint-sized-pescalator (PRA Manufacturing, Nanaimo, British Columbia, Canada). The pescalator was comprised of a 30 cm diameter fiberglass pipe with an Archimedies screw built into the center. As the pescalator rotated, it captured and transported water and fish up and out of the raceway. At the top of the pescalator, fish and water were deposited into a 10 cm transport pipe. The transport pipe delivered each fish directly into an anesthetic (MS222) bath.

Once anesthetized, diseased, mortally wounded and residual steelhead were removed from the study group. Remaining healthy steelhead smolts were tagged within the body cavity using 12-gauge hypodermic syringes loaded with individual 12 mm Destron-Fearing 400-kHz

PIT-tags. Fish were tagged according to criteria described in Prentice et al. (1987). To prevent disease transmission, each hypodermic needle was soaked in ethyl alcohol for 10 minutes and allowed to dry before being reloaded with a PIT-tag. Needles were used only 18 times each to ensure sharpness and promote rapid healing of the tag incision.

Immediately following tagging, each unique tag code for each fish was entered into a database. In addition to the tag code, date of tag implantation, tag personnel identification code, fish length, water temperature and obvious abnormalities (disease, flag tail and injuries) were recorded.

A 10 cm diameter pipe half full of water was used to transfer the tagged fish into 1,200 L release containers for recovery. During tagging and initial recovery, the release containers were supplied with a continuous flow of river water in addition to metered compressed oxygen. Water and dissolved oxygen levels were closely monitored throughout the entire 36-hour recovery period. Approximately 402 tagged steelhead were placed inside each release container. Loading densities were established to ensure that no release container held more than 0.03 Kg of fish/liter water (Kg fish/L).

Containers with recovering tagged steelhead were supplied with 100-150 L/min of river water through a 5 cm flex-hose. Water temperature and dissolved oxygen levels inside each release container were closely monitored and recorded to ensure that the pre-release recovery history of each container was similar within and between tagging groups. PIT-tag release groups were randomized at the time of tagging, release containers alternated between release groups and tagging personnel rotated between and among tagging groups.

3.3 Transportation and Release Procedures

Releases of PIT-tagged WFH steelhead took place at the Methow River and tailrace release sites on April 19, 21, 23, 25, 27 and 29 and May 1, 3, 5, 7, 9, 11, 13, 15 and 17. On each of the fifteen release days, five release containers were transported with a flatbed truck to each of the barge loading sites.

Pateros release groups were removed from the water supply lines at 0800 hours and transported to the barge loading site at the Methow River. In the afternoons, five tailrace release containers were removed from the water supply lines at 1300 hours and transported to the barge loading site in the Wells tailrace. Release times were staggered to allow Pateros fish additional time to arrive at Wells Dam prior to the release of tailrace fish.

After being disconnected from the river water supply lines, metered compressed oxygen was immediately supplied to each release container. To compensate for differences in travel distances between the Methow and tailrace barge loading sites, the transport vehicle destined for the tailrace site made purposeful excursions to ensure that the total travel times, stress and subsequent pre-release histories of the Methow and tailrace release groups were similar.

At the barge loading stations the release containers were hoisted off the transport trucks and loaded onto barges for final release. Barges were outfitted with water supply lines. Immediately after the release containers were loaded onto the barges, the metered compressed oxygen supply system was disconnected and the on-board river water supply system turned on. Dissolved oxygen and water temperatures for each container were recorded periodically throughout the transportation process. Desired dissolved oxygen concentrations inside each container was manually adjusted to maintain between 9 and 12 mg O_2/L. Injured and moribund fish were removed and recorded. River water flow through each container on the barge was estimated at 75-125 L/minute.

Barges carrying release containers were towed to their respective release locations (Figure 2). Temperature, dissolved oxygen and fish status were recorded prior to final release. Fish were released directly into the Columbia River though 20 x 15 cm eccentric reducers. Water to water transfers were maintained throughout the entire study.

Fish were released at the Methow and tailrace release sites approximately 1 hour and 15 minutes after water supply lines at the WFH were disconnected. The Methow releases were initiated at 0915 hours and the tailrace releases were initiated at 1415 hours.

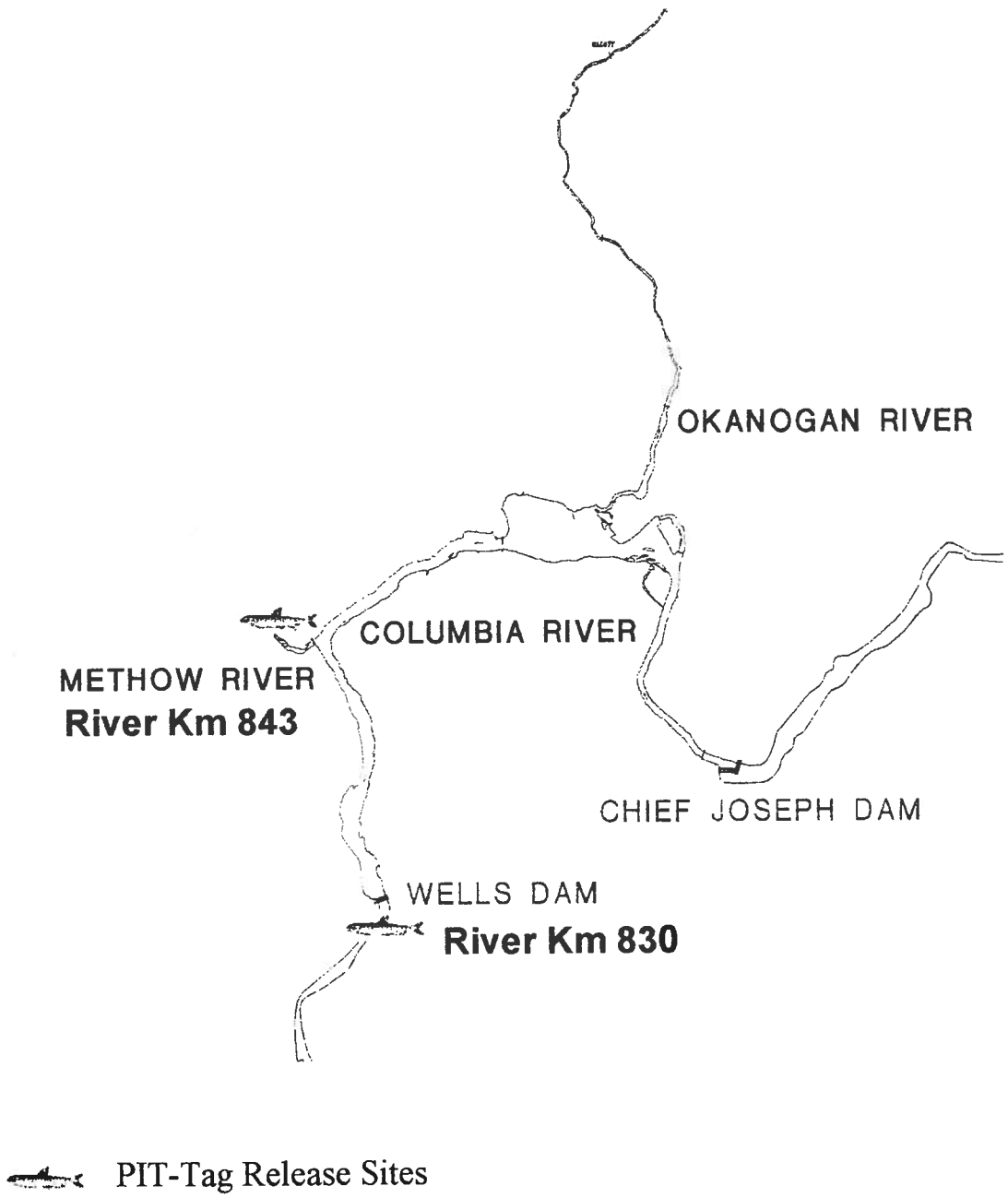
3.4 Physiological Monitoring

A sub-sample of 10 fish from the Pateros release group and 10 fish from the tailrace release group were collected on eight of the fifteen release days. These fish were used for the collection of important physiological information pertinent to the interpretation of survival estimates. Measures of smoltification (gill ATPase and smolt index), measures of stress (plasma cortisol, plasma glucose and liver HSP70), morphological measures (length, weight) and indices of fish health (color and texture of internal organs, fin erosion, descale, infection) were collected. The physiological information collected was used to assess differences in stress, fish condition and fish health within and between replicate release pairs. In addition, comparisons were also made between replicate releases destined for the same release locations. Additional information collected from the post-mortem examination of steelhead included estimates of PIT-tag retention, observations of tag placement and tag implantation related injuries.

To provide a baseline level of fish stress, condition and health, a control group of 20 untagged steelhead was also sampled. Control fish were not tagged but did experience identical collecting, holding and sampling conditions as treatment (tagged) fish.

Collection of stress measures was particularly important for assessing the impact of stress experienced by fish during the collection, tagging and recovery components of the study. In addition, stress levels within and between replicate release pairs were compared to indices of fish health, smolt status and fish condition. Statistical comparisons of physiological measures were accomplished with one-way ANOVA's followed by Tukey tests (Zar, 1984).

Figure 2. Release sites utilized during the 1999 Wells steelhead survival study.

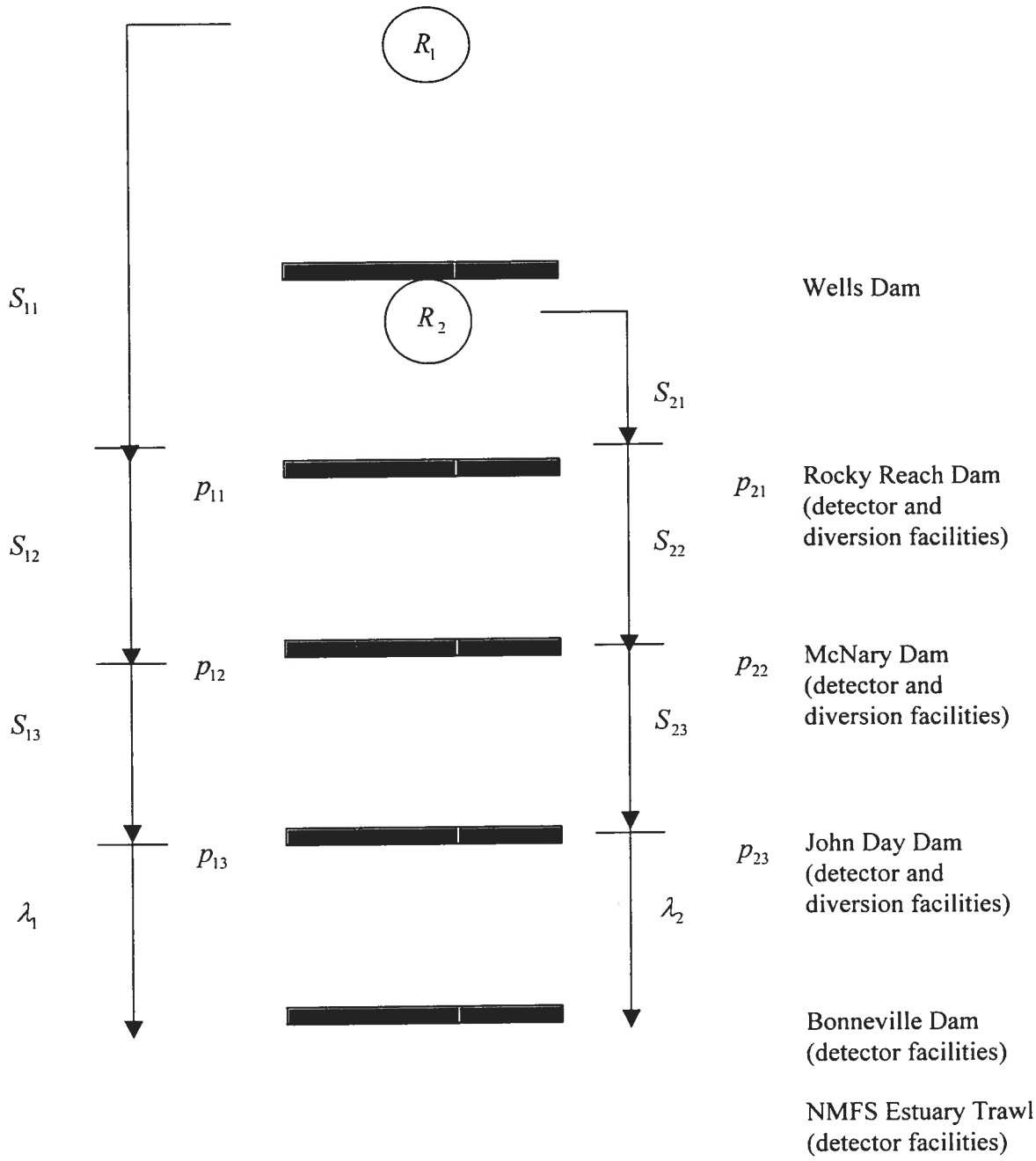


3.5 PIT-Tag Detection

PIT-tagged steelhead released during the 1999 survival study were detected at five downstream locations (Figure 3). The first of these sites was located in the second surface collector entrance and gatewell bypass pipe at Rocky Reach Dam. At Rocky Reach Dam, the detection of 400 kHz PIT-tags was made possible by the installation of two dual coil PIT-tag detection systems. This system was installed by Biomark, Inc. of Boise, Idaho and funded by the Public Utility District No. 1 of Douglas County specifically for the recapture of survival study fish. Downloading of the Rocky Reach PIT-tag detection system data and operation of the fish bypass facility was conducted by the Public Utility District No. 1 of Chelan County.

Recapture and detection of study fish also occurred at McNary, John Day and Bonneville dams. Additional detections took place at the Columbia River estuary-sampling site where the NMFS operates a mid-water trawl equipped with a PIT-tag detection tunnel. The PTAGIS database managed by the Pacific States Marine Fisheries Commission was used to store and archive all the release and recapture information available for study fish. Operation of downstream fish passage facilities and PIT-tag detection facilities was funded by the United States Army Corps of Engineers and the Bonneville Power Administration. Faculty and staff at the Columbia Basin Research Unit, University of Washington conducted model testing, verified model assumptions and provided detection and reach survival probabilities.

Figure 3: Schematic of release sites and PIT-tag detection facilities used in the 1999 Wells Dam Survival Study (Parameters that will be estimated from the release-recapture data are indicated).



3.6 Estimation of Detection and Reach Survival Probabilities

The Single release-recapture (SRR) model was used to provide estimates of reach-specific survival and capture for all but the last recovery site (Figure 3). Estimates of reach survival were generated for tagged WFH steelhead passing from release sites (R_1 and R_2), to the tailrace of Rocky Reach Dam. Estimates of reach specific survival were also estimated for fish passing from the tailrace of Rocky Reach Dam to the tailrace of McNary Dam and from the tailrace of McNary Dam to the tailrace of John Day Dam. Detection rates were concurrently estimated for Rocky Reach, McNary and John Day dams with the SRR model.

Survival estimates for fish passing through Wells Dam ($\hat{S}_W$) were generated indirectly from the results of both the upstream and downstream releases for hatchery steelhead by the expression:

$$\hat{S}_W = \frac{\hat{S}_{11}}{\hat{S}_{21}} \tag{1}$$

with associated variance estimates based on the Delta Method (Seber 1982: pp. 7-9) of

$$\begin{aligned} \hat{Var}\left(\hat{S}_W\right) &\doteq \left(\frac{\hat{S}_{11}}{\hat{S}_{21}}\right)^2 \left[\frac{Var\left(\hat{S}_{11}\right)}{\hat{S}_{11}^2} + \frac{Var\left(\hat{S}_{21}\right)}{\hat{S}_{21}^2}\right] \\ &\doteq \hat{S}_W^2 \left[\hat{CV}\left(\hat{S}_{11}\right)^2 + \hat{CV}\left(\hat{S}_{21}\right)^2\right] \end{aligned} \tag{2}$$

and where

$$\hat{CV}\left(\hat{\theta}\right) = \frac{\sqrt{Var\left(\hat{\theta}\right)}}{\hat{\theta}}.$$

Separate estimates of $\hat{S}_W$ were calculated for each replicate release pairing of WFH steelhead. Pateros and tailrace releases were conducted every other day for a total of fifteen releases.

Proportionate daily detection distributions of the R_1 and R_2 smolts was sufficient but not necessary for valid estimation of S_W. Estimates of $\hat{S}_{11}$ and $\hat{S}_{21}$ can be derived independently without proportionate detection distributions of upstream and downstream smolts based on the assumption of the single release-recapture model. The assumptions of the single release-recapture model are the following (Skalski et al. 1998):

A1. The test fish are representative of the population of inference.

A2. Test conditions are representative of the conditions of interest.

A3. The number of fish released is exactly known.

A4. PIT-tag codes are accurately recorded at the time of tagging and at all detection sites.

A5. For replicated studies, data from different releases are statistically independent.

A6. The fate of each individual fish is independent of the fates of all other fish.

A7. All fish in a release group have equal survival and detection probabilities.

A8. Prior detection history has no effect on subsequent survival and detection probabilities.

In order to estimate S_W, the survival S_{11} is assumed to be of the form:

$$S_{11} = S_W \cdot S_{21} \tag{3}$$

leading to the relationship

$$\frac{S_{11}}{S_{21}} = \frac{S_W \cdot S_{21}}{S_{21}} = S_W \ .$$

The equality (3) suggests two additional assumptions for valid estimation of Wells project survival. These are:

A9. Survival in the Wells Project (S_W) is conditionally independent of survival in the Rocky Reach (S_{21}) Project.

A10. Releases (R_1) and (R_2) experience the same survival probability in the Rocky Reach (S_{21}) Project.

Assumption (9) implies that there is no synergistic relationship between survival processes in the Wells and Rocky Reach projects. In other words, smolts that survived the Wells Project were no more or less susceptible to mortality in the Rocky Reach Project than smolts released in the tailrace of Wells. Assumption (10) is satisfied by downstream mixing of the two release groups R_1 and R_2, but can also be satisfied if the survival process at Rocky Reach (S_{21}) was stable over the course of smolt passage by the two releases. A stable survival process might well be expected for one to a few days under similar flow and dam operations at Rocky Reach. Near constant survival rates at Lower Granite, Little Goose, and Lower Monumental projects over the majority of the outmigration have been reported by Skalski et al. (1997). Furthermore, unlike paired Ricker and Index release-recapture methods of the earlier Mid-Columbia survival studies, the assumption of equal detection rates is not necessary for estimator (1) to be valid. Downstream mixing of the releases is desirable, as it helps to ensure the common downstream survival as release groups encounter the same conditions in the common river reaches.

The most efficient estimator of S_W will depend on the relationship between the releases $(R_1 \text{ and } R_2)$ and the downstream survival and detection probabilities. If all downstream parameters are different between releases, survival will be estimated by Equation (1). This is model $H_{k-1,\phi}$ of Burnham et al. (1987: pp. 177-120). Intermediate models may also exist (Burnham et al. 1987: p. 116, pp. 120-126). The most efficient estimate of Wells Project survival (S_W) will be based on the statistical model for the releases R_1 and R_2 that properly share all common parameters. The best representation for the survival and capture processes of releases $(R_1 \text{ and } R_2)$ can be found using Program RELEASE (Burnham et al. 1987) or SURPH.1 (Smith et al. 1994). Sequential modeling will be performed for each pair of primary releases to

determine the most appropriate and precise estimate of S_W and the associated variance estimate.

The fifteen replicate release groups will be used to provide independent estimates of Wells project survival $\left(\hat{S}_{Wi}\right)$ over the course of the study. The replicate releases were conducted to encompass seasonal trends in survival over time and over varying survival conditions.

A weighted average survival estimate of the replicate releases will be calculated according to the formula

$$\hat{\bar{S}} = \frac{\sum_{i=1}^{k} W_i \hat{S}_i}{\sum W_i} \tag{4}$$

where k = number of replicate releases;

$\hat{S}_i$ = survival estimates from the ith release pair $(i = 1, \ldots, k)$;

$$W_i = \frac{1}{\left(\frac{\hat{Var}\left(\hat{S}_i\right)}{\hat{S}_i^2}\right)} = \frac{1}{CV\left(\hat{S}_i\right)^2} \tag{5}$$

with variance

$$Var\left(\hat{\bar{S}}\right) = \frac{\sum_{i=1}^{k} W_i \left(\hat{S}_i - \hat{\bar{S}}\right)^2}{(k-1)\sum_{i=1}^{k} W_i}. \tag{6}$$

It was found that by weighting simply using the inverse of $Var\left(\hat{S}_i\right)$, the weights were correlated with the point estimates [i.e., Equation (2)], resulting in downward bias in the average survival. By calculating the relative variance [Equation (5)], this correlation between the variance estimate and the point estimate is eliminated.

The $(1-\alpha)$ 100% approximate confidence interval for the weighted average of the survival estimates will be computed by

$$\hat{\bar{S}} \pm Z_{1-\frac{\alpha}{2}} \sqrt{Var\left(\hat{\bar{S}}\right)}.$$

Detection rates at the estuary-sampling site were low in 1999. Consequently, detection data collected at this site were pooled with detection data at Bonneville Dam to provide more precise survival and detection estimates.

3.6.1 Test of Assumptions

The assumptions of the single and paired release-recapture models were rigorously tested for each release group utilized in the development of project specific survival estimates. In the following sections, test-wise error rates (α) are adjusted for an experimental-wise error rate (α_{EX}) of 0.10. In computing a large number of tests, the risk that a test will reject the null hypothesis increases as the number of tests increases. The experimental-wise error rate helps to screen out those tests which may be rejected due to randomness, and focuses attention on those tests that warrant further attention. To address the concern that this process may eliminate too much test sensitivity, individual test p-values are also reported. For each sequence of tests, test-wise error rates are adjusted by the following:

$$\alpha = 1 - \sqrt[t]{1-\alpha_{EX}} = 1 - \sqrt[t]{1-\alpha_{0.10}} = 1 - \sqrt[t]{0.90}$$

where α = test-wise error rate,

α_{EX} = experimental-wise error rate, and

t = number of tests in a sequence.

Tests of Assumptions Within a Release Based on the Single Release-Recapture Model

For the single release-recapture model to be valid, certain data patterns should be evident from the detection histories. For each release group, a series of tests of assumptions can be performed to determine the validity of the model (i.e., goodness-of -fit). The data from a single release can be summarized by an m-array matrix of the form below:

	Recovery Site			
Release Site	Rocky Reach (2)	McNary (3)	John Day (4)	Bonneville (5)
Initial (1)	m_{12}	m_{13}	m_{14}	m_{15}
Rocky Reach (2)		m_{23}	m_{24}	m_{25}
McNary (3)			m_{34}	m_{35}
John Day (4)				m_{45}

Where $m_{ij}'s$ are the number of smolts released at site *i* that are next detected at site *j*.

Burnham et al. (1987: p. 65, pp. 71-74) presents a series of tests of assumptions called Test 2 that examine whether upstream detections affect downstream survival and/or detection. For each release, two contingency table tests are performed, as follows:

Test 2.2

m_{13}	m_{14}	m_{15}
m_{23}	m_{24}	m_{25}

$$\chi_2^2 \qquad (7)$$

Test 2.3

$m_{14} + m_{24}$	$m_{15} + m_{25}$
m_{34}	m_{35}

$$\chi_1^2 \qquad (8)$$

Overall significance of Test 2 would be based on the sum of the chi-square statistics $\chi_2^2 + \chi_1^2 = \chi_3^2$. Test-wise error rates will be adjusted for the experimental-wise error rate of $\alpha_{EX} = 0.10$.

Burnham et al. (1987: p. 65, pp.74-77) also presents a series of test assumptions called Test 3 which further examines whether upstream detection histories affect downstream survival and/or detection. For each release, contingency tables can be constructed of the form:

		Detection History to McNary Dam		
		101	111	
Detection History	11			
at John Day and	10			(9)
Bonneville Dams	01			
	00			χ^2_3

Contingency table (9) tests whether detection at Rocky Reach Dam has a subsequent effect on detection histories at John Day and Bonneville Dams. To test whether detection at Rocky Reach and/or McNary Dam has a subsequent effect on the detection history at Bonneville Dam, a contingency table can be constructed of the form:

		Detection History at John Day Dam				
		1111	1101	1011	1001	
Detection History	1					(10)
at Bonneville	0					χ^2_3

Contingency tables (9) and (10) are slight modifications from Burnham et al. (1987) to take into account more information from the individual detection histories.

Tests of Assumptions Between Releases Within a Paired-Release

At each downstream PIT-tag detection site (i.e., Rocky Reach, McNary, John Day, Bonneville), a test of the assumption of mixing among the releases of smolt (e.g., R_1 and R_2) will be conducted. An R x C contingency table test of homogeneous detections downriver over time will be performed using a table of the form:

		Release	
		R_1	R_2
	1		
Day of	2		
Detections	3		
	⋮	⋮	⋮
	D		

(11)

A contingency table of form (11) will be calculated for each of the 15 Pateros-Tailrace paired releases. Each test will be performed at $\alpha = 0.10$. Because of the multiple tests across release-pairs, Type I error rates will also be adjusted for an overall experimental-wise error rate of 0.10.

To test whether releases with a paired-release (e.g., R_1 and R_2) have similar downstream survival and detection histories for Rocky Reach Dam and below, likelihood ratio tests will be performed to compare models $H_{1\phi}$ and $H_{k-1\phi}$ as well as intermediate scenarios. These tests will be used to help determine the most parsimonious model for the estimation of S_W. Burnham et al. (1987: pp.128, Test 1.T2) suggests using a 2 x 2 contingency table test to determine where the detection and survival rates for the R_1 and R_2 releases are equal at and below Rocky Reach Dam (i.e., $p_{11} = p_{21}$, $S_{12} = S_{22}$, $p_{12} = p_{22}$, etc.), another indication of complete mixing. The 2 x 2 table would be of the form:

	Release	
	R_1	R_2
m_1	m_{11}	m_{21}
z_1	z_{11}	z_{21}

(12)

where m_1 is the number of smolts detected at Rocky Reach for a release and z_1 is the number of smolts that were released that were not detected at Rocky Reach but were subsequently detected at McNary Dam or below. While contingency table (12) tests equality of overall detection for releases R_1 and R_2, it does not provide the fine-grained test of equal site-specific detection and survival rates for both releases available using the likelihood ratio tests. For this reason, inferences concerning downstream mixing will be largely based on the sequential use of likelihood ratio tests.

3.6.2 Modeling Paired-Tag Releases

For each pair of Pateros and tailrace release groups used to estimate survival through the Wells Project, a model fitting routine was performed to identify the most appropriate and parsimonious likelihood model. Two approaches to model fitting were used for each release pair: (a) forward-step fitting routine and (b) test of overall fit of the selected model.

The forward-step fitting routine began with all detection, survival, and last reach probabilities unique. The forward sequential procedure then tested whether in order $\underset{\sim}{p_1}$, $\underset{\sim}{S_2}$, $\underset{\sim}{p_2}$, $\underset{\sim}{S_3}$, $\underset{\sim}{p_3}$, and $\underset{\sim}{\lambda}$ were homogeneous between release groups from Pateros and Wells tailrace. The forward-step fitting procedures kept survival probabilities S_{11} and S_{21} unique in all steps of the testing. Testing continued until downriver parameters were found to be homogeneous within a paired release. The selected model was then compared to the fully parameterized Cormack-Jolly-Seber (CJS) model to assess whether the selected model adequately described the capture data.

3.6.3 Smolt Survival Comparison

Using the estimates from 1998 and this year (1999), a comparison of mean survival was performed. The test of equal survival was based on an asymptotic z-test of the form:

$$z = \frac{\left|\hat{\bar{S}}_{1998} - \hat{\bar{S}}_{1999}\right|}{\sqrt{V\hat{a}r\left(\left(\hat{\bar{S}}_{1998}\right) + V\hat{a}r\left(\hat{\bar{S}}_{1999}\right)\right)}}$$

where

$\hat{\bar{S}}_{1998}$ = weighted average of Wells survival from the 1998 PIT-tag study, and

$\hat{\bar{S}}_{1999}$ = weighed average of Wells survival from the 1999 PIT-tag study.

The two-tailed test of equality of survival estimates will be performed at α =0.10.

4.0 RESULTS

4.1 Fish Collection

Steelhead collected from Pond #2 were not directly counted. Instead volumetric displacement was used to estimate the number of steelhead collected from Pond #2. The day before tagging, approximately 4,500 steelhead were crowded and fish pumped into a transport truck. The transport truck then released these fish directly into pre-tagging raceways located proximal to the PIT-tagging facility. No steelhead losses were recorded during the fish pumping and transportation process. The steelhead collected from Pond #2 were allowed to recover in the pre-tagging raceways at least 48-hours prior to being tagged.

4.2 Tagging and Holding

In total, 74,669 steelhead were collected for tagging purposes. Not all of the 74,669 hatchery steelhead collected for tagging were retained and tagged. In total, 1,812 excess steelhead were released directly into the Columbia River below Wells Dam. An additional, 1,719 steelhead were removed from the study after being anesthetized and/or tagged. The majority of these fish (1,358) were removed because they did not represent the population of steelhead expected to migrate through Wells Dam in 1999. These fish exhibited signs of disease, serious injury, precocity and in some cases grotesque growth abnormalities (twin tailed fish). A smaller component (361) of the fish removed from the study included fish released with non-functioning or duplicate PIT-tags.

Steelhead smolts were the population of inference for the 1999 survival study at the Wells Hydroelectric Project. As such, precocious steelhead parr were excluded because they were not expected to migrate through the dam in 1999. Fish with serious injuries and growth abnormalities were excluded because they were not expected to survive the tagging procedure.

In addition to fish in excess to study needs, 416 PIT-tagged fish were volitionally released due to a failure in a release container intake screen. As a result, these fish were not assigned to a tag group used for the survival study.

The remaining 70,722 steelhead were tagged and used in two separate studies. The Wells Project survival study utilized 60,382 steelhead while the Okanogan PIT-tag / radio-tag survival comparisons study utilized the remaining 10,340 steelhead.

Of the 60,382 steelhead smolts PIT-tagged for the Wells Project Survival Study, a total of 43 (0.06%) tagged steelhead died after being tagged. Of these mortalities, 24 (56%) occurred during replicate #9 and were the result of an accidental overdose of anesthetic in one dishpan. The remaining 19 mortalities were divided between the Pateros (14) and tailrace release groups (5) (Table 1). In addition to tagging related losses, an additional 163 (0.25%) tagged steelhead were sacrificed for physiological sampling. A total of 55 shed PIT-tags were recovered inside release containers utilized for the Wells Project survival study. In total, 30,072 PIT-tagged steelhead were released at Pateros and 30,049 PIT-tagged steelhead were released into the Wells tailrace (Table 1).

4.3 Transportation and Release

Releases of PIT-tagged WFH steelhead took place at the Methow River and tailrace release sites on April 19, 21, 23, 25, 27 and 29 and May 1, 3, 5, 7, 9, 11, 13, 15 and 17. On each of the fifteen release days, five release containers were transported to each of the barge loading sites on time and within the parameters established in Section 3.3 (Methods and Materials). Standardization of loading, transportation, and barge loading times was achieved throughout the study. Loading required 15 minutes, transport time ranged from 13 to 16 minutes and barge loading times remained constant within and between replicate releases.

Dissolved oxygen and water temperatures for each container were recorded at pre-determined intervals throughout the transportation process. Records of dissolved oxygen and temperature indicated similar trends within and between replicate release sites. Concentrations of dissolved oxygen varied slightly between release containers but was consistently maintained between 9 and 12 mg O_2/L throughout the transportation interval.

Water temperatures varied less than one degree during the transportation phase of the study. Water temperatures in the Pateros and tailrace release containers were maintained within 1°C of Columbia River water temperatures. Over the course of the study, Columbia River water temperatures climbed from 7°C on the first release day to almost 10° C by the end of the study.

All thirty steelhead releases were initiated at the Methow and tailrace release sites within 1 hour and 20 minutes after water supply lines at the WFH were disconnected. As scheduled, the Pateros releases were initiated at 0915 hours and the tailrace releases were initiated at 1415 hours.

Table 1: Tag releases for the 1999 Wells steelhead survival study.

Tagging Study	Release Site	Release No.	Tagged	Morts.	Sacrificed	Tags shed	**Total Released**
Wells Project	Pateros	1	2,012		10		2,002
		2	2,019	4		1	2,014
		3	2,035	1	10	1	2,023
		4	2,009			5	2,004
		5	2,021	4	10	1	2,006
		6	2,010			3	2,007
		7	2,020	1	10		2,009
		8	2,010			2	2,008
		9	2,020	3	10	1	2,006
		10	2,007			1	2,006
		11	2,019		11	1	2,007
		12	2,010			2	2,008
		13	2,020		11	3	2,006
		14	2,010	1		2	2,007
		15	1,971		10	2	1,959
Wells Project	Pateros	Sub-total	30,193	14	82	25	30,072

Table 1 (Continued).

Tagging Study	Release Site	Release No.	Tagged	Morts.	Sacrificed	Tags shed	**Total Released**
Wells Project	Tailrace	1	2,026		10		2,016
		2	2,008				2,008
		3	2,020		10	1	2,009
		4	2,005			3	2,002
		5	2,020	2	10	3	2,005
		6	2,017				2,017
		7	2,020	1	11		2,008
		8	2,009			2	2,007
		9	2,020	24	10		1,986
		10	2,011			4	2,007
		11	2,020		10	2	2,008
		12	2,010	1		7	2,002
		13	2,021		10	2	2,009
		14	2,012			1	2,011
		15	1,970	1	10	5	1,954
Wells Project	Tailrace	Sub-total	30,189	29	81	30	30,049
Wells Project	**Survival Study**	**Grand Total**	**60,382**	**43**	**163**	**55**	**60,121**

4.4 Physiological Monitoring

Measures of smolt morphology, smolt readiness, indices of stress, fish condition and fish health were collected from eight of the fifteen PIT-tag release groups. These samples were collected from fish scheduled for release on April 19, 23, 27 and May 1, 5, 9, 13 and 17. Physiological samples of smolt status, fish health and stress levels were conducted to facilitate interpretation of variations in post-release behavior and survival within and between release groups of steelhead.

The mean fork length of WFH steelhead in each sample group ranged from 186.9 to 201.1 mm (Table 2-A). A statistical analysis of mean fork length between groups found no significant differences (Tukey test, $p > 0.05$). This included comparisons between release locations, release days and control (untagged) versus treatment (tagged) fish. The mean weight of sample groups ranged from 63.8 to 72.8 g. A statistical analysis of the differences between sample groups found no significant ($p > 0.05$) differences between mean fish weights (Table 2-B).

Indices of fish health were all typical of healthy fish for all sample groups. The smolt index for all groups ranged from 4 to 5 indicating that most fish still retained faint parr marks. The highest smolt index was observed for the first release group (Table 2-C). Fat coverage of the mesenteries ranged from 50% to 100% for all samples, indicating that the fish sampled were in good health and properly nourished. Indices of fat coverage did decrease toward the later half of the study. Fat coverage of the mesenteries averaged 98% at the beginning of the study compared to 62% toward the end of the study (Table 2-C). Scale loss was nominal in all groups including the untagged physiological control group. Fin erosion was not observed to any measurable extent in any of the groups sampled. Color and size of internal organs was noted as normal for all groups sampled. Organ color and size were used an in indicator that fish were generally healthy with no signs of disease.

Blood plasma was collected for analysis of plasma glucose. Concentrations of glucose were utilized as an indicator of short and long-term stress. Plasma glucose concentrations ranged from 5.38 to 9.77 mMoles/L plasma (Table 3-A). No significant ($p > 0.05$) differences between Methow and tailrace release groups were noted in the groups sampled. In general, mean glucose concentrations declined slightly from the start to the end of the study.

The range of glucose values observed during 1999 for PIT-tagged steelhead smolts were similar to literature values for chinook smolts following short-term handling stress and were only slightly higher than typical resting levels (Maule et al., 1988). The concentrations of glucose found in the blood of WFH steelhead smolts after capture, PIT-tagging and holding for 48-hours were similar to fish sampled prior to PIT-tagging and were similar to fish exposed to short-term handling during other studies (Iwama et al., 1995; Barton et al., 1986). Typically, plasma glucose concentrations increase rapidly following a short-term stress. In the absence of additional stress plasma glucose concentrations are expected to return to resting values within 24-hours of the stress event (Iwama et al., 1995; Barton et al., 1986).

As a secondary indicator of short-term handling stress, plasma cortisol concentrations were recorded. Concentrations of plasma cortisol during the 1999 study ranged from 9.74 to 71.65 ng cortisol/ml plasma for tagged steelhead (Table 3-B). The highest mean value was for the Methow release group 9 and this value was significantly ($p < 0.05$) different than all other groups sampled. No other significant differences were observed. Observed values overlapped considerably between sample groups and between control (non-tagged) and PIT-tagged groups.

Plasma cortisol values in the 100 to 250 ng/ml plasma range are typical of fish, including steelhead smolts, exposed to short-term handling and transport stress. Values as high as 500 ng/ml have been reported for steelhead smolts following severe confinement (Barton and Iwama, 1991). Cortisol levels measured in steelhead smolts during the 1999 survival study were below typical values for salmonids exposed to short-term handling and were close to values recorded for fish at rest (5-100 ng/ml ; Barton and Iwama, 1991).

Coupled with the collection of short-term stress indices, liver HSP70 levels were recorded as a measure of long-term stress exposure. Levels of HSP70 are expressed as a percentage compared to a standard. For this study, HSP70 concentrations in liver from juvenile coho exposed to a heat shock treatment were used as the standard. Coho were sampled after exposure to a 10°C thermal shock for 2 hours. Differences in long-term stress were determined by comparing the relative HSP70 values between sample groups. HSP70 levels ranged from 0.28 to 0.53 of the standard (Table 3-C). A statistical analysis of the differences between groups found no significant differences between groups including comparisons between the control (untagged) group and all other sampled tag groups (1-way ANOVA; $p < 0.05$). The relative units measured indicated that group means represent concentrations of HSP70 that were 28% to 53% of concentrations for a heat shocked fish.

Gill ATPase levels were measured to provide a quantitative comparison of smolt readiness. Values recorded for steelhead smolts ranged from 19.69 to 37.89 nmoles/mg protein/minute (Table 3-D). A statistical analysis of the differences found a significant difference between Methow release group 1 and tailrace release group 15 ($p < 0.05$). These differences would not effect the estimation of survival through Wells Dam. Values from all sample groups were low compared to values from Lower Columbia River steelhead juveniles (Weitkamp and Loeppke, 1983).

Columbia River steelhead smolts collected closer to the ocean typically have gill ATPase values considerably higher than those observed in 1999 at Wells. Weitkamp and Loeppke (1983) reported values in the 387 to 602 nmoles/mg protein/minute range for steelhead smolts at Priest Rapids and McNary dams. It is common for the ATPase values from inland stocks of salmonids to be low at the start of migration. In contrast, ATPase values for coastal stocks that encounter saltwater shortly after migration typically exhibit much higher ATPase values (Ewing et al., 1980). The values observed in 1999 were comparable to values reported during past analyses conducted at the Wells Fish Hatchery (Heather Bartlett, pers. comm.).

Table 2. Lengths, Weights and Health indices for Wells Hatchery steelhead smolts, 1999.

A. Lengths.

Date	Sample Group	Release Group	Source	Mean (mm)	S.D.	Min. (mm)	Max. (mm)	n
April 19	1	1	Tagged	193.4	10.38	168	212	20
April 19	2	2	Pre-PIT	194.3	12.63	170	217	20
April 23	3	3	Tagged	194.3	10.13	182	215	20
April 27	4	5	Tagged	196.5	15.33	171	233	20
May 1	5	7	Tagged	195.3	21.77	168	271	21
May 5	6	9	Tagged	201.1	13.67	175	219	20
May 9	7	11	Tagged	186.9	14.82	170	224	21
May 13	8	13	Tagged	187.4	18.00	232	163	21
May 17	9	15	Tagged	197.9	12.65	174	219	20

B. Weights.

Date	Sample Group	Release Group	Source	Mean (g)	S.D.	Min. (g)	Max. (g)	n
April 19	1	1	Tagged	66.7	12.11	40	92	20
April 19	2	2	Pre-PIT	68.5	15.46	42	98	20
April 23	3	3	Tagged	66.0	13.12	48	96	20
April 27	4	5	Tagged	69.2	16.72	46	113	20
May 1	5	7	Tagged	63.8	14.51	41	96	21
May 5	6	9	Tagged	72.6	15.96	45	100	20
May 9	7	11	Tagged	66.1	15.76	39	107	21
May 13	8	13	Tagged	72.8	22.70	133	47	21
May 17	9	15	Tagged	69.2	13.22	48	94	20

C. Health indices.

Date	Sample Group	Release Group	Source	Smolt Index	Fat index	% Fat coverage	Liver	n
April 19	1	1	Tagged	5.0	3.6	90	1.9	20
April 19	2	2	Pre-PIT	4.8	3.9	98	2.0	20
April 23	3	3	Tagged	4.6	3.7	92	1.7	20
April 27	4	5	Tagged	4.7	3.5	88	2.0	20
May 1	5	7	Tagged	4.7	3.2	80	2.0	21
May 5	6	9	Tagged	4.7	3.3	82	1.8	20
May 9	7	11	Tagged	4.5	3.2	80	2.0	21
May 13	8	13	Tagged	4.4	2.5	62	1.9	21
May 17	9	15	Tagged	4.5	2.9	72	2.0	20

Table 3. Mean, standard error and sample size for physiological sampling of Wells Hatchery steelhead smolts, 1999.

A. Blood plasma glucose.

			Glucose (mMoles/L plasma)		
Release Group	Tank No.	Release Site	Mean	1 s.e.	n
Control	Raceway	N/A	8.16	0.374	10
Control	Raceway	N/A	9.16	0.546	10
1	17	Pateros	9.77	1.195	10
1	16	Tailrace	8.15	0.884	10
3	18	Pateros	8.65	0.912	10
3	16	Tailrace	7.31	0.557	10
5	18	Pateros	6.85	0.572	10
5	16	Tailrace	7.77	0.710	10
7	24	Pateros	6.71	0.498	10
7	15	Tailrace	5.38	0.251	10
9	25	Pateros	6.93	0.614	10
9	20	Tailrace	6.33	0.542	10
11	16	Pateros	5.73	0.365	10
11	19	Tailrace	5.72	0.272	10
13	23	Pateros	6.21	0.328	10
13	24	Tailrace	6.19	0.439	10
15	25	Pateros	6.21	0.368	10
15	24	Tailrace	6.08	0.196	10

B. Blood plasma cortisol.

			Cortisol (ng/ml plasma)		
Release Group	Tank No.	Release Site	Mean	1 s.e.	n
Control	Raceway	N/A	26.11	4.151	10
Control	Raceway	N/A	30.51	12.275	10
1	17	Pateros	30.88	2.554	10
1	16	tailrace	35.23	4.792	10
3	18	Pateros	14.30	2.008	10
3	16	tailrace	15.72	2.177	10
5	18	Pateros	15.03	1.442	10
5	16	tailrace	17.52	1.251	10
7	24	Pateros	31.04	3.721	10
7	15	tailrace	29.54	9.507	10
9	25	Pateros	71.65	13.985	10
9	20	tailrace	33.57	6.622	10
11	16	Pateros	14.53	2.688	10
11	19	tailrace	9.74	0.964	10
13	23	Pateros	15.34	1.908	10
13	24	tailrace	13.69	1.066	10
15	25	Pateros	16.06	0.898	10
15	24	tailrace	14.29	0.861	10

Table 3. (Continued).

C. Liver HSP70.

Release Group	Tank No.	Release Site	HSP70 (relative index)		
			Mean	1 s.e.	n
Control	Raceway	N/A	0.34	0.035	10
Control	Raceway	N/A	0.46	0.065	10
1	17	Pateros	0.28	0.055	10
1	16	tailrace	0.53	0.067	10
3	18	Pateros	0.39	0.060	10
3	16	tailrace	0.45	0.092	10
5	18	Pateros	0.38	0.067	10
5	16	tailrace	0.50	0.071	10
7	24	Pateros	0.35	0.054	10
7	15	tailrace	0.43	0.067	10
9	25	Pateros	0.35	0.040	10
9	20	tailrace	0.46	0.069	10
11	16	Pateros	0.39	0.056	10
11	19	tailrace	0.45	0.118	10
13	23	Pateros	0.32	0.041	10
13	24	tailrace	0.50	0.102	10
15	25	Pateros	0.36	0.037	10
15	24	tailrace	0.52	0.071	10

D. Gill ATPase.

Release Group	Tank No.	Release Site	ATPase (nmoles/mg protein/min.)		
			Mean	1 s.e.	n
Control	Raceway	N/A	29.43	1.847	10
Control	Raceway	N/A	31.43	3.078	10
1	17	Pateros	37.89	5.054	10
1	16	tailrace	29.16	2.837	10
3	18	Pateros	27.26	2.177	10
3	16	tailrace	23.58	3.171	10
5	18	Pateros	30.74	2.683	10
5	16	tailrace	30.11	2.600	10
7	24	Pateros	31.42	3.347	10
7	15	Tailrace	29.75	2.703	10
9	25	Pateros	28.57	1.809	10
9	20	Tailrace	29.31	3.549	10
11	16	Pateros	26.20	2.355	10
11	19	Tailrace	30.74	3.430	10
13	23	Pateros	30.09	2.968	10
13	24	Tailrace	26.94	3.210	10
15	25	Pateros	23.32	2.179	10
15	24	Tailrace	19.69	1.756	10

4.5 Estimation of Detection and Reach Survival Probabilities

Yearling steelhead smolts released at Pateros and released into the Wells tailrace had the potential to be collected and passively interrogated at downstream PIT-tag detection facilities. Detection facilities at Rocky Reach, McNary, John Day, and Bonneville dams provided the majority of the detections for 1999. Study fish detected at Bonneville Dam and the National Marine Fisheries Service experimental PIT-tag trawl were pooled for all of the analyses. In 1999, limited smolt transportation occurred at McNary Dam. Consequently, few PIT-tagged smolts were diverted into barges and transported around the detectors at John Day and Bonneville dams. Detection histories for barged smolts were censored at McNary Dam for all analyses. Release group specific detection histories are summarized in Table 4.

For simplicity, each tag group was given a three-part group identification code. The first part is the day-of-the-year for the release date, followed by a letter denoting release location (i.e., w = Wells tailrace, p = Pateros), and ending in a release group number from each release location. For example, 107p1 denotes the first release group which was tagged on day 107 and released at Pateros on day-of-the-year 109.

Subsequent analysis utilized all 15 replicate release pairs for estimating reach specific survival and dam specific detection probabilities. Additional analyses were used to evaluate the validity of model assumptions associated with the single release-recapture (SRR) and paired release-recapture (PRR) recapture models.

Using the single release-recapture model (Cormack 1964, Jolly 1965, Seber 1965), reach specific survival was estimated for the following reaches:

1. Release location to the tailrace of Rocky Reach Dam (S_1).
2. Rocky Reach tailrace through to the tailrace of McNary Dam (S_2).
3. McNary tailrace through to the tailrace of John Day Dam (S_3).

Reach survival probabilities and associated standard errors are reported in Table 5.

The SRR release-recapture model also provided capture probabilities for the following PIT-tag detector dams:

1. Rocky Reach Dam (p_1).
2. McNary Dam (p_2).
3. John Day Dam (p_3).

For the last reach between John Day and Bonneville Dams, only the joint product of survival and detection at Bonneville Dam (λ) could be estimated (Table 5).

In general, detection probabilities in 1999 were higher than those observed in 1998. Mean capture probabilities in 1999 for steelhead were 0.250, 0.198, and 0.358 at Rocky Reach, McNary, and John Day dams, respectively. Mean values for yearling chinook in 1998 were 0.098, 0.111, and 0.118 at Rocky Reach, McNary and John Day dams, respectively.

Table 4. Complete detection history for each release group. Counts of smolt by detection history for each release group used in the 1999 Wells smolt survival studies. The digit 1 denotes detected; 0, not detected; and 2, censored at Rocky Reach, McNary, John Day, and Bonneville tailraces. Detection histories reflect data downloaded from PTAGIS July 14, 1999.

Release	1111	0111	1011	0011	1101	0101	1001	0001	1110	0110	1010	0010	1100	0100	1000	0000	1200	0200
Pateros																		
107p1	4	10	21	49	6	23	42	125	13	31	47	158	22	87	286	1058	4	17
109p2	6	11	13	50	3	28	47	107	14	34	45	207	14	67	192	1156	4	18
111p3	2	12	24	62	11	26	59	91	18	42	89	186	39	77	314	948	4	18
113p4	7	12	23	42	8	36	35	121	10	53	55	189	32	91	227	1045	5	12
115p5	5	23	12	63	9	39	30	136	4	56	43	200	29	121	166	1044	5	20
117p6	2	14	22	57	5	41	23	131	9	61	61	204	28	89	231	989	5	35
119p7	4	9	12	45	4	20	44	134	2	43	50	208	17	95	245	1005	7	55
121p8	4	7	26	46	4	17	36	92	15	46	60	246	29	78	267	989	8	38
123p9	4	14	12	59	8	29	44	136	12	36	72	235	23	85	234	998	0	5
125p10	3	13	11	45	4	22	44	103	15	48	78	226	33	99	263	995	3	0
127p11	4	7	22	62	10	20	45	77	23	42	88	199	30	70	339	969	0	1
129p12	2	10	8	49	4	17	31	78	9	58	66	234	22	96	258	1064	0	2
131p13	4	11	19	44	0	20	12	92	6	68	61	273	15	89	252	1036	1	2
133p14	2	19	9	50	6	8	15	65	7	50	41	297	17	97	176	1146	0	2
135p15	10	9	24	49	6	10	16	50	19	60	93	264	24	77	291	950	1	3
Wells																		
107w1	10	13	13	40	7	27	46	121	6	41	57	179	33	102	275	1015	7	24
109w2	2	22	15	61	7	21	23	172	7	41	38	201	16	105	191	1065	3	18
111w3	4	12	29	48	6	25	42	119	18	34	78	185	20	60	321	978	8	20
113w4	5	11	27	62	13	36	52	115	19	56	71	173	48	84	343	873	0	14
115w5	2	20	8	50	5	48	24	146	8	65	38	232	23	127	154	1027	3	23
117w6	5	16	26	67	7	33	36	127	13	63	59	193	34	114	215	958	14	31
119w7	1	5	23	50	4	24	48	110	14	39	77	206	28	84	303	928	16	48
121w8	4	11	25	57	6	27	45	138	15	44	81	230	31	75	293	868	14	43
123w9	3	17	14	57	5	23	38	126	6	66	46	236	23	88	222	1013	2	1
125w10	6	17	14	54	8	28	52	106	16	47	64	209	32	106	315	926	0	5
127w11	7	13	26	48	6	15	58	84	15	47	100	220	39	78	406	843	0	2
129w12	5	10	21	62	4	16	39	77	17	54	87	235	26	97	333	918	0	2
131w13	5	9	24	54	4	14	30	71	27	60	87	243	31	80	327	946	0	4
133w14	3	18	11	59	4	15	13	66	14	64	66	290	14	107	188	1079	0	0
135w15	3	7	18	47	3	11	24	47	25	79	97	279	40	86	300	878	2	2

Table 5. Cormack-Jolly-Seber estimates of survival and detection probabilities for each release group used in the 1999 Wells smolt survival studies. The joint probability of recovery from John Day to Bonneville and being detected at Bonneville Dam (λ) is reported in the last column. Standard errors are reported in parentheses.

Release	Survival			Probability of Detection at			Combined detection and survival (λ)
	Release to Rocky Reach	Rocky Reach to McNary	McNary to John Day	Rocky Reach	McNary	John Day	
Pateros							
107p1	0.921 (0.050)	0.658 (0.061)	0.931 (0.098)	0.241 (0.017)	0.179 (0.017)	0.300 (0.027)	0.252 (0.024)
109p2	0.767 (0.043)	0.688 (0.058)	1.208 (0.119)	0.219 (0.016)	0.187 (0.017)	0.302 (0.028)	0.211 (0.021)
111p3	0.856 (0.034)	0.748 (0.055)	0.981 (0.088)	0.324 (0.017)	0.192 (0.016)	0.348 (0.028)	0.230 (0.020)
113p4	0.838 (0.042)	0.706 (0.054)	1.132 (0.106)	0.239 (0.016)	0.224 (0.017)	0.296 (0.027)	0.215 (0.021)
115p5	0.877 (0.051)	0.756 (0.061)	0.958 (0.082)	0.172 (0.013)	0.234 (0.017)	0.325 (0.026)	0.254 (0.022)
117p6	0.977 (0.054)	0.627 (0.049)	1.124 (0.097)	0.197 (0.014)	0.235 (0.017)	0.322 (0.027)	0.221 (0.020)
119p7	0.995 (0.057)	0.680 (0.062)	1.147 (0.129)	0.198 (0.014)	0.196 (0.017)	0.257 (0.027)	0.183 (0.020)
121p8	0.924 (0.046)	0.719 (0.061)	0.976 (0.098)	0.242 (0.016)	0.184 (0.016)	0.358 (0.031)	0.184 (0.018)
123p9	0.902 (0.045)	0.751 (0.062)	1.127 (0.111)	0.226 (0.015)	0.159 (0.014)	0.291 (0.026)	0.200 (0.019)
125p10	0.886 (0.042)	0.780 (0.064)	1.081 (0.115)	0.256 (0.016)	0.173 (0.015)	0.294 (0.029)	0.164 (0.018)
127p11	0.881 (0.038)	0.659 (0.051)	0.998 (0.089)	0.317 (0.018)	0.178 (0.016)	0.385 (0.031)	0.213 (0.019)
129p12	0.962 (0.057)	0.640 (0.059)	1.019 (0.106)	0.207 (0.015)	0.178 (0.016)	0.347 (0.034)	0.158 (0.017)
131p13	1.121 (0.076)	0.532 (0.051)	1.056 (0.099)	0.165 (0.014)	0.181 (0.016)	0.386 (0.034)	0.160 (0.017)
133p14	0.961 (0.072)	0.662 (0.070)	0.811 (0.078)	0.142 (0.013)	0.163 (0.016)	0.460 (0.038)	0.168 (0.017)
135p15	0.917 (0.043)	0.644 (0.050)	0.868 (0.069)	0.270 (0.017)	0.190 (0.016)	0.529 (0.038)	0.174 (0.017)
Average	0.907 (0.018)	0.688 (0.016)	1.021 (0.029)	0.241 (0.014)	0.194 (0.007)	0.357 (0.020)	0.203 (0.008)
Wells							
107w1	0.913 (0.046)	0.716 (0.060)	1.017 (0.107)	0.247 (0.016)	0.205 (0.017)	0.274 (0.027)	0.212 (0.022)
109w2	1.019 (0.070)	0.669 (0.066)	0.927 (0.089)	0.148 (0.013)	0.177 (0.016)	0.310 (0.026)	0.258 (0.022)
111w3	0.905 (0.041)	0.613 (0.048)	1.153 (0.106)	0.290 (0.017)	0.186 (0.016)	0.326 (0.028)	0.228 (0.021)
113w4	0.966 (0.040)	0.650 (0.045)	1.042 (0.086)	0.299 (0.016)	0.227 (0.017)	0.327 (0.026)	0.248 (0.021)
115w5	0.980 (0.066)	0.676 (0.058)	1.232 (0.117)	0.135 (0.012)	0.244 (0.017)	0.264 (0.025)	0.189 (0.019)
117w6	0.879 (0.041)	0.785 (0.056)	0.916 (0.075)	0.232 (0.015)	0.238 (0.017)	0.360 (0.027)	0.258 (0.021)
119w7	0.943 (0.042)	0.760 (0.065)	1.013 (0.110)	0.272 (0.016)	0.183 (0.017)	0.298 (0.028)	0.190 (0.019)
121w8	0.980 (0.042)	0.720 (0.055)	1.108 (0.103)	0.261 (0.015)	0.191 (0.015)	0.310 (0.026)	0.208 (0.019)
123w9	0.991 (0.060)	0.625 (0.054)	1.129 (0.102)	0.182 (0.014)	0.190 (0.016)	0.322 (0.028)	0.204 (0.019)
125w10	1.006 (0.048)	0.658 (0.052)	1.010 (0.094)	0.251 (0.016)	0.199 (0.016)	0.319 (0.028)	0.213 (0.020)
127w11	0.989 (0.039)	0.689 (0.055)	0.954 (0.090)	0.331 (0.017)	0.162 (0.015)	0.366 (0.030)	0.197 (0.018)
129w12	1.004 (0.047)	0.675 (0.056)	0.866 (0.078)	0.265 (0.016)	0.170 (0.015)	0.419 (0.032)	0.200 (0.018)
131w13	0.948 (0.043)	0.637 (0.048)	0.962 (0.081)	0.280 (0.016)	0.192 (0.016)	0.436 (0.034)	0.181 (0.017)
133w14	0.926 (0.059)	0.677 (0.060)	0.864 (0.072)	0.168 (0.014)	0.189 (0.016)	0.481 (0.036)	0.173 (0.017)
135w15	0.955 (0.042)	0.685 (0.050)	0.932 (0.080)	0.275 (0.016)	0.203 (0.016)	0.469 (0.039)	0.135 (0.015)
Average	0.959 (0.010)	0.683 (0.013)	1.003 (0.028)	0.259 (0.013)	0.201 (0.006)	0.360 (0.018)	0.210 (0.008)

4.6 Estimation of Survival through the Wells Project

The analysis of Wells project survival consisted of three elements; (a) test of assumptions, (b) model fitting, and (c) estimation of reach survival. These elements of the estimation of Wells project survival are provided below.

4.6.1 Tests of Assumptions

The Pateros and Wells tailrace releases of tagged WFH steelhead were used to estimate survival through the Wells Project. However, before reliable survival estimates can be derived, each PIT-tag release must fulfill various assumptions of the release-recapture models. Unlike Mid-Columbia paired and index survival studies of the 1980s, survival and detection probabilities can be independently estimated for each release group (Table 5). The ability to independently estimate parameters for each release of PIT-tagged steelhead allows for more robust estimation of project survival. Nevertheless, minimal model assumptions must be met and the best approach to estimating reach survival must be determined. The subsequent tests of assumptions will assist in the selection of the most appropriate approach for estimating reach survival.

Homogeneous Downstream Mixing of Release Groups

A convenient but not necessary condition for validly estimating reach survival is the downstream mixing of Pateros and tailrace replicate release groups. One measure of mixing is the homogeneous arrival of smolts from the two releases at downstream detector dams (Appendix A). Table 6 summarizes the P-values for tests of homogeneous arrival at Rocky Reach, McNary, John Day, and Bonneville Dams. The release pairs generally had homogeneous arrival patterns at McNary, John Day, and Bonneville Dams $(p > 0.10)$. Eleven of 45 chi-square tests (24.4%) at these dams were significant at $P \leq 0.10$. However, all 15 paired-release groups showed significant non-mixing $(P \leq 0.10)$ when they arrived at Rocky Reach Dam, the first downstream dam with PIT-tag detectors. Inspection of the arrival plots (Appendix A) nevertheless suggests good mixing, with both releases within pairs showing very similar modes of arrival at detector dams.

In order to use the simple Ricker (1958) relative recovery estimates for the Wells survival estimates, detection and survival rates at and below Rocky Reach Dam must be equal. Burnham et al. (1987) Test T1.2 was used to test this assumption of the simple Ricker model. Table 7 summarizes the P-values associated with the tests of significance while Appendix B provides details of the analysis. Six of the 15 pairs showed significant differences in detection

and survival probabilities to Rocky Reach Dam. Only 2 of the 30 tests (6.7%) showed significant differences in detection or survival rates at McNary or John Day Dam.

Likelihood ratio tests will ultimately be used to determine the most appropriate description for the mixing of the individual releases within a paired-release.

Burnham et al. (1987) Test 2: Upstream Detections Do Not Affect Downstream Survival and /or Detection

To validate estimation of smolt survival using the SRR model, upstream detection history should have no effect on downstream detection and survival probabilities of test fish. Test 2.2 tests whether the detections at Rocky Reach affected downstream detection histories at McNary, John Day, or Bonneville dams. Test 2.3 tests whether detections at Rocky Reach or McNary affect downstream detections at John Day or Bonneville dams. Of the overall Test 2 results, four of the 30 release groups (16.7%) were significant at $\alpha = 0.10$ (Table 8). However, after adjustment for an experimental-wise error rare of $\alpha_{EX} = 0.10$ ($\alpha = 0.0036$), no Test 2 results were significant. In addition, details of the 2.2 and 2.3 tests showed no consistent pattern of violating model assumptions across release groups (Appendix B).

Burnham et al. (1987) Test 3: Upstream Detections Do Not Affect Downstream Survival and/or Detection

Another series of tests developed by Burnham et al. (1987) also tests whether upstream detection histories affect downstream detection or survival. Test 3.1 tests whether detection at Rocky Reach affects detection histories at John Day or Bonneville Dams (Table 8). Test 3.2 tests whether detections at Rocky Reach and McNary affect detection histories at Bonneville Dam. Eleven of 60 Tests 3.1 and 3.2 were significant at $P \leq 0.10$ (18.3%). Eight of these rejections occurred in four releases (i.e., 131p13, 133p14, 135p15, and 107w1). Only 1 of 60 release groups (i.e., 170w1) was significant after adjustment for an experimental-wise error rate of $\alpha_{EX} = 0.10$ (α=0.0018). Details of the 3.1 and 3.2 tests can be found in Appendix B.

Table 6. Results (i.e., P-values) of chi-square tests of mixing for Pateros and Wells release groups based on arrival timing at Rocky Reach, McNary, John Day, and Bonneville dams.

Release Date (Day-of-the-year)	P-value			
	Rocky Reach	McNary	John Day	Bonneville
107	<0.0001	0.4739	0.2367	0.8427
109	<0.0001	0.4006	0.1697	0.3564
111	<0.0001	0.2870	0.7516	0.6763
113	<0.0001	0.1748	0.0625	0.5160
115	<0.0001	0.2563	0.0760	0.0599
117	<0.0001	0.6301	0.6473	0.3928
119	<0.0001	0.4097	0.6471	0.9866
121	<0.0001	0.3880	0.2240	0.8467
123	<0.0001	0.2867	0.0313	0.0683
125	<0.0001	0.1707	0.3592	0.1248
127	<0.0001	0.4150	0.4548	0.6314
129	<0.0001	0.0026	0.0770	0.0905
131	<0.0001	0.2209	0.3733	0.9497
133	<0.0001	0.3004	0.0263	0.0344
135	<0.0001	0.7012	0.0168	0.5095

Table 7. Results (i.e., P-values) of Burnham et al. (1987) Test 1.T2 for equal detection and survival probabilities at downriver detection sites for the Pateros and Wells tailrace releases.

Release Date	P-value		
(Day-of-the-year)	Rocky Reach	McNary	John Day
107	0.4703	0.1713	0.7385
109	0.0015	0.2723	0.1900
111	0.6701	0.0739	0.5032
113	<0.0001	0.9278	0.9788
115	0.0388	0.9457	0.9540
117	0.6987	0.3075	0.9644
119	0.0002	0.6133	0.2104
121	0.6504	0.6050	0.0091
123	0.1022	0.1558	0.3260
125	0.3736	0.3501	0.2806
127	0.2665	0.9224	0.9907
129	0.0031	0.6246	0.6457
131	<0.0001	0.6330	0.5898
133	0.4261	0.4579	0.7705
135	0.9403	0.2507	0.9995

Tests of Handling Effects at Rocky Reach and Rock Island Dams

In 1999, smolt passing through the bypass systems at Rocky Reach and Rock Island Dams were collected and anesthetized for potential tagging as part of the Chelan PUD smolt survival studies. Over four thousand PIT-tagged steelhead smolts released upstream as part of the Douglas PUD smolt survival studies were intercepted and anesthetized a second time at the Chelan projects. Chi-square contingency table tests were used to assess whether this second handling affected downstream detection and survival probabilities (Table B7 - B8, Appendix B). Only 2 of the 30 release groups used in estimating Wells project survival (6.7%) showed significant differences between handled and non-handled smolts at Rocky Reach Dam at $\alpha =$ 0.10. Only 1 of 30 (3.3%) of the release groups showed significant differences between handled and non-handled smolts at Rock Island Dam ($\alpha = 0.10$). For both tests, the occurrence of rejections was less than nominal levels (i.e., 10%), suggesting no overt handling problems. After an adjustment to an experimental-wise error rate of α_{EX}=0.10 (α=0.0036), none of the tests at either site were significant. For this reason, all smolts regardless of detection histories at Rocky Reach and Rock Island Dams were included in the reach survival estimates.

Table 8. Results (i.e., P-values) of Burnham et al. (1987) Tests 2 and 3 for goodness-of-fit to the single release-recapture assumptions for the Pateros and Wells tailrace releases. Also included are the results (P-values) of tests for the effects of smolt handling at Rocky Reach and Rock Island dams.

Release	Burnham Tests							Handling Effects at	
	2.2	2.3	Overall 2	3.1	3.2	Overall 3	2 + 3	Rocky Reach	Rock Island
Pateros									
107p1	0.8764	0.5066	0.8672	0.5961	0.6916	0.7641	0.9066	0.5283	0.7642
109p2	0.0111	0.9874	0.0292	0.0683	0.6294	0.1822	0.0369	0.6339	0.2462
111p3	0.1596	0.4749	0.2427	0.5201	0.4426	0.5507	0.4257	0.5300	0.2669
113p4	0.7306	0.8551	0.8823	0.1656	0.0333	0.0319	0.1068	0.8155	0.6458
115p5	0.5991	09093	0.7921	0.1501	0.1350	0.0923	0.2182	0.8425	0.9254
117p6	0.0309	0.4496	0.0569	0.1105	0.6689	0.2703	0.0880	0.4796	0.8017
119p7	0.2503	0.0826	0.1226	0.4585	0.8951	0.7833	0.4388	0.6254	0.8189
121p8	0.4143	0.6699	0.5841	0.7357	0.0154	0.0696	0.1365	0.0468	0.5067
123p9	0.8266	0.5396	0.8597	0.9647	0.2660	0.6452	0.8352	0.9345	0.8446
125p10	0.3193	0.4487	0.4142	0.7239	0.5434	0.7487	0.7074	0.3706	0.4981
127p11	0.3172	0.5221	0.4391	0.8929	0.3663	0.7058	0.6899	0.8012	0.0973
129p12	0.0548	0.7005	0.1137	0.8267	0.5770	0.8247	0.4531	0.8305	0.7894
131p13	0.0098	0.6634	0.0240	0.0562	0.0274	0.0104	0.0019	0.5210	0.9654
133p14	0.2865	0.8304	0.4671	0.0288	0.0620	0.0119	0.0259	0.1323	0.9835
135p15	0.8670	0.9574	0.9622	0.0458	0.0413	0.0125	0.0564	0.7637	0.8408
Wells									
107w1	0.6166	0.5217	0.7108	0.0391	0.0004	0.0002	0.0010	0.9444	0.3289
109w2	0.2949	0.0673	0.1223	0.3354	0.2799	0.3006	0.1620	0.3216	0.3400
111w3	0.3522	0.9661	0.5541	0.4484	0.5097	0.5480	0.6312	0.2402	0.5050
113w4	0.8679	0.8004	0.9509	0.3426	0.3282	0.3417	0.6239	0.2379	0.7899
115w5	0.8731	0.7812	0.9507	0.5937	0.6787	0.7553	0.9263	0.8923	0.2721
117w6	0.4912	0.5874	0.6333	0.6968	0.5077	0.7088	0.7908	0.3696	0.9636
119w7	0.3291	0.8854	0.5234	0.6018	0.2377	0.4131	0.5008	0.1433	0.5151
121w8	0.8326	0.9477	0.9462	0.6546	0.8790	0.8905	0.9760	0.7749	0.9184
123w9	0.1483	0.0903	0.0826	0.1666	0.7047	0.3721	0.1555	0.6323	0.8784
125w10	0.0451	0.7253	0.0970	0.9722	0.5439	0.8825	0.4662	0.9208	0.2867
127w11	0.0928	0.2387	0.1049	0.6072	0.4243	0.5919	0.2915	0.8140	0.5263
129w12	0.0948	0.5194	0.1627	0.7332	0.7935	0.8886	0.5912	0.8877	0.1635
131w13	0.8148	0.2927	0.6785	0.8156	0.5213	0.7840	0.8587	0.7990	0.9438
133w14	0.5229	0.9862	0.7298	0.5272	0.6225	0.6783	0.8088	0.8655	0.4165
135w15	0.3888	0.4666	0.4900	0.5707	0.3931	0.5440	0.5937	0.0519	0.3125

4.6.2 Modeling Paired-Tag Releases

All model testing was conducted at a significance level of $\alpha = 0.10$. Results of the model selection procedures for each of the 15 paired Pateros-Wells tailrace releases is summarized in Table 9. In 7 of the 15 paired releases, model parameters were homogeneous beginning with the detection probabilities at Rocky Reach Dam (i.e., Model $M_{\underset{\sim}{S_1}}$, Ricker model). Alternative models were selected for the 8 remaining replicate releases. The best model that described the April 21, 25, 27 and May 1, 11 and 13 releases was model $M_{\underset{\sim}{S_1},\underset{\sim}{p_1}}$ which allowed detection rates at Rocky Reach to vary between the treatment and control release groups. For the April 29 release, the model selected was $M_{\underset{\sim}{S_1},\underset{\sim}{p_1},\underset{\sim}{S_2}}$, while model $M_{\underset{\sim}{S_1},\underset{\sim}{p_1},\underset{\sim}{S_2},\underset{\sim}{p_2}}$ was selected for the May 5 release. The April 29 model allowed detection and survival rates for the tailrace and Pateros releases to vary independently from release to Rocky Reach. The May 5 model allowed detection rates to vary only at Rocky Reach and McNary and allowed survival from release to Rocky Reach to vary. Table 10 reports the estimates of the survival and detection parameters for the most parsimonious models selected by the stepwise model-fitting procedure.

Table 9. Forward-sequential model selection results for Pateros-Wells tailrace release pairs.

a. Release on day-of-the-year 107

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.0523	1	0.8192
$M_{\underset{\sim}{S_1}}$ vs. CJS	6.4191	6	0.3779

b. Release on day-of-the-year 109

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	10.2114	1	0.0014
$S_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.0399	1	0.8417
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}}$ vs. CJS	8.2488	5	0.1431

c. Release on day-of-the-year 111

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	2.0091	1	0.1564
$M_{\underset{\sim}{S_1}}$ vs. CJS	5.8055	6	0.4453

Note: Model fit to the data were indicated by a "~" when the parameters were treated as a vector (i.e. different between releases within a pair). The notation indicates which parameter was tested for homogeneity given (i.e. " | ") the specification of the other model parameters.

Table 9. (Continued)

d. Release on day-of-the-year 113

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	7.3107	1	0.0069
$S_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	1.4151	1	0.2342
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}}$ vs. CJS	1.7040	5	0.8884

e. Release on day-of-the-year 115

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	4.3323	1	0.0374
$S_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.1614	1	0.6878
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}}$ vs. CJS	2.6950	5	0.7469

f. Release on day-of-the-year 117

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	2.8793	1	0.0897
$S_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	3.3030	1	0.0692
$p_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.3043	1	0.5812
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{S_2}}$ vs. CJS	2.5247	4	0.6402

Table 9. (Continued)

g. Release on day-of-the-year 119

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	12.1825	1	0.0005
$S_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.3419	1	0.5587
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}}$ vs. CJS	2.4386	5	0.7857

h. Release on day-of-the-year 121

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.7799	1	0.3772
$M_{\underset{\sim}{S_1}}$ vs. CJS	8.8393	6	0.1828

i. Release on day-of-the-year 123

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	4.4783	1	0.0343
$S_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	3.1730	1	0.0749
$p_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	2.8163	1	0.0933
$S_3 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	<0.0001	1	1.0000
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}}$ vs. CJS	1.6583	3	0.6462

Table 9. (Continued)

j. Release on day-of-the-year 125

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.0229	1	0.8798
$M_{\underset{\sim}{S_1}}$ vs. CJS	8.6227	6	0.1959

k. Release on day-of-the-year 127

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.3264	1	0.5678
$M_{\underset{\sim}{S_1}}$ vs. CJS	2.8238	6	0.8306

l. Release on day-of-the-year 129

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	9.6127	1	0.0019
$S_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.2293	1	0.6321
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}}$ vs. CJS	3.8487	5	0.5714

Table 9. (Continued)

m. Release on day-of-the-year 131

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	29.5386	1	<0.0001
$S_2 \mid \underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.2566	1	0.6124
$M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}}$ * vs. CJS	1.1431	4	0.8874

* For this model, the V-C matrix was singular, and as such, the next model $M_{\underset{\sim}{S_1}, \underset{\sim}{p_1}, \underset{\sim}{S_2}}$ was used in obtaining estimates and standard errors.

n. Release on day-of-the-year 133

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	1.9006	1	0.1680
$M_{\underset{\sim}{S_1}}$ vs. CJS	3.6002	6	0.7306

o. Release on day-of-the-year 135

Hypothesis	χ^2	df	P-value
$p_1 \mid \underset{\sim}{S_1}, \underset{\sim}{S_2}, \underset{\sim}{p_2}, \underset{\sim}{S_3}, \underset{\sim}{p_3}, \underset{\sim}{\lambda}$	0.0544	1	0.8156
$M_{\underset{\sim}{S_1}}$ vs. CJS	5.1685	6	0.5224

Table 10. Estimates of survival, detection, and λ parameters for the best-fit paired-release models selected by stepwise-fitting procedures.

Population	Survival			Detection			Product of Capture/ Survival Below John Day
	to Rocky Reach	RR --> McNary	McN --> John Day	Rocky Reach	McNary	John Day	
107p1	0.893 (0.037)	0.687 (0.043)	0.971 (0.074)	0.244 (0.012)	0.192 (0.012)	0.287 (0.019)	0.231 (0.016)
107w1	0.940 (0.038)						
109p2	0.812 (0.039)	0.702 (0.040)	1.000 (0.000)	0.206 (0.014)	0.178 (0.010)	0.315 (0.015)	0.241 (0.012)
109w2	0.945 (0.046)			0.159 (0.011)			
111p3	0.893 (0.030)	0.699 (0.032)	1.000 (0.000)	0.307 (0.012)	0.185 (0.010)	0.348 (0.015)	0.236 (0.012)
111w3	0.862 (0.030)						
113p4	0.864 (0.034)	0.693 (0.032)	1.000 (0.000)	0.232 (0.013)	0.220 (0.011)	0.328 (0.015)	0.244 (0.011)
113w4	0.947 (0.033)			0.305 (0.015)			
115p5	0.903 (0.034)	0.735 (0.040)	1.000 (0.000)	0.167 (0.012)	0.233 (0.011)	0.310 (0.013)	0.232 (0.011)
115w5	0.945 (0.045)			0.140 (0.010)			
117p6	0.976 (0.055)	0.649 (0.043)	1.000 (0.000)	0.197 (0.014)	0.236 (0.011)	0.343 (0.014)	0.241 (0.011)
117w6	0.879 (0.041)	0.766 (0.044)		0.232 (0.015)			
119p7	0.960 (0.040)	0.745 (0.040)	1.000 (0.000)	0.205 (0.012)	0.184 (0.010)	0.290 (0.014)	0.195 (0.011)
119w7	0.966 (0.037)			0.265 (0.014)			
121p8	0.895 (0.024)	0.738 (0.028)	1.000 (0.000)	0.253 (0.008)	0.184 (0.010)	0.339 (0.015)	0.202 (0.011)
121w8	1.000 (0.000)						
123p9	0.902 (0.046)	0.770 (0.050)	1.000 (0.000)	0.226 (0.015)	0.155 (0.011)	0.328 (0.014)	0.217 (0.011)
123w9	0.991 (0.060)	0.673 (0.050)		0.182 (0.014)	0.177 (0.013)		
125p10	0.914 (0.025)	0.726 (0.029)	1.000 (0.000)	0.253 (0.009)	0.184 (0.010)	0.316 (0.014)	0.193 (0.010)
125w10	0.977 (0.025)						
127p11	0.882 (0.030)	0.673 (0.037)	0.975 (0.067)	0.324 (0.012)	0.170 (0.011)	0.375 (0.022)	0.205 (0.013)
127w11	0.988 (0.032)						
129p12	0.927 (0.032)	0.671 (0.034)	0.928 (0.072)	0.215 (0.012)	0.174 (0.011)	0.386 (0.024)	0.180 (0.013)
129w12	1.000 (0.000)			0.266 (0.016)			
131p13	1.000 (0.000)	0.592 (0.024)	1.000 (0.000)	0.185 (0.009)	0.186 (0.010)	0.413 (0.017)	0.171 (0.010)
131w13	0.948 (0.044)	0.644 (0.039)		0.280 (0.016)			
133p14	0.903 (0.047)	0.670 (0.045)	0.840 (0.058)	0.155 (0.010)	0.177 (0.011)	0.471 (0.026)	0.171 (0.012)
133w14	0.975 (0.050)						
135p15	0.905 (0.033)	0.666 (0.035)	0.894 (0.058)	0.273 (0.012)	0.196 (0.011)	0.500 (0.027)	0.154 (0.011)
135w15	0.966 (0.035)						

4.6.3 Wells Project Survival Estimates

From the model selection process came the separate estimates of survival S_{11} and S_{21} for each release (Table 10) from their release locations to Rocky Reach Dam within a paired-release. The ratio of these separate estimates (Equation 1) provides the estimates of Wells project survival ($\hat{S}_W$) from the mouth of the Methow River to the Wells Dam tailrace (Table 11). The weighted average for the 1999 study was ($\hat{S}_W$) = 0.943 (SE = 0.016) compared to a weighted average of $\hat{S}_W$ = 0.997 (SE = 0.015) calculated from the 1998 investigations. A z-test of the difference in the mean survival estimates for 1998 and 1999 were significantly different at P = 0.0138. Differences in estimates could be attributable to sampling error, year effects, and/or differences between chinook and steelhead smolts.

Table 11. Replicate estimates of Wells project survival ($\hat{S}_W$) from Pateros to Wells Dam tailrace based on the best parsimonious model selected for each paired-release using the stepwise-fitting procedure. Weighted average and standard error based on Equations (4 -6).

Release Groups	$(\hat{S}_W)$
107p1/107w1	0.950 (0.055)
109p2/109w2	0.859 (0.059)
111p3/111w3	1.036 (0.050)
113p4/113w4	0.912 (0.048)
115p5/115w5	0.956 (0.064)
117p6/117w6	1.110 (0.081)
119p7/199w7	0.994 (0.056)
121p8/121w8	0.895 (0.024)
123p9/123w9	0.910 (0.072)
125p10/125w10	0.936 (0.035)
127p11/127w11	0.893 (0.042)
129p12/129w12	0.927 (0.032)
131p13/131w13	1.055 (0.049)
133p14/133w14	0.926 (0.068)
135p15/135w14	0.937 (0.048)
Weighted Average	0.943 (0.016)

5.0 DISCUSSION

5.1 Fish Collection

In total, 74,669 steelhead were collected for tagging purposes during the 1999 survival study. The volitional collection and handling of hatchery steelhead in 1999 took place without measurable impact upon the study animals. The use of a 20 cm Aqualite harvester, a 2,000 L fish transportation container and short distances to move fish helped to maintain fish health at optimum levels throughout the collection phase of the study.

5.2 Tagging and Holding

Of the 74,669 steelhead collected at the Wells Fish Hatchery, 3,531 steelhead smolts were not tagged. Many of these fish were in excess to the number required for the study and were simply released from the Wells hatchery without being anesthetized. Others were anesthetized and, upon being selected for tagging, were excluded because they were diseased, mortally wounded or displayed outward signs of precocity.

An important assumption of the 1999 steelhead survival study was that the fish being marked were representative of the population of inference. The population of inference for the study included only migratory steelhead smolts. Fish seriously injured due to collection and hatchery handling procedures were not representative of the population of inference and were subsequently not tagged. Precocious steelhead parr were also excluded because they were not expected to migrating during 1999. Precocious steelhead included fish that were dark in coloration and ripe with milt. Rather than migrating through the project, precocious fish were expected to migrate upstream to spawning areas.

Additionally, the survival model requires that the number of fish released with tags be known. In order to know how many tagged fish have been released, tag shed must be carefully managed. Diseased and mortally wounded fish are often incapable of healing. As a result, wounded fish can continue shedding PIT-tags long after they have been released.

Tagging and holding facilities utilized in 1999 were designed to minimize fish stress and to maximize fish survival to releases. In total, only 43 (0.07%) PIT-tagged steelhead died prior to release. The majority of these fish (24) died on tag day 9 and were from a single dish pan of fish. It was determined that this particular group of fish was unintentionally overdosed with MS-222. In addition to tag implantation and anesthetic related mortalities, an additional 55 (0.09%) shed PIT-tags were recovered inside release containers. After accounting for tag shed and post-tagging mortality the study goal of releasing 30,000 steelhead at each of the two release locations was achieved with a total of 30,072 fish released at Pateros and 30,049 fish released into the Wells tailrace.

5.3 Transportation and Release

Techniques utilized for transportation and release of fish were consistent both within and between replicate release groups. Transport times totaled less than one hour and fifteen minutes from tagging sites to release locations for all fifteen release groups. Recovery and transport times remained constant within and between release groups. Transportation, loading and travel conditions (water temperature, travel time, dissolved oxygen concentrations and final fish condition) were almost identical for each of the Pateros and tailrace releases. The use of specially designed release containers and on-board oxygen supply systems ensured that fish condition, upon arrival, was comparable for all thirty release groups. No changes to the loading, transportation or release techniques will be required for future PIT-tag survival studies utilizing the Methow and tailrace release sites.

5.4 Physiological Monitoring

An important component of any paired release-recapture survival study is the comparability between the treatment and control release groups. Additionally, it is assumed that tagged fish will survive at a rate that is similar to the untagged population migrating through Wells Dam. Physiological monitoring provided a comparative index of fish health and stress between treatment and control release groups and provided a robust comparison of physiological indices between tagged and untagged fish.

Variability within replicate release pairs (e.g. fish health, smolt condition and stress levels) has the potential to bias estimates of survival through the dam. By measuring these conditions a more accurate description of actual project effects can be developed. For example, differences in fish health within a replicate pair might result in biased estimates of relative survival through Wells Dam.

Variability in fish health, condition and fish handling between replicate releases would not bias estimates of survival but could complicate the interpretation of the resultant survival estimates. For example, differences in fish health between replicate pairs might coincidentally correlate with unrelated change in river operation. Without measuring the differences between replicate release groups, one might improperly concluded that river operations were responsible for the observed response in fish survival when in fact fish health might be the overriding survival process.

To address concerns related to variability within and between release pairs, statistical comparisons of fish physiology and morphology were conducted. To provide this information, 163 (0.27%) tagged steelhead and 20 untagged steelhead were sacrificed and sampled prior to release.

In general, no significant differences were observed between tagged and untagged steelhead. This included indices of morphology, health, condition and stress. No meaningful differences in health, condition and stress were observed within replicate release pairs sampled (Methow versus tailrace). Significant differences were found between some replicates for plasma glucose and cortisol but none were noted for HSP70. Note that groups that were different for glucose were not the same groups that were different for cortisol. Also it is important to note that the entire range of cortisol, glucose and HSP70 values were similar to values reported in the literature for fish at rest.

For health indices, all measures (descaling, fin erosion, percentage mesenteric fat, liver condition and visible parr marks) indicated good health with relatively high fat reserves and a complete lack of disease or tissue damage. No significant differences in health indices were detected either within or between replicate release pairs sampled. ATPase values in gill tissues were only higher between two of the release groups sampled. The difference observed was isolated to a difference between Methow release group 1 and tailrace release group 15. These differences would not result in biased survival estimates for Wells Dam.

Based on the 8 release groups and one control group studied, PIT-tagged Wells Hatchery steelhead smolts were appropriate surrogates for untagged steelhead smolts migrating past Wells Dam in 1999. Significant differences in fish health, fish condition and smolt readiness were lacking within replicate pairs and were subsequently isolated from the estimation of relative survival through Wells Dam. Trends in estimated fish survival, over time, did not appear to be related to fish condition, fish health or fish handling indices.

5.5 Estimation of Detection and Reach Survival Probabilities

A model fitting routine was used to identify the most appropriate model for estimating detection and survival for each individual pairing of tagged fish. Overall, detection probabilities for WFH steelhead were higher than anticipated. Detection rates at all sites were not significantly different with the notable exception at Rocky Reach Dam where seven out of 15 replicate release pairs experienced significantly different detection conditions within each pair.

Mean detection probabilities for all 15 Douglas PUD release groups averaged 0.250 at Rocky Reach, 0.198 at McNary and 0.358 at John Day dams. Detection rates in 1999 at all sites exceeded pre-season detection estimates. In particular, detection rates at John Day Dam were considerably higher than detection rates observed for yearling chinook release in 1998. Differences in flow year, spill operations and species of fish studied likely contributed to the differences in capture rates observed between the 1999 and 1998 survival studies.

Estimated reach survival from the mouth of the Methow River to the Rocky Reach tailrace and from the Wells tailrace to the Rocky Reach tailrace averaged 0.907 ($\hat{SE} = 0.018$) and 0.959 ($\hat{SE} = 0.010$) for steelhead released in 1999. The 1999 estimates of steelhead survival were not markedly different from the estimates of yearling chinook survival during the 1998 outmigration. Estimated survival for 1998 yearling chinook migrating from the Methow to the Rocky Reach tailrace and from the Wells tailrace to the Rocky Reach tailrace averaged 0.943 ($\hat{SE} = 0.073$) and 0.952 ($\hat{SE} = 0.066$), respectively.

Survival downstream of Rocky Reach, as expected, was homogeneous between the two Douglas PUD release groups. Consequently, replicate reach survival estimates were pooled to provide more precise estimates of survival through the downstream river reaches. Estimated survival from the Rocky Reach tailrace to the McNary tailrace was precise and averaged 0.686 ($\hat{SE} = 0.010$) for Douglas PUD tagged fish (error of 1.96% about a 95% confidence interval).

The estimate of survival from the Rocky Reach tailrace to the McNary tailrace in 1999 for summer steelhead (0.686, $\hat{SE} = 0.010$) was not significantly different ($p > 0.10$) than the estimates of survival for 1999 yearling spring chinook (0.727, $\hat{SE} = 0.053$), 1998 yearling spring chinook (0.720, $\hat{SE} = 0.084$), 1998 yearling Methow run-of-river chinook (0.720, $\hat{SE} = 0.084$) and 1998 yearling summer chinook (0.659, $\hat{SE} = 0.040$).

5.6 Estimation of Survival through the Wells Project

Fifteen replicate releases of hatchery summer steelhead smolts were conducted during the 1999 survival study at Wells Dam. In general, the Pateros/tailrace release pairing experienced homogeneous survival and detection rates, travel time, arrival timing and detection distributions at Bonneville, John Day and McNary dams. The only exception to this generalization was at Rocky Reach Dam where capture distributions and arrival timing were more variable within the replicate release pairings.

Estimates of survival for summer steelhead smolts migrating from the mouth of the Methow River to the tailrace of Wells Dam ranged from 0.859 to 1.110. Project survival (pool and dam) for yearling steelhead in 1999 averaged 0.943 with a standard error (SE) of 0.016 and a 95% CI of $\pm$ 3.1%.

6.0 SUMMARY OF FINDINGS

For the second year in a row, Douglas PUD has produced precise estimates of survival for juvenile fish migrating through the Wells Hydroelectric Project. Summer steelhead smolts migrating from the mouth of the Methow River mixed adequately with smolts released in the tailrace of Wells Dam. Project survival estimates for Wells Dam were high during 1999 and once again exceeded the No Net Impact survival standards of the proposed Wells Habitat Conservation Plan. The weighted average estimate of summer steelhead survival in 1999 was 0.943. Precision for the 1999 Wells survival study was also high with a 95% CI of +/- 3.1%. These estimates of survival, similar to estimates derived in 1998, were sufficiently precise to utilize toward evaluating the No Net Impact survival standards of the proposed Wells Habitat Conservation Plan.

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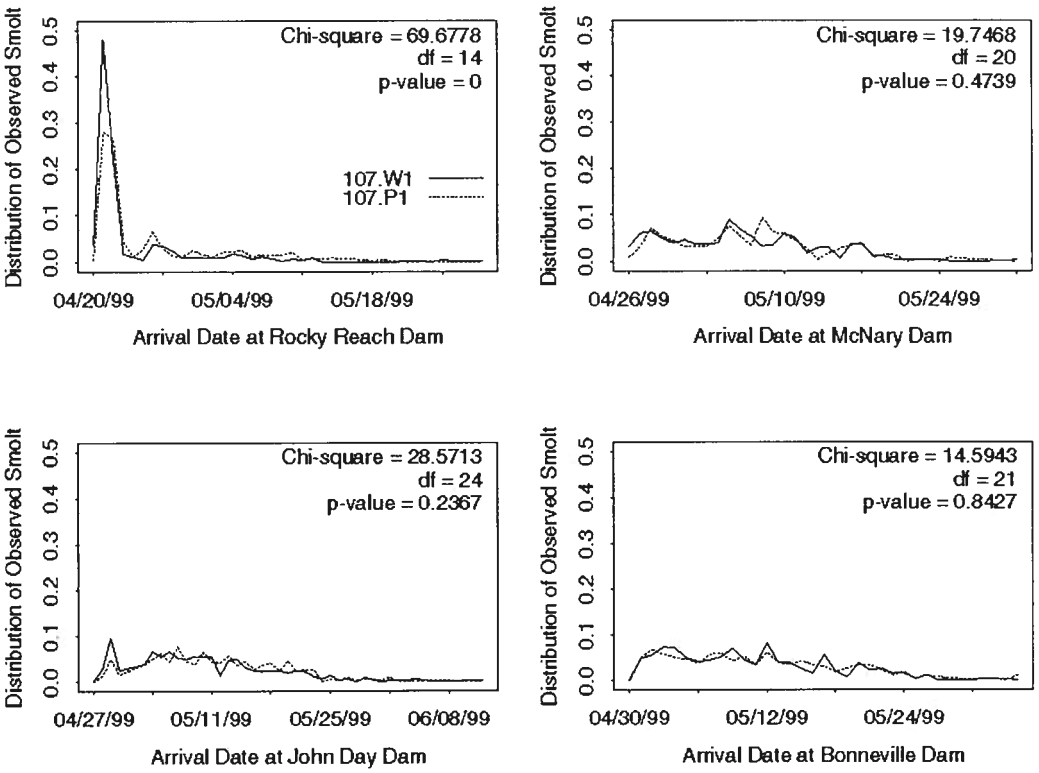
APPENDIX A

Graphics and chi-square tests of downstream detection trends for paired PIT-tag release groups.

Paired Travel Time Plots



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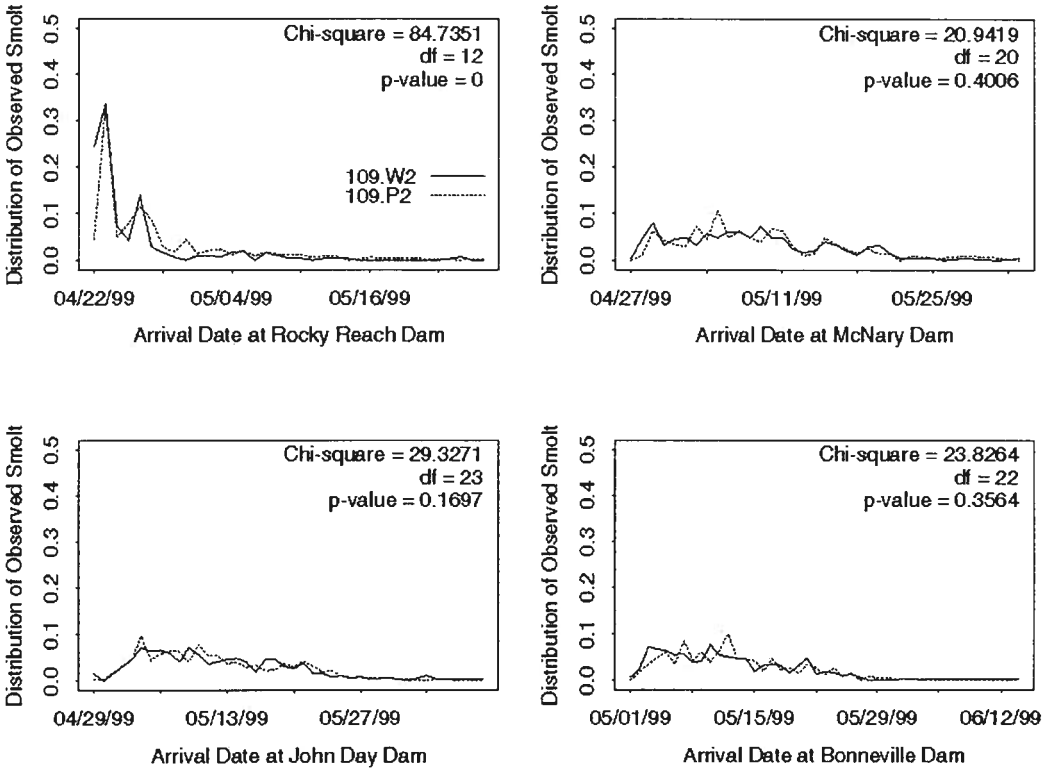

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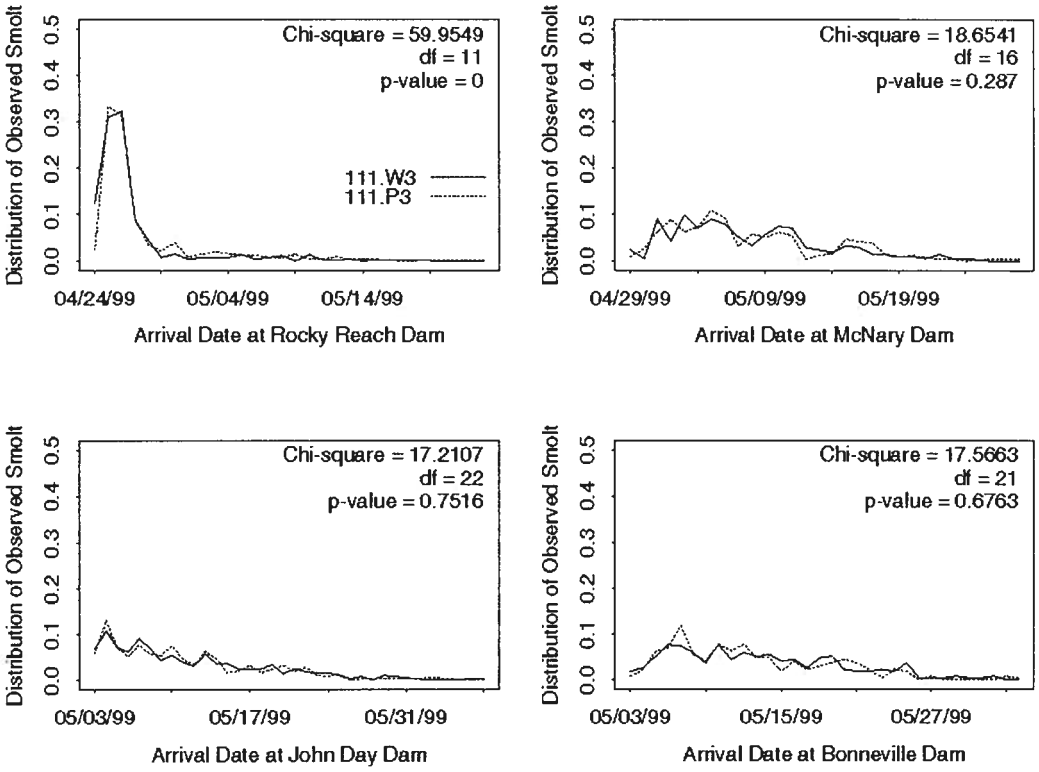

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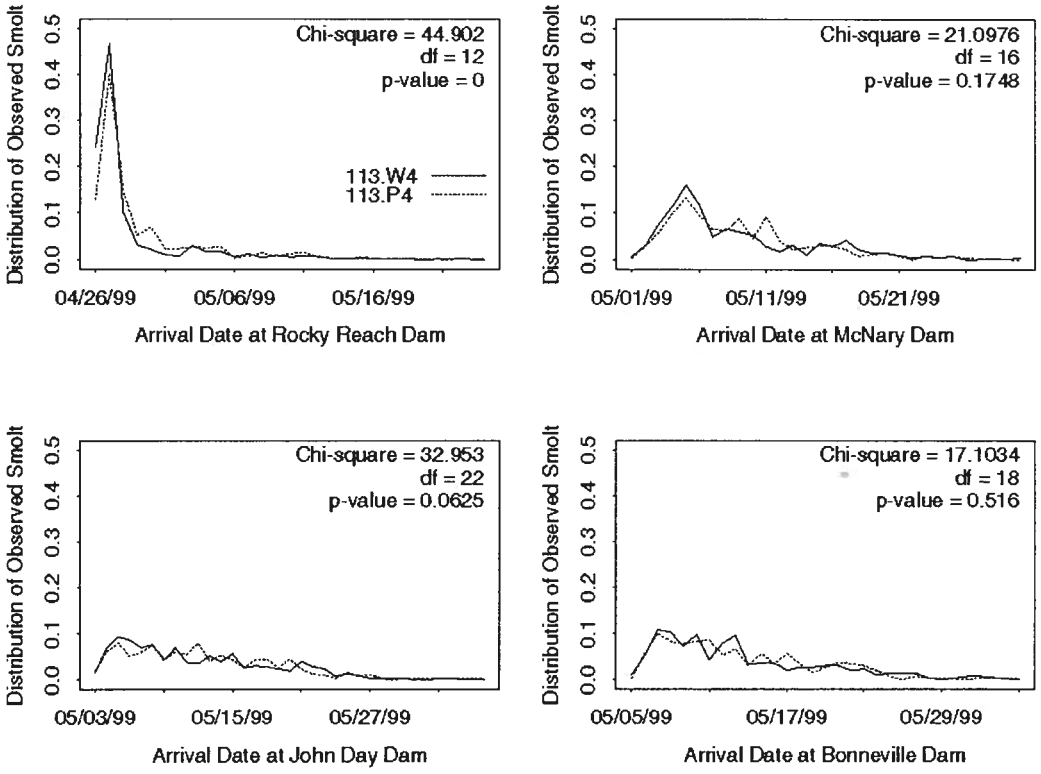

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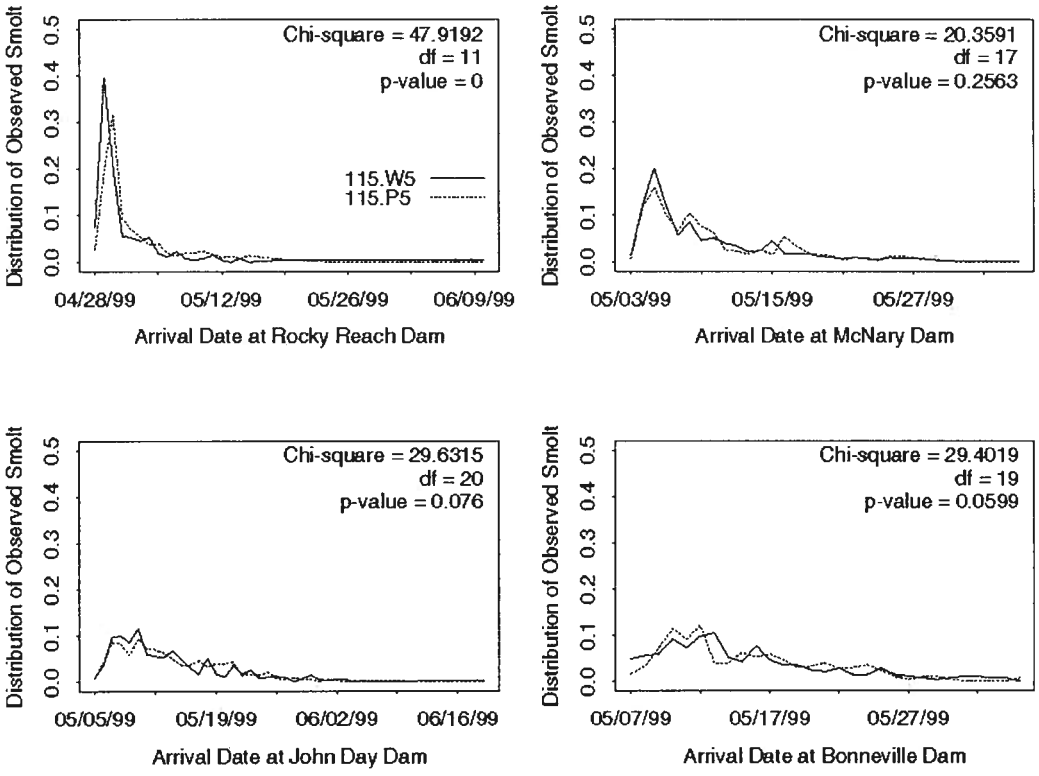

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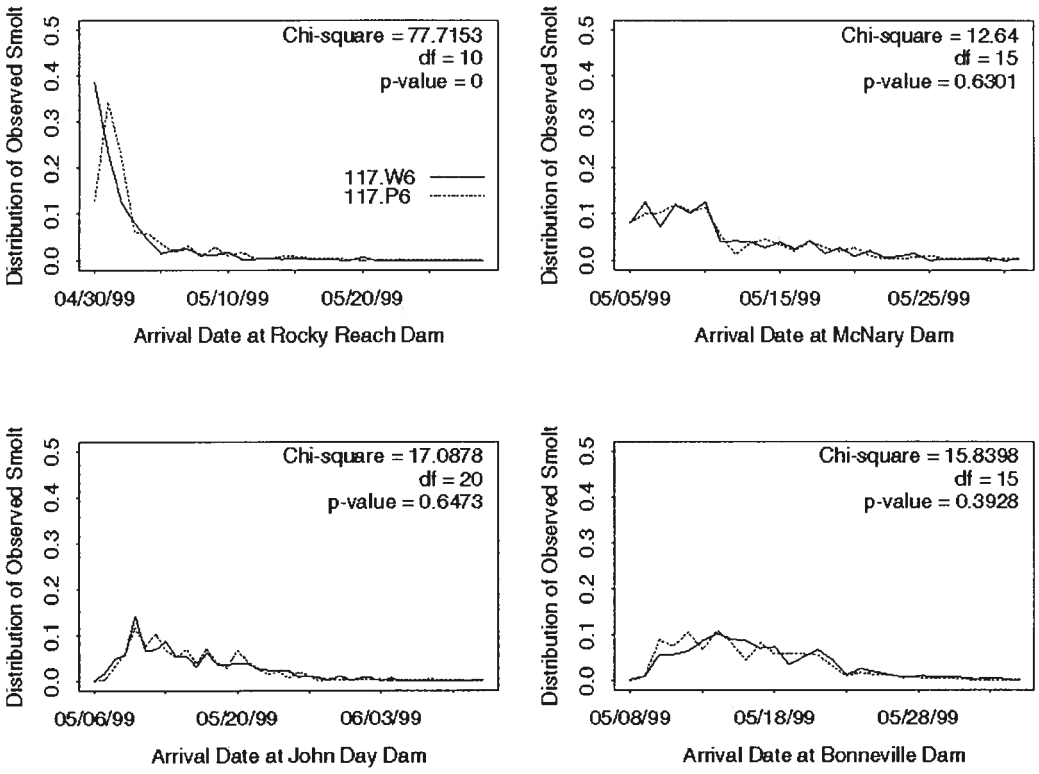

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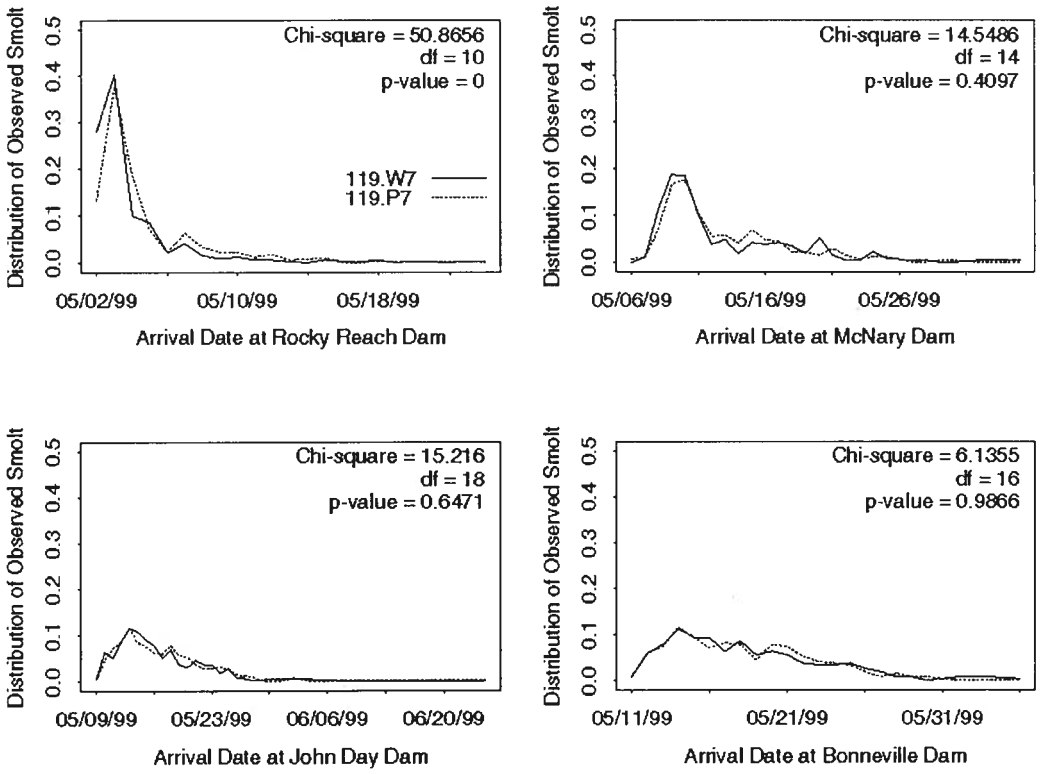

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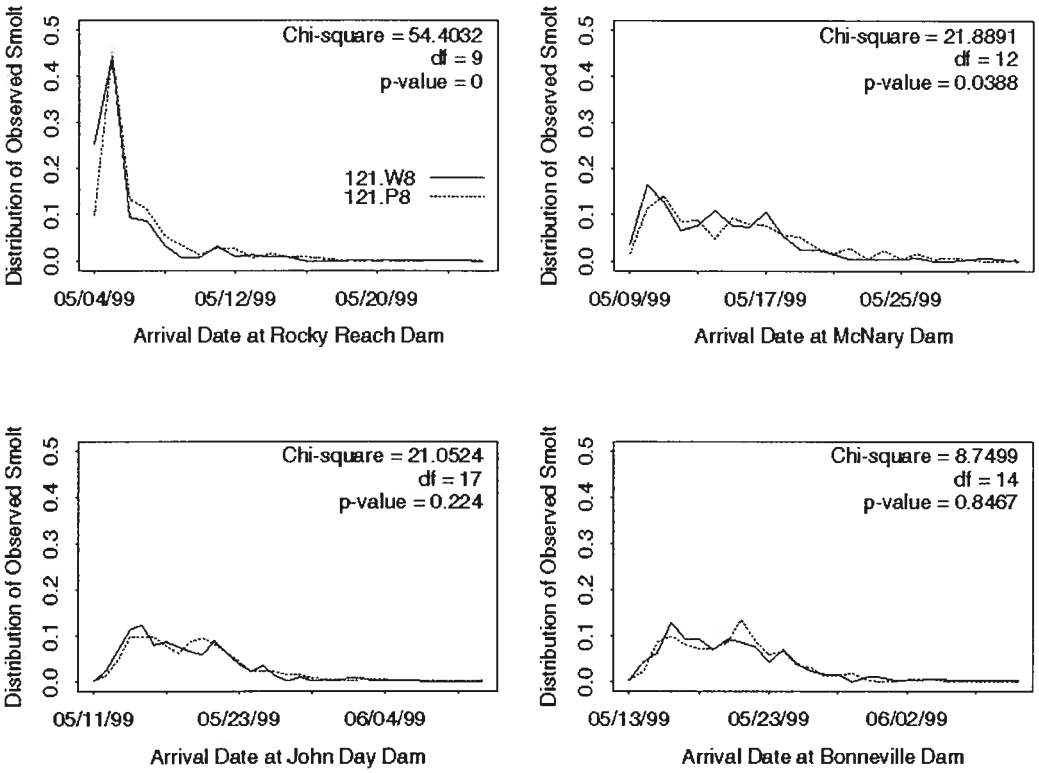

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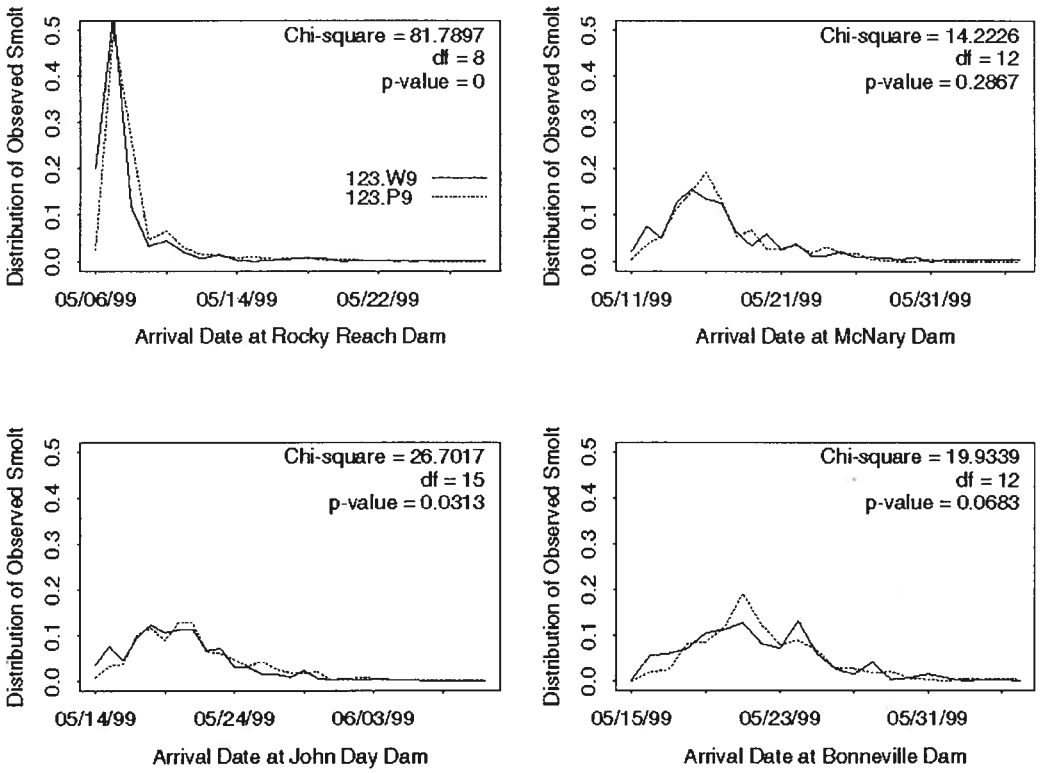

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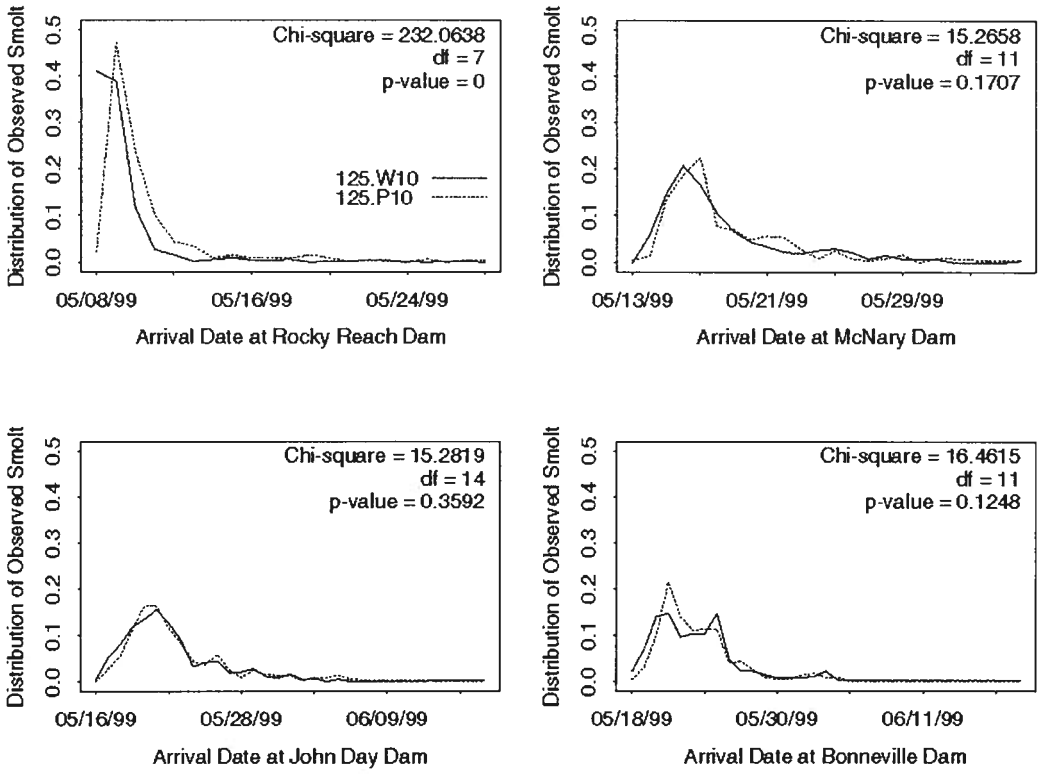

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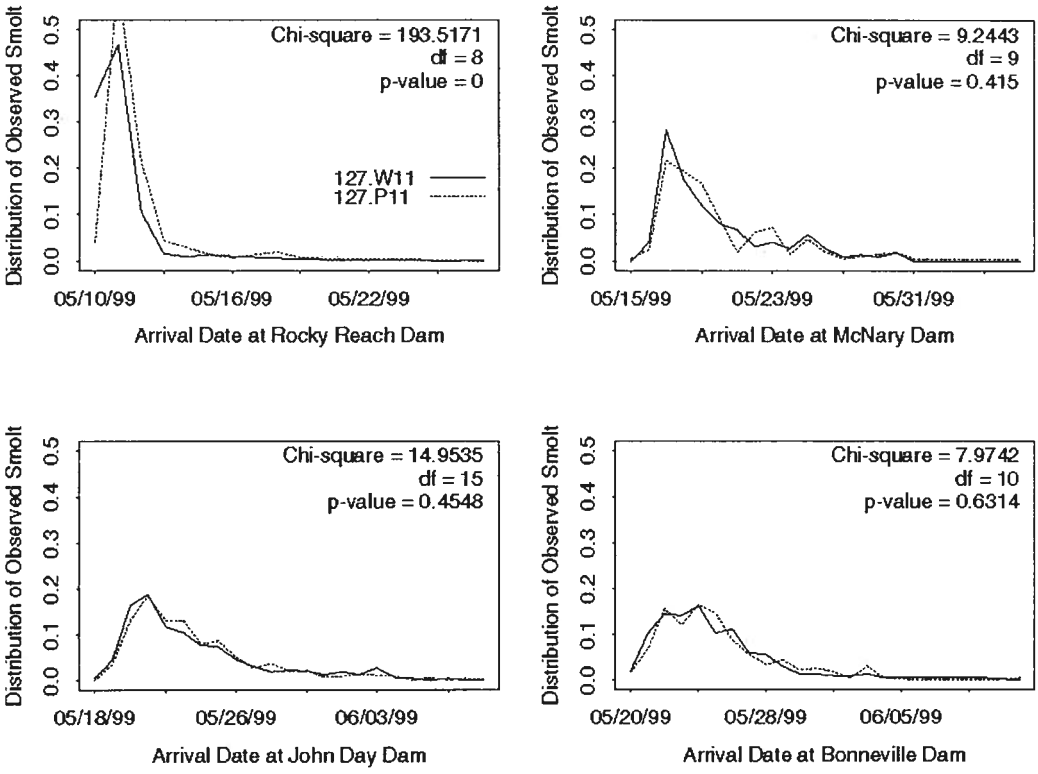

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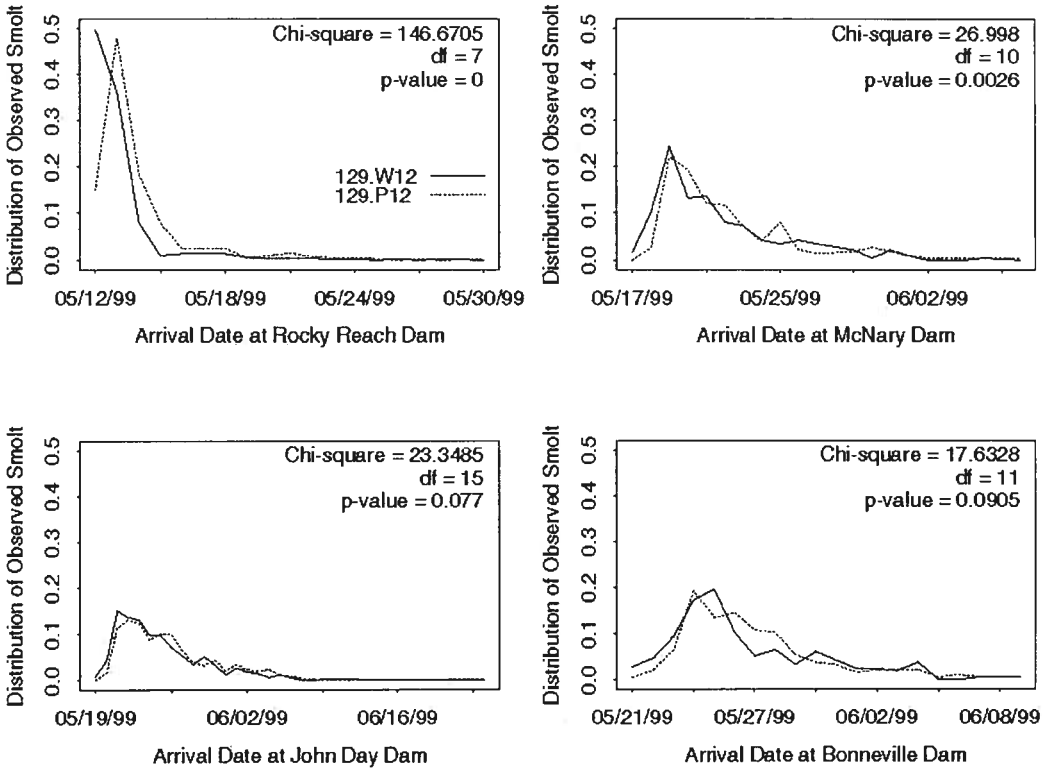

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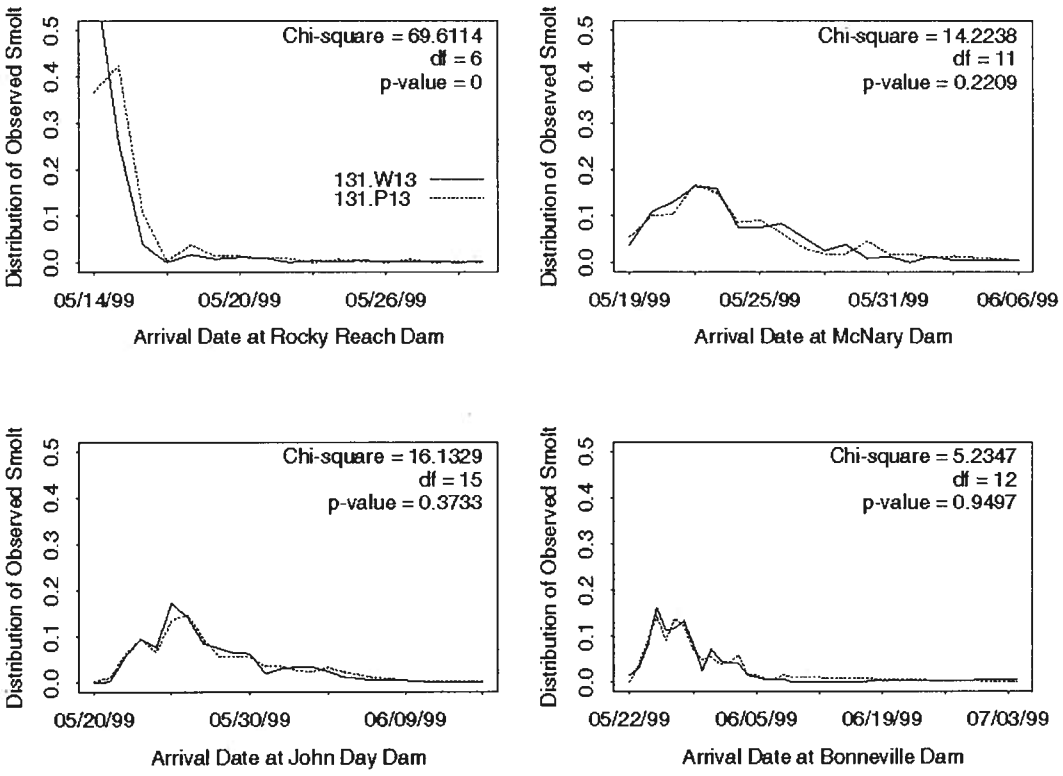
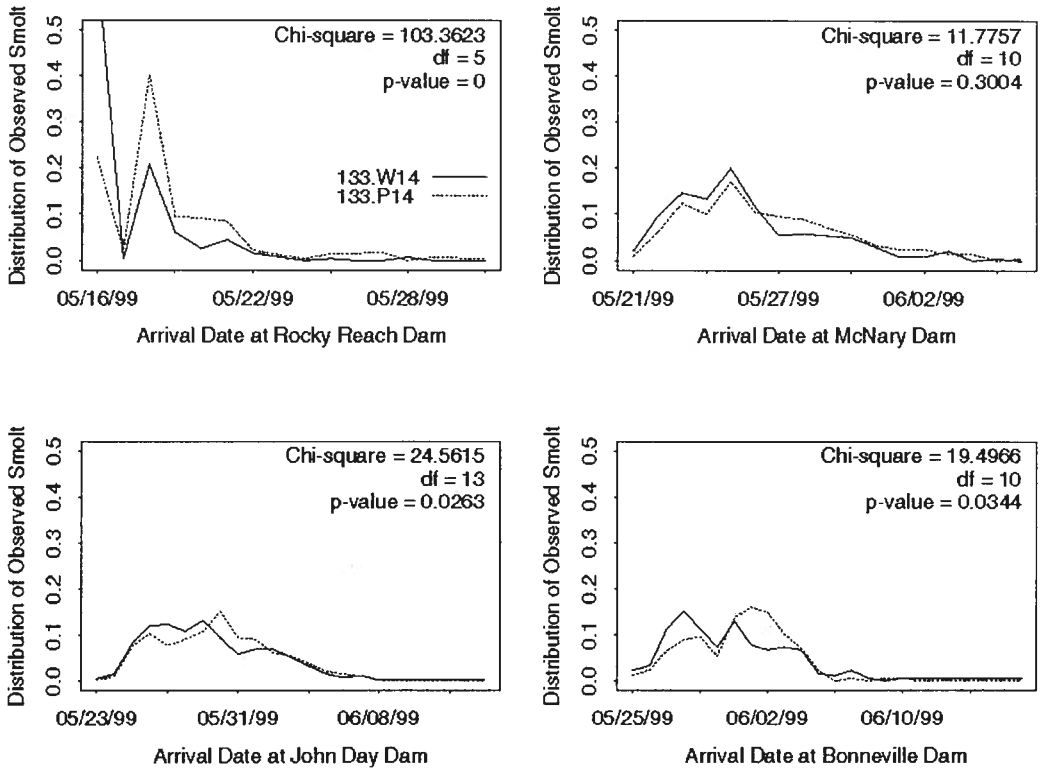
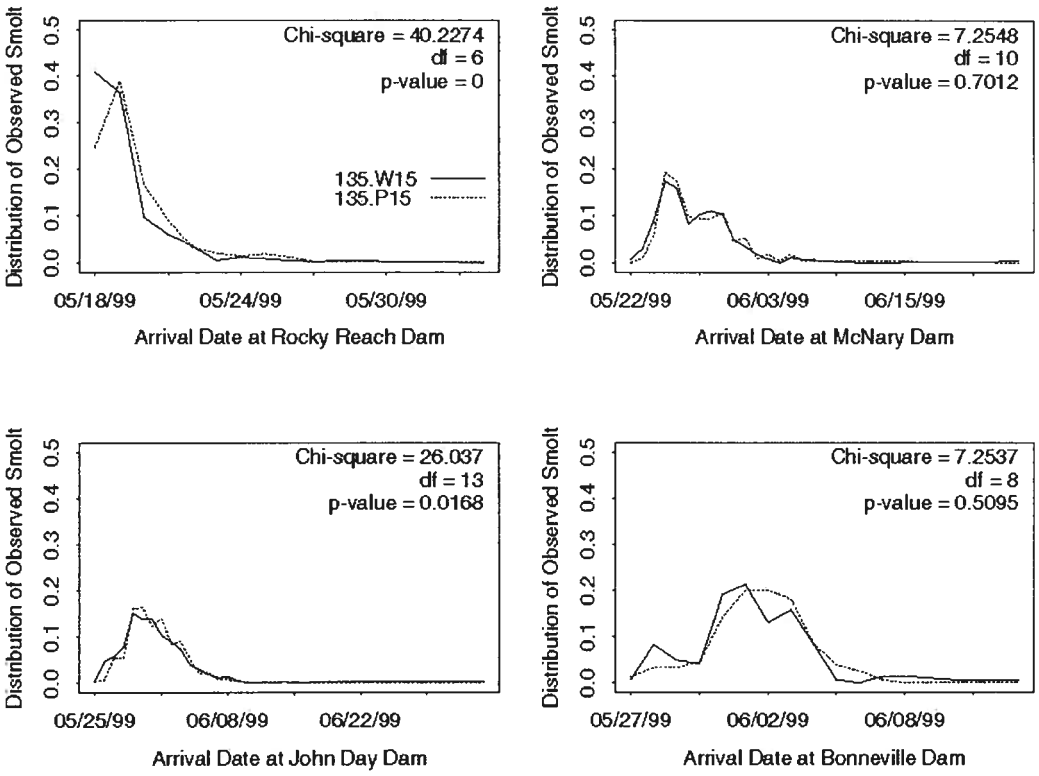


Paired Travel Time Plots



Paired Travel Time Plots



APPENDIX B

Chi-square tables for Burnham et al. (1987) Tests 1, 2, and 3. Chi-square tests for the effects of smolt handling at Rocky Reach and Rock Island dams.

Table B1. Burnham Test T1.2 for Pateros and Wells tailrace paired-releases. The m_1 are the number of fish detected at that dam, z_1 are the number of fish *not detected* at that dam, but detected downstream.

Release Date (Day-of-the-Year)		Rocky Reach					McNary Dam				
		Release		χ_1^2	P-value		*Release*		χ_1^2	P-value
	History	Pateros	Wells			*History*	Pateros	Wells		
107	$m_{.1}$	445	454			$m_{.1}$	196	239		
	$z_{.1}$	500	547	0.5212	0.4703	$z_{.1}$	442	456	1.8718	0.1713
109	$m_{.1}$	338	302			$m_{.1}$	177	221		
	$z_{.1}$	522	641	10.0871	0.0015	$z_{.1}$	469	510	1.2052	0.2723
111	$m_{.1}$	560	526			$m_{.1}$	227	179		
	$z_{.1}$	514	503	0.1815	0.6701	$z_{.1}$	511	501	3.1934	0.0739
113	$m_{.1}$	402	578			$m_{.1}$	249	272		
	$z_{.1}$	556	551	17.37	< 0.0001	$z_{.1}$	465	500	0.0082	0.9278
115	$m_{.1}$	303	265			$m_{.1}$	286	298		
	$z_{.1}$	658	711	4.2695	0.0388	$z_{.1}$	484	498	0.0046	0.9457
117	$m_{.1}$	386	409			$m_{.1}$	249	285		
	$z_{.1}$	632	644	0.1498	0.6987	$z_{.1}$	498	508	1.0412	0.3075
119	$m_{.1}$	395	514			$m_{.1}$	204	199		
	$z_{.1}$	609	566	14.0663	0.0002	$z_{.1}$	493	514	0.2554	0.6133
121	$m_{.1}$	449	514			$m_{.1}$	200	213		
	$z_{.1}$	570	625	0.2054	0.6504	$z_{.1}$	506	576	0.2676	0.6050
123	$m_{.1}$	409	359			$m_{.1}$	211	231		
	$z_{.1}$	599	614	2.6703	0.1022	$z_{.1}$	558	517	2.0148	0.1558
125	$m_{.1}$	454	507			$m_{.1}$	237	260		
	$z_{.1}$	556	572	0.7917	0.3736	$z_{.1}$	507	499	0.8729	0.3501
127	$m_{.1}$	561	657			$m_{.1}$	206	220		
	$z_{.1}$	478	507	1.2348	0.2665	$z_{.1}$	493	536	0.0095	0.9224
129	$m_{.1}$	400	532			$m_{.1}$	218	229		
	$z_{.1}$	544	553	8.7481	0.0031	$z_{.1}$	466	521	0.2394	0.6246

Table B1. (Continued)

Release Date (Day-of-the-Year)		Rocky Reach					McNary Dam			
		Release		χ_1^2	P-value		*Release*		χ_1^2	P-value
	History	Pateros	Wells			*History*	Pateros	Wells		
131	$m_{.1}$	370	535			$m_{.1}$	213	230		
	$z_{.1}$	599	535	28.2858	< 0.0001	$z_{.1}$	501	509	0.2280	0.6330
133	$m_{.1}$	273	313			$m_{.1}$	206	239		
	$z_{.1}$	588	619	0.6335	0.4261	$z_{.1}$	477	505	0.5510	0.4579
135	$m_{.1}$	484	512			$m_{.1}$	215	254		
	$z_{.1}$	522	558	0.0056	0.9403	$z_{.1}$	496	512	1.3194	0.2507

Table B2. Burnham Test T1.2 for Pateros and Wells tailrace paired-releases. The m_1 are the number of fish detected at John Day dam, z_1 are the number of fish *not detected* at that dam, but detected downstream.

Release Date (Day-of-the-Year)		John Day			
		Release		χ_1^2	P-value
	History	Pateros	Wells		
107	$m_{.1}$	333	359		
	$z_{.1}$	196	201	0.1115	0.7385
109	$m_{.1}$	380	387		
	$z_{.1}$	185	223	1.7179	0.1900
111	$m_{.1}$	435	408		
	$z_{.1}$	187	192	0.4482	0.5032
113	$m_{.1}$	391	424		
	$z_{.1}$	200	216	0.0007	0.9788
115	$m_{.1}$	406	423		
	$z_{.1}$	214	223	0.0033	0.9540
117	$m_{.1}$	430	442		
	$z_{.1}$	200	203	0.0020	0.9644
119	$m_{.1}$	383	415		
	$z_{.1}$	202	186	1.5686	0.2104
121	$m_{.1}$	450	467		
	$z_{.1}$	149	216	6.8129	0.0091
123	$m_{.1}$	444	445		
	$z_{.1}$	217	192	0.9649	0.3260
125	$m_{.1}$	439	427		
	$z_{.1}$	173	194	1.1640	0.2806
127	$m_{.1}$	447	476		
	$z_{.1}$	152	163	0.0001	0.9907

Table B2. (Continued)

Release Date (Day-of-the-Year)		John Day			
		Release		χ_1^2	P-value
	History	Pateros	Wells		
129	$m_{.1}$	436	491		
	$z_{.1}$	130	136	0.2114	0.6457
131	$m_{.1}$	486	509		
	$z_{.1}$	124	119	0.2906	0.5898
133	$m_{.1}$	475	525		
	$z_{.1}$	94	98	0.0851	0.7705
135	$m_{.1}$	528	555		
	$z_{.1}$	82	85	< 0.0001	0.9995

Table B3. Burnham Test 2.2 for individual release groups. This procedure tests the assumption of whether detections at Rocky Reach affect downstream survival and/or detection.

Release		Test 2.2			χ^2_2	P-value
Pateros		Recovery Site				
	Release Site	McNary	John D.	Bonn.		
107p1	Pateros	151	207	125		
	Rocky Reach	45	68	42	0.2844	0.8674
109p2	Pateros	140	257	107		
	Rocky Reach	37	58	47	9.0052	0.0111
111p3	Pateros	157	248	91		
	Rocky Reach	70	113	59	3.6697	0.1596
113p4	Pateros	192	231	121		
	Rocky Reach	57	78	35	0.6278	0.7306
115p5	Pateros	239	263	136		
	Rocky Reach	52	47	30	1.0248	0.5991
117p6	Pateros	205	261	131		
	Rocky Reach	44	83	23	6.9531	0.0309
119p7	Pateros	167	253	134		
	Rocky Reach	37	62	44	2.7704	0.2503
121p8	Pateros	148	292	92		
	Rocky Reach	52	86	36	1.7623	0.4143
123p9	Pateros	164	294	136		
	Rocky Reach	47	84	44	0.3810	0.8266
125p10	Pateros	182	271	103		
	Rocky Reach	55	89	44	2.2834	0.3193
127p11	Pateros	139	261	77		
	Rocky Reach	67	110	45	2.2966	0.3172
129p12	Pateros	181	283	78		
	Rocky Reach	37	74	31	5.8098	0.0548

Table B3. (Continued)

Release	Test 2.2				χ^2_2	P-value
		Recovery Site				
	Release Site	McNary	John D.	Bonn.		
131p13	Pateros	188	317	92		
	Rocky Reach	25	80	12	9.2511	0.0098
133p14	Pateros	174	347	65		
	Rocky Reach	32	50	15	2.4999	0.2865
135p15	Pateros	156	313	50		
	Rocky Reach	59	117	16	0.2855	0.8670
Wells		McNary	John D.	Bonn.		
107w1	Wells	183	219	121		
	Rocky Reach	56	70	46	0.9671	0.6166
109w2	Wells	189	262	172		
	Rocky Reach	32	53	23	2.4424	0.2949
111w3	Wells	131	233	119		
	Rocky Reach	48	107	42	2.0872	0.3522
113w4	Wells	187	235	115		
	Rocky Reach	85	98	52	0.2833	0.8679
115w5	Wells	260	282	146		
	Rocky Reach	38	46	24	0.2714	0.8731
117w6	Wells	226	260	127		
	Rocky Reach	59	85	36	1.4218	0.4912
119w7	Wells	152	256	110		
	Rocky Reach	47	100	48	2.2229	0.3291
121w8	Wells	157	287	138		
	Rocky Reach	56	106	45	0.3665	0.8326
123w9	Wells	194	293	126		
	Rocky Reach	37	60	38	3.8173	0.1483

Table B3. (Continued)

Release	Test 2.2				χ^2_2	P-value
		Recovery Site				
	Release Site	McNary	John D.	Bonn.		
125w10	Wells	198	263	106		
	Rocky Reach	62	78	52	6.1967	0.0451
127w11	Wells	153	268	84		
	Rocky Reach	67	126	58	4.7545	0.0928
129w12	Wells	177	297	77		
	Rocky Reach	52	108	39	4.7124	0.0948
131w13	Wells	163	297	71		
	Rocky Reach	67	111	30	0.4096	0.8148
133w14	Wells	204	349	66		
	Rocky Reach	35	77	13	1.2967	0.5229
135w15	Wells	183	326	47		
	Rocky Reach	71	115	24	1.8895	0.3888

Table B4. Burnham Test 2.3 for individual release groups. This procedure tests the assumption of whether detections at McNary affect downstream survival and/or detection.

Release		Test 2.3		χ_1^2	P-value
Pateros		Recovery Site			
	Release Site	John Day	Bonn.		
107p1	Pateros + Rocky Reach	275	167		
	McNary	58	29	0.4410	0.5066
109p2	Pateros + Rocky Reach	315	154		
	McNary	65	31	0.0003	0.9874
111p3	Pateros + Rocky Reach	361	150		
	McNary	74	37	0.5105	0.4749
113p4	Pateros + Rocky Reach	309	156		
	McNary	82	44	0.0334	0.8551
115p5	Pateros + Rocky Reach	318	166		
	McNary	88	48	0.0130	0.9093
117p6	Pateros + Rocky Reach	344	154		
	McNary	86	46	0.5717	0.4496
119p7	Pateros + Rocky Reach	315	178		
	McNary	68	24	3.0134	0.0826
121p8	Pateros + Rocky Reach	378	128		
	McNary	72	21	0.1818	0.6699
123p9	Pateros + Rocky Reach	378	180		
	McNary	66	37	0.3763	0.5396

Table B4. (Continued)

Release		Test 2.3		χ_1^2	P-value
Pateros		Recovery Site			
	Release Site	John Day	Bonn.		
125p10	Pateros + Rocky Reach	360	147		
	McNary	79	26	0.5738	0.4487
127p11	Pateros + Rocky Reach	371	122		
	McNary	76	30	0.4098	0.5221
129p12	Pateros + Rocky Reach	357	109		
	McNary	79	21	0.1480	0.7005
131p13	Pateros + Rocky Reach	397	104		
	McNary	89	20	0.1895	0.6634
133p14	Pateros + Rocky Reach	397	80		
	McNary	78	14	0.0459	0.8304
135p15	Pateros + Rocky Reach	430	66		
	McNary	98	16	0.0029	0.9574
Wells		John Day	Bonn.		
107w1	Wells + Rocky Reach	289	167		
	McNary	70	34	0.4106	0.5217
109w2	Wells + Rocky Reach	315	195		
	McNary	72	28	3.3480	0.0673
111w3	Wells + Rocky Reach	340	161		
	McNary	68	31	0.0018	0.9661
113w4	Wells + Rocky Reach	333	167		
	McNary	91	49	0.0639	0.8004
115w5	Wells + Rocky Reach	328	170		
	McNary	95	53	0.0771	0.7812

Table B4. (Continued)

Release		Test 2.3		χ_1^2	P-value
Wells		John Day	Bonn.		
117w6	Wells + Rocky Reach	345	163		
	McNary	97	40	0.2945	0.5874
119w7	Wells + Rocky Reach	356	158		
	McNary	59	28	0.0208	0.8854
121w8	Wells + Rocky Reach	394	183		
	McNary	74	33	0.0043	0.9477
123w9	Wells + Rocky Reach	353	164		
	McNary	92	28	2.8683	0.0903
125w10	Wells + Rocky Reach	341	158		
	McNary	86	36	0.1235	0.7253
127w11	Wells + Rocky Reach	394	142		
	McNary	82	21	1.3882	0.2387
129w12	Wells + Rocky Reach	405	116		
	McNary	86	20	0.4151	0.5194
131w13	Wells + Rocky Reach	408	101		
	McNary	101	18	1.1069	0.2927
133w14	Wells + Rocky Reach	426	79		
	McNary	99	19	0.0003	0.9862
135w15	Wells + Rocky Reach	441	71		
	McNary	114	14	0.5299	0.4666

Table B5. Burnham et al. (1987) Test 3.1 for individual release groups. This procedure tests whether capture histories at Rocky Reach affect downstream detection histories at John Day and Bonneville.

Release	Capture History at John Day and Bonneville Dams	Capture History to McNary Dam		χ^2_3	P-value
		101	111		
107p1	11	10	4		
	10	31	13		
	01	12	6		
	00	87	22	1.8876	0.5961
109p2	11	11	6		
	10	34	14		
	01	28	3		
	00	67	14	7.1161	0.0683
111p3	11	12	2		
	10	42	18		
	01	26	11		
	00	77	39	2.2607	0.5201
113p4	11	12	7		
	10	53	10		
	01	36	8		
	00	91	32	5.0863	0.1656
115p5	11	23	5		
	10	56	4		
	01	39	9		
	00	121	29	5.3151	0.1501
117p6	11	14	2		
	10	61	9		
	01	41	5		
	00	89	28	6.0240	0.1105
119p7	11	9	4		
	10	43	12		
	01	20	4		
	00	95	17	2.5943	0.4585
121p8	11	7	4		
	10	46	15		
	01	17	4		
	00	78	29	1.2723	0.7357
123p9	11	14	4		
	10	36	12		
	01	29	8		
	00	85	23	0.2748	0.9647

Table B5. (Continued)

Release	Capture History at John Day and Bonneville Dams	Capture History to McNary Dam		χ^2_3	P-value
		101	111		
125p10	11	13	3		
	10	48	15		
	01	22	4		
	00	99	33	1.3220	0.7239
127p11	11	7	4		
	10	42	23		
	01	20	10		
	00	70	30	0.6155	0.8929
129p12	11	10	2		
	10	58	9		
	01	17	4		
	00	96	22	0.8946	0.8267
131p13	11	11	4		
	10	68	6		
	01	20	0		
	00	89	15	7.5519	0.0562
133p14	11	19	2		
	10	50	7		
	01	8	6		
	00	97	17	9.0372	0.0288
135p15	11	9	10		
	10	60	19		
	01	10	6		
	00	77	24	8.0108	0.0458
Wells					
107w1	11	13	10		
	10	41	6		
	01	27	7		
	00	102	33	8.3624	0.0391
109w2	11	22	2		
	10	41	7		
	01	21	7		
	00	102	16	3.3895	0.3354
111w3	11	12	4		
	10	34	18		
	01	25	6		
	00	60	20	2.6525	0.4484

Table B5. (Continued)

Release	Capture History at John Day and Bonneville Dams	Capture History to McNary Dam		χ^2_3	P-value
		101	111		
113w4	11	11	5		
	10	56	19		
	01	36	13		
	00	84	48	3.3366	0.3426
115w5	11	20	2		
	10	65	8		
	01	48	5		
	00	127	23	1.8988	0.5937
117w6	11	16	5		
	10	63	13		
	01	33	7		
	00	114	34	1.4372	0.6968
119w7	11	5	1		
	10	39	14		
	01	24	4		
	00	84	28	1.8609	0.6018
121w8	11	11	4		
	10	44	15		
	01	27	6		
	00	75	31	1.6212	0.6546
123w9	11	17	3		
	10	66	6		
	01	23	5		
	00	88	23	5.0716	0.1666
125w10	11	17	6		
	10	47	16		
	01	28	8		
	00	106	32	0.2322	0.9722
127w11	11	13	7		
	10	47	15		
	01	15	6		
	00	78	39	1.8356	0.6072
129w12	11	10	5		
	10	54	17		
	01	16	4		
	00	97	26	1.2829	0.7332

Table B5. (Continued)

Release	Capture History at John Day and Bonneville Dams	Capture History to McNary Dam		χ^2_3	P-value
		101	111		
131w13	11	9	5		
	10	60	27		
	01	14	4		
	00	80	31	0.9406	0.8156
133w14	11	18	3		
	10	64	14		
	01	15	4		
	00	107	14	2.2225	0.5275
135w15	11	7	3		
	10	79	25		
	01	11	3		
	00	86	40	2.0082	0.5707

Table B6. Burnham et al. (1987) Test 3.2 for individual release groups. This procedure tests whether capture histories at Rocky Reach and McNary affect downstream detection history at Bonneville.

Release	Capture History at John Day and Bonneville Dams	Capture History to John Day Dam				χ^2_3	P-value
		1111	1101	1011	1001		
107p1	0	13	47	31	158		
	1	4	21	10	49	1.4598	0.6916
109p2	0	14	45	34	207		
	1	6	13	11	50	1.7340	0.6294
111p3	0	18	89	42	186		
	1	2	24	12	62	2.6859	0.4426
113p4	0	10	55	53	189		
	1	7	23	12	42	8.7154	0.0333
115p5	0	4	43	56	200		
	1	5	12	23	63	5.5610	0.1350
117p6	0	9	61	61	204		
	1	2	22	14	57	1.5582	0.6689
119p7	0	12	50	43	208		
	1	4	12	9	45	0.6058	0.8951
121p8	0	15	60	46	246		
	1	4	26	7	46	10.4024	0.0154
123p9	0	12	72	36	235		
	1	4	12	14	59	3.9579	0.2660
125p10	0	15	78	48	226		
	1	3	11	13	45	2.1422	0.5434
127p11	0	23	88	42	199		
	1	4	22	7	62	3.1693	0.3663
129p12	0	9	66	58	234		
	1	2	8	10	49	1.9778	0.5770
131p13	0	6	61	68	273		
	1	4	19	11	44	9.1504	0.0274
133p14	0	7	41	50	297		
	1	2	9	19	50	7.3346	0.0620
135p15	0	19	93	60	264		
	1	10	24	9	49	8.2421	0.0413

Table B6. (Continued)

Release	Capture History at John Day and Bonneville Dams	Capture History to John Day Dam				χ^2_3	P-value
		1111	1101	1011	1001		
Wells							
107w1	0	6	57	41	179		
	1	10	13	13	40	18.0409	0.0004
109w2	0	7	38	41	201		
	1	2	15	22	61	3.8343	0.2799
111w3	0	18	78	34	185		
	1	4	29	12	48	2.3150	0.5097
113w4	0	19	71	56	173		
	1	5	27	11	62	3.4431	0.3282
115w5	0	8	38	65	232		
	1	2	8	20	50	1.5155	0.6787
117w6	0	13	59	63	193		
	1	5	26	16	67	2.3250	0.5077
119w7	0	14	77	39	206		
	1	1	23	5	50	4.2298	0.2377
121w8	0	15	81	44	230		
	1	4	25	11	57	0.6753	0.8790
123w9	0	6	46	66	236		
	1	3	14	17	57	1.4037	0.7047
125w10	0	16	64	47	209		
	1	6	14	17	54	2.1397	0.5439
127w11	0	15	100	47	220		
	1	7	26	13	48	2.7953	0.4243
129w12	0	17	87	54	235		
	1	5	21	10	62	1.0321	0.7935
131w13	0	27	87	60	243		
	1	5	24	9	54	2.2546	0.5213
133w14	0	14	66	64	290		
	1	3	11	18	59	1.7652	0.6225
135w15	0	25	97	79	279		
	1	3	18	7	47	2.9906	0.3931

Table B7. Counts of smolt by capture history for fish detected in the Rocky Reach 6-inch pipe, and at McNary, John Day, and Bonneville Dams. Chi-square tests compare these counts with smolt counts for fish not handled at Rocky Reach but detected somewhere downriver.

Release	1111	1110	1101	1100	1011	1010	1001	1000	1200	χ^2	df	p value
Pateros												
107p1	0	3	3	6	7	14	13	111	2	7.0773	8	0.5283
109p2	3	7	1	3	4	16	11	63	2	6.1193	8	0.6339
111p3	2	6	3	18	10	42	31	142	1	7.0619	8	0.5300
113p4	3	3	4	15	6	23	15	87	1	4.4392	8	0.8155
115p5	2	2	4	11	6	20	17	65	2	4.1592	8	0.8425
117p6	1	5	0	6	7	16	8	62	1	7.5401	8	0.4796
119p7	1	3	0	7	1	11	13	62	2	6.1953	8	0.6254
121p8	3	2	2	4	5	22	10	62	3	15.7043	8	0.0468
123p9	1	2	2	4	1	15	6	47	0	2.3997	7	0.9345
125p10	2	4	1	4	2	14	7	39	0	8.6730	8	0.3706
127p11	0	7	2	5	5	14	8	64	0	3.8112	7	0.8012
129p12	0	0	0	1	0	5	4	23	0	3.5440	7	0.8305
131p13	0	0	0	2	1	8	1	14	0	6.1618	7	0.5210
133p14	2	2	2	8	5	9	3	60	0	11.1483	7	0.1323
135p15	2	4	0	4	7	28	4	75	0	4.9425	8	0.7637
Wells												
107w1	5	2	4	14	5	19	20	114	3	2.8328	8	0.9444
109w2	0	2	1	2	3	13	3	44	2	9.2510	8	0.3216
111w3	2	8	1	10	13	42	14	138	6	10.3665	8	0.2402
113w4	4	6	6	23	9	35	18	164	0	9.2097	7	0.2379
115w5	1	5	4	12	6	24	15	85	2	3.5878	8	0.8923
117w6	0	5	1	5	5	9	7	30	4	8.6847	8	0.3696
119w7	0	2	1	2	7	18	14	95	7	12.1816	8	0.1433
121w8	1	3	1	9	10	26	13	96	2	4.8368	8	0.7749
123w9	0	2	1	7	4	11	5	43	1	6.1332	8	0.6323
125w10	0	2	0	5	2	9	6	38	0	2.5823	7	0.9208
127w11	0	2	2	4	3	14	7	53	0	3.6962	7	0.8140
129w12	0	2	1	2	1	8	5	37	0	2.9707	7	0.8877
131w13	2	0	1	0	0	3	0	10	0	3.8315	7	0.7990
133w14	0	2	1	2	2	10	2	42	0	3.2039	7	0.8655
135w15	1	10	0	12	11	23	4	99	1	15.3957	8	0.0519

Table B8. Counts of smolt by capture history for fish recaptured at Rock Island Dam, and at McNary, John Day, and Bonneville Dams. Chi-square tests compare these counts with smolt counts for fish not recaptured at Rocky Island Dam but detected somewhere downriver.

Release	111	110	101	100	011	010	001	200	χ^2	df	P- value
Pateros											
107p1	0	0	1	1	1	5	2	1	4.1341	7	0.7642
109p2	2	1	0	2	2	4	4	0	9.0914	7	0.2462
111p3	0	0	0	6	1	5	3	1	8.8064	7	0.2669
113p4	0	0	2	4	2	5	2	0	5.1163	7	0.6458
115p5	0	2	1	2	2	3	2	1	2.5225	7	0.9254
117p6	0	2	0	1	1	5	4	0	3.8068	7	0.8017
119p7	0	0	0	2	0	2	1	0	3.6518	7	0.8189
121p8	0	0	0	2	1	1	0	0	6.2870	7	0.5067
123p9	1	0	0	2	1	5	3	0	3.411	7	0.8446
125p10	0	0	1	4	1	2	2	0	6.3623	7	0.4981
127p11	0	1	3	3	2	3	2	0	12.0995	7	0.0973
129p12	0	0	0	2	1	2	0	0	3.9157	7	0.7894
131p13	0	1	0	0	1	3	1	0	1.896	7	0.9653
133p14	0	1	0	1	1	6	2	0	1.464	7	0.9835
135p15	0	0	0	1	1	1	1	0	3.4467	7	0.8408
Wells											
107w1	2	1	1	3	1	5	1	0	8.0417	7	0.3289
109w2	0	0	1	1	0	5	1	1	7.9169	7	0.3400
111w3	1	3	2	2	1	7	2	1	6.3019	7	0.5050
113w4	0	2	3	3	2	6	3	0	3.9120	7	0.7899
115w5	0	1	4	6	2	4	4	1	8.7371	7	0.2721
117w6	0	1	1	4	2	3	3	1	1.9302	7	0.9636
119w7	0	1	1	0	2	3	4	0	6.2134	7	0.5151
121w8	0	0	0	2	1	4	2	0	2.6120	7	0.9184
123w9	0	0	0	2	2	4	2	0	3.0709	7	0.8784
125w10	0	0	1	2	0	0	3	0	8.5482	7	0.2867
127w11	0	1	1	0	3	6	2	0	6.1154	7	0.5263
129w12	0	0	1	1	2	6	2	0	10.4703	7	0.1635
131w13	0	1	0	2	1	5	0	0	2.2639	7	0.9438
133w14	1	0	0	2	0	9	3	0	6.0598	6	0.4165
135w15	0	2	0	3	3	2	1	0	8.2328	7	0.3125

APPENDIX C

Responses to comments received on the Draft report entitled: "Project survival estimates for yearling summer steelhead migrating through the Wells Hydroelectric Project, 1999."

RESPONSE TO COMMENTS FROM STEVE SMITH, NMFS

The following pages contain Steve Smith's (NMFS) comments related to the 1999 Wells PIT-tag survival study. Steve's comments are italicized and are followed by our responses.

Steve's Comments Follow:

The subject document reports the results of important smolt survival research conducted by Douglas County PUD #1 in 1999. The research was apparently well planned and well executed and is explained in a straightforward manner in the draft report. The researchers showed uncommon care in handling study animals, and the report carefully documents efforts taken to ensure the well-being of the handled subjects. Our comments are primarily editorial. Of the suggestions made below, the readability of the report would be most improved if the contents of the "Methods," "Results," and "Discussion" sections were more consistent with the section titles. There is far too much methodology in the "Results" section, most of it redundant to "Methods," and the content of the "Discussion" is almost completely redundant of the results presented in "Results."

We have omitted many of the redundant statements contained within the Results and Discussion sections. The content of the Discussion section has been modified to include more traditional "discussion" topics. Also see responses to comments on Page 30, Section 4.5 title; Section 5.0 "Discussion"; Section 5.5, paragraph 5.

Specific Comments

Second page of Executive Summary, para. 4, line 6—*Suggest replacing "less synchronized" with "not synchronized."*

The suggested change has been made.

Third page of Executive Summary, last line—*The executive summary gives the average estimated survival for McNary-to-John Day, but we found no place in the report itself that reported or discussed this result. Also, the average estimated survival from Wells Dam to Rocky Reach Dam is not given. We recognize that there are differences in jurisdiction for the reaches that are not reported, but without some mention that the estimate is reported by Chelan PUD, (or other such explanation), its absence is conspicuous.*

The replicate estimates of survival from McNary-to-John Day are contained within Table 5 (Results). The estimates of reach survival for this section of river are also discussed and compared with previous (1998) findings for fish migrating through this same section of river. Estimates of survival from Wells to Rocky Reach Dam can also be found within Table 5. We have modified Table 5 so that the weighted average estimates of survival for all common river reaches can be found in this one table. We also have improved the Discussion section so that it now includes the estimates of survival from release to Rocky Reach tailrace.

Page iii —"APPEDICES"

***Page 1, para. 1, line 6 and throughout report**—Suggest using "detection probability," "detection history," etc. in place of "recapture," "capture history," etc. Most readers will know, but it is better to make it clear that fish are not actually handled to gather data after release.*

We agree. The suggested change is a clearer description of the PIT-interrogation process. As such, "detection probability," and "detection history," have been substituted for "recapture," and "capture history," throughout the entire document.

***Page 1, para. 2, line 7**—Suggest "Estimated survival...averaged" in place of "Survival...averaged"*

The suggested change has been made.

***Page 2, para. 2**—Suggest referring to the more detailed map of the area above Wells Dam (Fig. 2) here.*

Agreed.

***Section 3.3, para. 1, line 3**—How were the release containers transported?*

All five release containers were transported on the back of one flatbed truck. The same truck was used for all thirty release groups. The sentence in question has been modified to include a description of how release containers were transported from the hatchery to the barge loading sites.

***Section 3.3, para. 2**—It might be helpful to mention here the reason for differences in release times.*

The following sentence was added to Section 3.3, para. 2. "Release times were staggered to allow Pateros fish additional time to arrive at Wells Dam prior to the release of tailrace fish."

***Page 7, para. 1, line 7**—What kind of handling did the control fish experience as they were collected? From where and how were they collected?*

The only difference between treatment and the control fish sampled for physiological indices was the anesthetizing and tagging procedure.

The following description was added to Page 7, para. 1. "To provide a baseline level of fish stress, condition and health, a control group of 20 untagged steelhead were also sampled. Control fish were not anesthetized and tagged but did experience identical collecting, holding and sampling conditions as treatment (tagged) fish."

***Figure 2 caption**—Does this imply that there are "unimportant" release sites?*

The word "Important," has been removed from Figure 2.

***Page 9, para. 2, line 2**—Many readers may need more specificity than "the Columbia River estuary-sampling site." Also, such a site is not shown on the diagram (Fig. 3).*

The PIT-trawl has been added to Figure 3 and the following wording was added to Page 9, para. 2, line 2. "Additional detections took place at the Columbia River estuary-sampling site where NMFS operates a mid-water trawl equipped with a PIT-tag detection tunnel."

***Page 12, line 1**—Suggest defining "mixing." We suspect that what is meant is "proportionate daily detection distributions at downstream dams" (what is later described as "homogeneous recoveries," etc.). This type of mixing is certainly desirable, and makes commonality of parameters more likely, but it may not be sufficient. Differences in the composition of the two groups, or differences in the way they were handled, for example, could lead to differences in parameters despite proportionality of detection distributions.*

We agree. Our definition of mixing is more accurately defined as, "proportionate daily detection distributions at downstream dams." Proportionate daily detection distributions within a replicate pair are desirable but not a requirement for the CJS model. Hence, the word mixing has been replaced with "proportionate daily detection," throughout the document including Page 12, line 1.

The sentence on page 12 now reads, "Proportionate daily detection distributions of the R_1 and R_2 smolts was sufficient but not necessary for valid estimation of S_W."

***Page 13, "Assumption (10) is satisfied by mixing the two release groups..."**—Was the intended wording "mixing of the two release groups"? If so, we again note that mixing may not be sufficient—if both groups experience handling mortality immediately after release, then survival from Wells Dam to Rocky Reach Dam will be lower for R_2 than for R_1, even if the survivors have proportional detection distributions at Rocky Reach. If "of" was not unintentionally omitted from the sentence, what is meant by "mixing the two release groups"?*

"Of" has been added to the phrase, "mixing of the two release groups."

***Page 15, para. 2**—The confidence interval is "approximate" or "asymptotic."*

Approximate.

***Page 15, para. 3**—Suggest "consequently" instead of "subsequently."*

The suggested change has been made.

***Page 16**—Need to explain exactly what m_{ij}'s are.*

The following sentence has been added to the final report. "Where m_{ij}'s are the number of smolts released at site i that are next detected at site j."

***Page 18, para. 1, line 3**—Suggest "detections" instead of "recoveries."*

The suggest chance has been made.

***Page 18, para. 1, last line**—Some discussion of proper use of experiment-wise error rates would be helpful (see comment regarding results below). In particular, the test-wise error rates implied by experiment-wise level of 0.10 should be stated.*

The following discussion regarding test-wise and experimental-wise error levels has been added to the final report. "In the following sections, test-wise error rates (α) are adjusted for an experimental-wise error rate (α_{EX}) of 0.10. In computing a large number of tests, the risk that a test will reject the null hypothesis increases as the number of tests increases. The experimental-wise error rate helps to screen out those tests which may be rejected due to randomness, and focuses attention on those tests that warrant further attention. To address the concern that this process may eliminate too much test sensitivity, individual test p-values are also reported. For each sequence of tests, test-wise error rates are adjusted by the following:

$$\alpha = 1 - \sqrt[t^{-1}]{1-\alpha_{EX}} = 1 - \sqrt[t^{-1}]{1-\alpha_{0.10}} = 1 - \sqrt[t^{-1}]{0.90}$$

where α = test-wise error rates,

α_{EX} = experimental-wise error rate, and

t = number of tests in a sequence."

***Page 19**—It is suggested that Burnham et al. provided a useful test of overall equality of parameters ("contingency table (12)"), but that it is not as fine-grained as likelihood ratio tests used in this analysis. In reality, TEST 1 of Burnham et al. is a series of contingency table tests with 1-to-1 correspondence to one possible sequence of fine-grained likelihood ratio tests.*

The final model selection process does not use these results, as Burnham states that for the Test 1 sequence of model selection, "that when different alternatives intermediate between models H_0 and $H_{k-1,\phi}$ are considered, these individual test components may have no interpretive value. Rather, one must then go to numerical methods for model fitting and testing (by way of likelihood ratio tests)" (Burnham, p.196).

***Section 4.2, para. 1**—The practice of "culling" has also been referred to, and criticized, as "high grading." In light of Assumption A1, there should at least be some discussion of the implications of rejecting even 1.8% of fish because of disease or other abnormalities.*

An entire paragraph has been added describing why precocious parr, diseased and critically injured fish were not PIT-tagged in 1999. Culling was directly related to satisfying Assumption A1 (test fish are representative of the population of inference). In order to satisfy Assumption A1, fish that were not expected to survive tagging (injured or diseased) or were not expected to migrate through Wells Dam during 1999 (parr and precocious) were excluded from the survival study. The 1999 survival study was set-up to analyze the effects of project passage on steelhead smolts not to measure the effects of tagging and transportation.

***Section 4.2, para. 2**—These are methods, not results.*

Methods were purposefully included in the Results section. By doing so, background information is provided to readers in a context that is much more understandable. It is a favor to non-technical readers who tend to skip over the Methods section of the report and will instead focus on how information contained within the Results and Discussion sections should be utilized for policy level decisions.

***Section 4.3**—Entire section is mostly methods.*

Same as above.

***Section 4.4, para. 1**—methods.*

Same as above.

***Section 4.4, para. 3**—Suggest including fat coverage in Table 2-C.*

Percent fat coverage has been added to Table 2-C.

***Page 25, line 1**—"ashort"*

This typo has been fixed to read, " a short."

***Page 25, para. 1**—Are significance tests for differences possible?*

No, however statistical tests to determine whether differences are significant can be conducted. The sentence in questions has been modified to clear up any confusion.

***Page 25, para. 4, line 3**—Which two sample groups were significantly different? Does this (or any of the physiological monitoring) have any implications for the results of the survival analyses?*

Pateros glucose sample one was significantly higher than 10 other sample groups (sample 7, 9, 12, 17, 15, 16, 18, 13, 14 and 10). We found no significant difference within a replicate release pair (e.g. Pateros sample 1 versus Tailrace sample 1). Differences in fish condition, between replicates, cannot induce bias into the survival estimation process. However, differences between groups can effect the interpretation of the resultant survival estimates over time (e.g. replicate 1 versus replicate 15).

Physiological samples are collected for two reasons. First, the collection of stress indices provides fish husbandry and tagging crews with immediate and tangible feedback on how fish handling practices can be improved or modified for future studies. Our goal from day 1 has been to index the non-tagged salmonid smolt populations migrating through Wells Dam (Assumption A1). To do this, we have attempted to partition or remove the handling, tagging and transportation stresses from the survival process at Wells Dam. The collection of physiological samples allows us to partition project effects from other observable survival effects such as disease, fish stress (handling and tagging) and fish condition.

Second, if large differences in survival estimates or survival trends are observed these trends may be related to project operation, river conditions and/or fish quality and handling. By collecting indices of fish condition and stress, in addition to project operations and river parameters (project operations, spill, TDG, river flow, turbidity, water temperates, D.O., etc…), the processes that are responsible for the estimates of survival derived can be more accurately described. This will hopefully aid in the development of relationships between survival and the survival processes measured.

***Page 30, Section 4.5 title**—Suggest "Estimation of Detection and Reach Survival Probabilities."*

The suggested change has been made.

***Page 30**–Except for reference to Table 4, entire page is methods.*

Again, we are attempting to frame the results presented in a more user friendly format. We agree, however that some of the methods included are unnecessarily redundant. In such cases, we have removed these types of sentences and phrases and have added additional results such as capture rates.

***Page 30, para 2, and elsewhere**—The day of year designations appear off by 2 days; e.g., April 19 is day 109, not 107.*

Our tag groups were tagged two days previous to their actual release. We have named the release groups by their day of tagging. To clarify this paragraph 2 was modified to read, "For example, 107p1 denotes the first release group which was tagged on day 107 and released two days later at Pateros on day-of-the-year 109."

***Section 4.6.1, para. 1**—methods, except for reference to Table 5.*

Section 4.6.1, paragraph 1 sets the stage for the Burnham test and mixing results presented within this section.

***Section 4.6.1, para. 2, line 1**—Again, mixing is not sufficient.*

Agreed, but mixing is one of many conditions reviewed to determine whether or not treatment and control fish experienced similar post-treatment river conditions including both the survival and detection processes.

***Page 35, Burnham Test 2, line 5/6**–There are 5 significant tests at 0.10, not 4. This is consistent with the 16.7% figure given. What is the effective test-wise error rate implied by experiment-wise 0.10?*

The effective test-wise error rates have been added to the report.

***Page 35, Burnham Test 3**—If experiment-wise error rate was computed based on 60 tests, the effective test-wise rate is 0.002, which seems rather extreme. More importantly, does not the rejection of a test at the experiment-wise level properly lead to rejection of the experiment, not just that one test?*

Most importantly, in a 1996 review of NMFS' juvenile survival studies, the Independent Scientific Group was critical of the use of experiment-wise error rates for assumption testing, on the grounds that power to detect true violations is severely reduced. The ISG further suggested that it is more appropriate to estimate the parameters of interest and determine the extent of bias that might exist due to assumption violations, rather than simply to test hypotheses of no bias. This type of research is still lacking in PIT-tag survival studies; perhaps it is time for scientists from NMFS and other agencies now conducting large-scale survival studies to tackle the question.

It must be remembered that the Burnham tests are included in this analysis as a guide to selecting a final model upon which to base our estimates of survival and capture probabilities. As such, we look to the results of the individual tests to give a clearer picture of the experiment and its stages. The use of experimental-wise adjusted errors is common (Snedecore and Cochran 1989: pp. 234-235), and the concern by the ISG is one of the reasons test-wise P-values are also reported. By using the experimental-wise adjusted errors, we can focus our attention to those particular tests which may have had an event which was unlikely to have happened purely by chance, and to delve deeper into the circumstances.

The final model selection process uses likelihood ratio testing, for the reason noted earlier.

***Page 38**—The results concerning handling effects are very interesting, and may be surprising to some. While the study was not designed to study this effect, we are glad to see the analysis reported here.*

The 2000 survival study contains a set of separate experiments designed to look specifically at the effects of handling and stress. During future survival studies we will continue to collect the full array of physiological indices.

***Table 8**—Was "Overall 3" left off intentionally? What about "Overall 2+3"?*

The requested tests were performed and the results have been included in the document.

***Section 4.6.2**--The first two paragraphs are methods. In most instances of methods in the "Results" section noted above, the methods were redundant to material already covered in "Methods." In this case, this is the first place these methods have appeared. The methods should be in the "Methods" section.*

The suggested change was made.

***Section 4.6.2 Methods**—In the Burnham et al. Test 1 series of contingency tests noted above, equality of parameters is tested beginning with the last (i.e., farthest downstream) parameter in the sequence. As parameters are found equal, the series of tests "works its way upstream" until a test of equality is rejected. The logic of this sequence lies in the assumption that if the two groups differ at first, they are more likely to converge in parameters as they move downstream. The method described in this report does not seem to share the same sort of intuitive logic. The first test conducted is for the "first" parameter (i.e., farthest upstream). If the capture rate at the first dam is deemed equal for the two groups, then the conclusion is that all subsequent parameters are also equal, subject to the test of the selected model against the fully parameterized CJS model. (The report does not indicate what would be done if the test of the selected model vs. the CJS model were significant). We are aware that PIT-tag data collected by Chelan PUD in 1998 were analyzed using both methods, with nearly identical results. However, it is not clear that this would be the general rule. The "forward-step" method described in this report seems to us more likely to make the error of choosing a model with too many parameters in common between the two groups, leading to biased estimates. Burnham's backward-step method probably makes more conservative model selections (i.e., more unique parameters), which decreases precision but does not cause bias. We suggest that this is another potential area for further collaborative research.*

Actually, Burnham is a little vague on the sequence of performing TEST 1's, suggesting that analysis start, with all capture and survival probabilities equal between the treatment and control releases, testing for a difference between survival estimates at the first period (Burnham 1987: sections 2.1.2 and 2.4.9). In Table 2.22, he then gives the results of an example analysis in the reverse order, starting with tests for equality between the final-period survival/capture probabilities.

***Section 4.6.2, para. 3, lines 10-13**—There are references to "survival...at Rocky Reach." Does it mean "survival from Wells to Rocky Reach?"*

Capture is at Rocky Reach and survival is from release to Rocky Reach. The appropriate references have been modified to reflect the comment.

***Section 4.6.3, line 6/7**—No method was given for tests of significance between 1998 and 1999 estimates.*

A z-test was used. Additional information was added to the Methods section.

***Section 5.0 "Discussion"**—This section contains very little of what would be called "Discussion" in a journal article. The section consists mainly of restatements of results. In fact, it looks like the "Results" section if the methods were removed. As presently written, Section 5.0 would probably more properly be referred to as "Summary."*

We have omitted many of the redundant statements contained within the Discussion section and have added more traditional " discussion" items.

***Section 5.5, para. 5**—The average survival estimate from Rocky Reach to McNary is a result which would usually not be introduced in a discussion section. There is no method given for comparing this estimating with those from 1998.*

Table 5 in the Results section introduces the Rocky Reach to McNary estimate of survival. Hence it can be discussed in the Discussion section. Section 3.6.3 discusses the use of z-tests for such comparisons.

We suggest that there are several topics worthy of a proper "Discussion" section. In no particular order:

- *Implications of "culling" fish before tagging.*
- *Implications of findings of physiological monitoring.*
- *Potential reasons for differences in detection probabilities between 1998 and 1999.*
- *Very high estimates of survival between McNary and John Day.*
- *Are these plausible results for this reach?*
- *If not, does it have implications for other survival estimates obtained in the study?*
- *Potential impacts of violations of assumptions. There are more rejections of Burnham Tests 2 and 3 than would be expected by chance. How much effect might there be on survival estimates?*

We agree and have included many of these topics of interest into the Discussion section of the report.

1999 PUBLIC UTILITY DISTRICT NO. 1 OF DOUGLS COUNTY NORTHERN PIKEMINNOW REMOVAL AND RESEARCH PROGRAM

APPENDIX H

1999 Public Utility District No. 1 of Douglas County Northern Pikeminnow Removal and Research Program

Prepared For

Public Utility District No. 1 of Douglas County
1151 Valley Mall Parkway
East Wenatchee, WA 98802-4497
Contract No. 99-10-WSW

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April 13, 2000

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Acknowledgments

Thanks to all personnel at Douglas PUD who were involved in coordinating the northern pikeminnow fishery. Special thanks to Shane Bickford for contributing many hours to permitting issues and coordination for the project. Columbia Research would like to thank all anglers participating in the 1999 removal efforts. These anglers provided skill and experience, which contributed to increased catch rates. Thanks to Wells Dam Fish Hatchery staff for providing information on smolt releases and access to the carcass pit. Jerry Moore also provided valuable freezer space at the hatchery. Thanks to the folks at Biomark and Chelan PUD for saving smolt mortalities, which were used for bait. Columbia Research would like to thank all the PUD employees at Wells Dam. These individuals provided anglers with safety information, and access to the hydroelectric facility both day and night. Thanks to Todd West at Chelan County PUD for providing data on northern pikeminnow removal efforts at Rock Island Dam, and Rocky Reach Dam. Thanks to enforcement officers for monitoring Columbia Research anglers and ensuring that all terms of the Scientific Collection Permit were followed. Joe Foster and Steve Dauma at Washington Department of Fish and Wildlife provided valuable input on research and coordination activities and are specifically thanked for providing support for the long line activities.

Abstract

Northern Pikeminnow removal efforts took place from May 18, 1999 to October 9, 1999. Anglers used hook and line and long line removal techniques to capture northern pikeminnow from 1 mile below Wells Dam upstream to the boat restricted zone (BRZ) of Chief Joseph Dam. Anglers utilized hook and line removal methods exclusively on the lower 14-mile stretch of the Okanogan River. A total of 20 anglers participated in the 19 week removal program.

Anglers captured a total of 9001 northern pikeminnow over 10" in fork length and 1381 northern pikeminnow under 10" in fork length. These fish (10,382 pikeminnow total) were captured during 4017.75 hours of angling effort translating into an overall catch per unit effort or fish per hour (CPUE) value of 2.58. A majority of the fish were captured in the immediate 1 mile tailrace below Wells Dam (9370 fish during 3591.25 angling hours, CPUE = 2.61). Anglers caught 888 northern pikeminnow in the lower Wells reservoir between Wells Dam and the town of Brewster. These captures took place during 349.5 hours of angling effort resulting in a CPUE value of 2.54. Effort within the Okanogan River consisted of 57 angling hours during which time 110 pikeminnow were captured (CPUE = 1.93). The lowest catch levels took place in the Upper Wells reservoir between Brewster and the BRZ of Chief Joseph Dam. There, anglers fished for 19.75 hours during which time 14 pikeminnow were captured (CPUE= .71).

Hook and line captures accounted for the majority of catch. A total of 6405 pikeminnow (or 62% of total catch) were captured using this gear type. These fish were captured during 2490.75 hours of angling effort translating into an overall hook and line CPUE of 2.57. Anglers fished for 2490.75 hours within the immediate 1 mile tailrace of Wells Dam capturing 5423 pikeminnow (CPUE =2.59). Hook and line effort within Wells reservoir consisted of 325.25 hours of angling effort (872 pikeminnow captured, CPUE = 2.68).

Long line captures accounted for 38% of the overall catch (3977 northern pikeminnow). A total of 764 long lines were set in the 1 mile stretch below Wells Dam. Tailrace long lines captured 3947 pikeminnow (CPUE = 2.64 when estimating that each long line takes 2 hours to set, retrieve, and maintain). Anglers placed 22 long line sets in the Wells reservoir and captured 30 northern pikeminnow translating into an overall long line reservoir CPUE value of .69.

A total of 1379 non target fish were captured and released representing 12% of the overall catch. This catch consisted of 10 separate species. Bridgelip suckers were by far the most frequently encountered (1007 fish or 73% of the non target catch. Hook and line incidental catch consisted of peamouth (134 fish), burbot (85 fish), bridgelip sucker (50 fish), walleye (48 fish), smallmouth bass (6 fish), sculpin (5 fish), columbia river chub (4 fish), chiselmouth (3 fish), and bullhead catfish (1 fish). Although sturgeon were incidentally hooked during the removal efforts (estimated at about 10 fish), none of these fish were counted as

the lines were immediately cut when these fish were hooked. Long line incidental catch consisted of bridgelip suckers (957 fish), sculpin (61 fish), peamouth (11 fish), channel catfish (4 fish), burbot (3 fish), and walleye (2 fish). All incidentally collected fish were released in a live healthy state. No anadromous salmonids were encountered during the 1999 removal efforts.

Biological data consisted of length, weight, sex, stomach contents, and gonad analysis. The majority (59%) of the sexed fish were female. The average female northern pikeminnow weighed 458 g (1.01 lbs), and measured 328 mm. (12.91 inches) in fork length. The average male northern pikeminnow weighed 240 g (.53lbs) and measured 278 mm. (10.95 inches) in fork length. The overall northern pikeminnow length was 328 mm. (12.05 inches). Overall pikeminnow weight average was 366 grams or .81 lbs, resulting in 8409.42 lbs of pikeminnow biomass removed in 1998.

From gonad analysis it was determined that pikeminnow spawning efforts peaked in July during the week of 7/12/99, at which time 89% of the sub-sampled pikeminnow were classified ripe. A 34% majority of the dissected stomachs were empty. The remaining stomachs contained prey items identified as crayfish (22%), unidentified fish (17%), smolt (16%), unidentified plant (7%), and unidentified insect (2%).

Introduction

Wells Dam, located at river mile 515 on the Columbia River (Figure 1), is owned and operated by Public Utility District No. 1 of Douglas County (DCPUD). DCPUD is mandated by the Federal Energy Regulatory Committee to enhance and protect fish and wildlife resources impacted by the construction of Wells hydroelectric project. With a dramatic decline in the abundance of salmonid stocks (*Oncorhynchus spp.*) in the Columbia River ecosystem, DCPUD has initiated numerous measures to enhance survival of juvenile salmonids passing through the Wells Dam tailrace and reservoir. Over each of the past five years Douglas PUD has funded projects focusing on the research and removal of the predacious northern pikeminnow (*Ptychochelius oregonensis*).

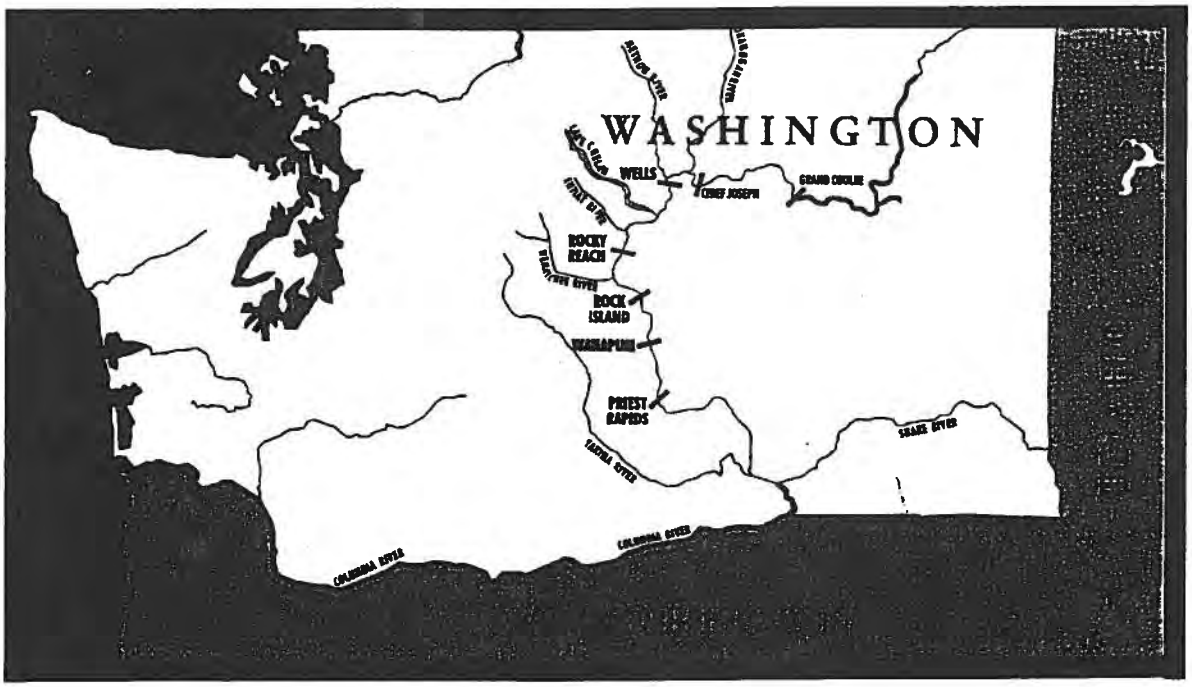
Pikeminnow research and removal has been recognized as an important part of restoring salmonid stocks which utilize waters within the Columbia River ecosystem (Vigg et al. 1990, Matthews et al. 1991). Northern pikeminnow removal and research was initiated on the lower Columbia River during the summer of 1990. A total of 17,334 pikeminnow were captured in the test fisheries (Vigg, 1990). In 1991 a total of 39,817 fish were removed from eight US Army Corps of Engineer dams on the lower main stems of the Columbia and Snake Rivers (Beaty et al. 1991). Shortly thereafter, mid-Columbia Public Utilities began to investigate the possibilities of initiating similar pikeminnow research and removal activities. In 1993 DCPUD jointly funded a juvenile salmonid predation study in the mid-Columbia region with Chelan County PUD and Grant County PUD (Burley et al. 1994). This study focused on identifying areas of northern pikeminnow abundance and areas of high predation on out migrating juvenile salmonids within the mid-Columbia region. Density index values of pikeminnow in the mid-Columbia reservoirs were as high as many reservoirs of the lower-Columbia. The immediate tailrace of Wells Dam and the outfall of Wells Hatchery were determined to be sites where large concentrations of pikeminnow could be found relative to the reservoir and forebay areas surrounding Wells Dam.

DCPUD initiated a northern pikeminnow test fishery in 1995. The goals of this pilot project were to assess the effectiveness of several gear types for removing pikeminnow, estimate the population of pikeminnow and removing pikeminnow from the tailrace of Wells Dam (Bickford and Klinge, 1996). During the summer of 1995 anglers captured 1198 pikeminnow, most of which were caught using hook and line removal techniques. Population estimates for the Wells tailrace were estimated at fewer than 10,761 fish. A similar removal program was undertaken in 1996 with goals of increasing effort and removing as many pikeminnow as possible from the Wells tailrace (Bickford, 1997). Unfortunately, difficult fishing conditions related to high river flows and velocity hampered removal efforts at Wells Dam. A total of 313 northern pikeminnow were captured in 1996, most on sport fishing gear. Commercial long line gear was also utilized, and although the lines did not capture a large amount of

pikeminnow, CPUE levels were high when this gear was tested. Low catch rates in 1996 prompted biologists at DCPUD to switch into a northern pikeminnow research phase in 1997. That year, northern pikeminnow were radio tagged throughout the Wells reservoir and tailrace. Northern Pikeminnow migration patterns, spawning locations, and preferred habitats were identified throughout Wells reservoir and from the Wells tailrace 11 miles downstream to Chelan Falls (Bickford and Skillstead, 2000).

During 1998 in an effort to increase catch levels, DCPUD entered into a contract with Columbia Research for the research and removal of northern pikeminnow. The Columbia Research removal strategy focused on an incentive based fishery with a crew of experienced anglers paid on a per-fish basis (anglers hired directly by DCPUD in 1995 and 1996 had been paid by the hour). From June 17 to September 1, 1998, anglers participating in the fishery captured 7347 pikeminnow during 3049.25 hours of angling effort (Jerald, 1998). Prompted by the success of that year's results, DCPUD once again entered into contract with Columbia Research in 1999 for the pikeminnow removal activities.

Figure 1
Wells Dam Location



Materials and Methods

Angling efforts were initiated on May 18, 1999 and were completed on December 9, 1999. Removal efforts were conducted weekly throughout this time period with the exception of the dates from August 22 to September 9. Anglers participating in the fishery were paid a $5.00 bounty for each captured pikeminnow over 10" in length, and a $1.00 bounty for pikeminnow under 10" in length. Anglers turned in their catch on a daily basis at the Wells Dam boat launch or at the Columbia Research field office in Chelan, Washington. Anglers were responsible for presenting daily data sheets specifying times fished to the nearest ¼ hour, locations fished, number of fish caught per location, long line set times, incidental catch, and tackle/baits used. To verify catch, northern pikeminnow over 12" in length had their tails clipped, frozen and submitted to a DCPUD biologist on a bi-weekly basis. Northern pikeminnow under 12" were frozen whole for length verification.

1999 Removal efforts took place within the immediate 1 mile tailrace area of Wells Dam, Wells reservoir to the boat restricted zone (BRZ) of Chief Joseph Dam, and the lower 13 miles of the Okanogan River. A scientific collection permit was obtained through Washington Department of Fish and Wildlife allowing anglers to fish in the mouth of the Wells Hatchery Outlet and the BRZ of Wells Dam. Captured northern pikeminnow were divided into four primary catch locations. Pikeminnow captured from Wells Dam to 1 mile downstream were designated "Wells tailrace". Fish captured from the Wells forebay to the town of Brewster were designated "lower Wells reservoir". Pikeminnow collected from Brewster to the BRZ of Chief Joseph Dam were classified as "upper Wells reservoir". Captures in the Okanogan River were designated catch location "Okanogan". Daily, weekly, and seasonal CPUE rates were calculated by location and by removal technique (sport fishing vs. long line).

Both sport fishing and long line removal techniques were utilized for pikeminnow capture. Sport fishermen used a variety of baits and tackle. Baits consisted of salmonid smolt mortalities, crayfish, worms, crickets, and chicken livers. Smolt mortalities were salvaged from Little Goose Dam, Lower Granite Dam, and McNary Dam juvenile bypass facilities. Personnel at the Wells Fish Hatchery also provided smolt mortalities. Columbia Research provided the smolt to the anglers when supplies were available. Otherwise, anglers purchased or collected the majority of their own baits. Fishing effort was applied specifically by boat in all locations. A small amount of effort took place from docks located along the banks near the Methow – Columbia River confluence area. Downriggers were fished specifically in the Wells Dam BRZ and immediate Wells tailrace.

Long line use was only authorized in the main stem Columbia due to concerns over incidental steelhead catch in the Okanogan and Methow rivers. Long lines used in 1999 were from 100' to 400' in length with each ground line having from

20 to 100 gabions. Leader and hooks were then tied to each gabion. Leaders consisted of 10 pound monofilament test approximately 2 feet in length. Long lines were baited with smolt mortalities, crayfish, crickets, worms and chicken livers. Long line gear was typically checked twice daily. This allowed anglers to release all non-target fish back into the river unharmed. Long line effort for the purpose of calculating CPUE was estimated by the number of lines set. It was estimated that, on average, each line took approximately 2 hours to set, retrieve, and maintain.

Biological Data was collected on the weekly catch. Sub-sample data consisted of fork length, weight, sex, stomach contents, and gonad maturity. Northern pikeminnow fork lengths were measured to the nearest millimeter. An Ohaus 5000 electronic scale was used to weigh fish to the nearest 2 grams. Pikeminnow were sexed and identified as male, female or unidentified. Stomach contents were then visually identified. Gonad maturity was identified on a scale of 0 to 4, corresponding to the following criteria:

0 - Unidentified	Gonads could not be distinguished between male and female.
1 - Immature	Gonads thin and streamlined, sex may be difficult to determine.
2 - Developing	Eggs and milt do not flow easily with pressure, but sex is easily determined. Eggs are small and gray in color.
3 - Ripe	Females contain orange-colored eggs. Eggs and milt flow freely with gentle pressure.
4 - Spent	Gonad size reduced. Some eggs or sperm may still be present.

Results

A total of 10,382 northern pikeminnow were captured during 4017.75 hours of angling effort resulting in an overall CPUE of 2.58 fish per angling hour. A majority of the fish (9001) were over 10" in fork length and 1381 fish were less than 10". Twenty anglers participated in removal efforts

A majority of pikeminnow (9370) were caught within the Wells tailrace and a total of 888 pikeminnow were captured within the lower Wells reservoir (Figure 2). Low catch values were logged at the other two locations (110 fish in the Okanogan and 14 fish in Wells upper reservoir). In regards to CPUE, the highest values were also obtained in the Wells tailrace and Wells lower reservoir (Figure 3). Anglers logged 3591.25 hours of effort within the Wells tailrace area to capture the 9370 pikeminnow (CPUE = 2.61). A total of 349.5 hours of effort were logged in the Wells lower reservoir to capture the 888 pikeminnow translating into a CPUE value of 2.54. Anglers participated in 57 hours of effort fishing the Okanogan (CPUE = 1.93) and 19.75 hours of effort in the upper Wells reservoir (CPUE = .71).

Figure 2
Catch By Location

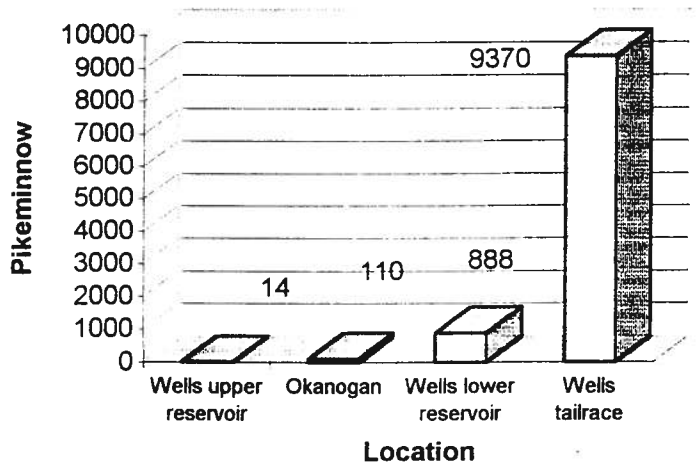
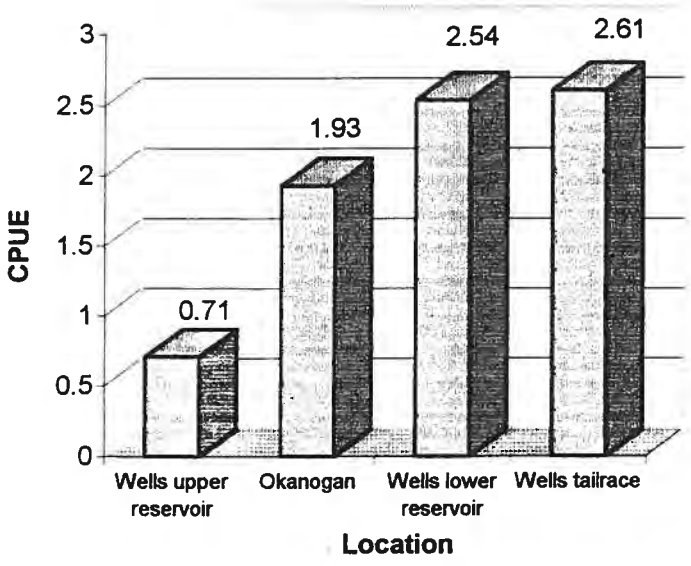


Figure 3
CPUE By Location



The highest bi-weekly catch levels occurred during the first half of the removal program (Figure 4). Total catch values dropped towards the end of July, and the lowest catch total was experienced during the last week of the removal efforts. High CPUE values corresponded to high catch rates for the first half of the collection activities (Figure 5). The peak bi-weekly CPUE value of 3.00 was obtained during mid July. CPUE values recorded in August and September fluctuated around 2.5 fish per hour. The lowest weekly CPUE value of 1.97 was recorded during the first week of October.

Figure 4
Bi-Weekly Catch (Hook & Line and Long Line)

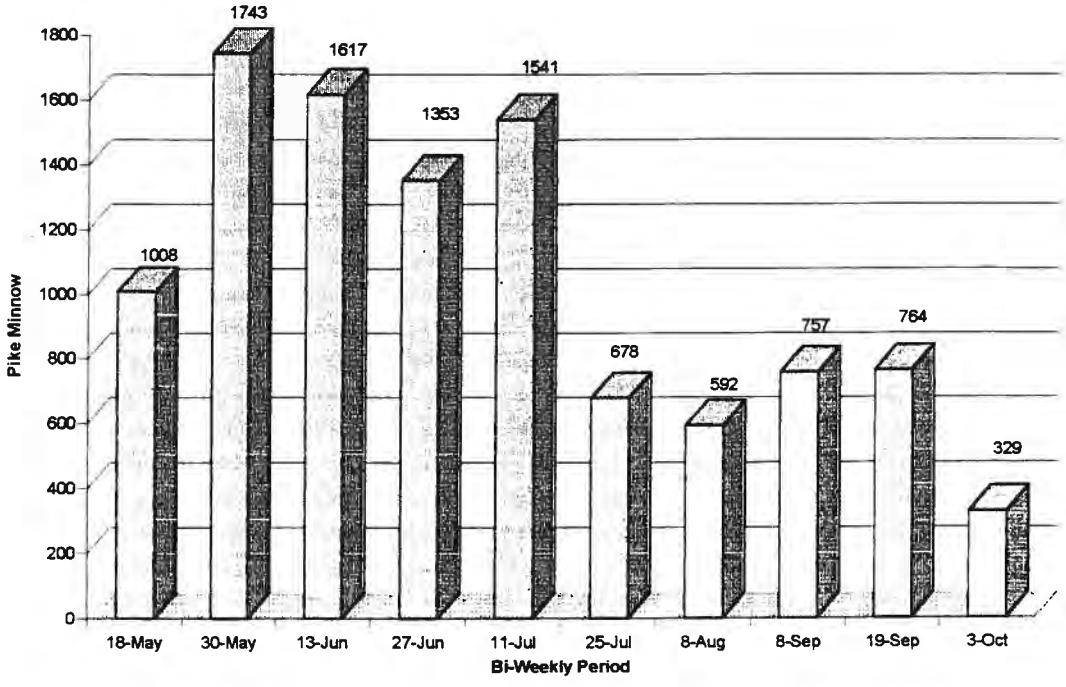
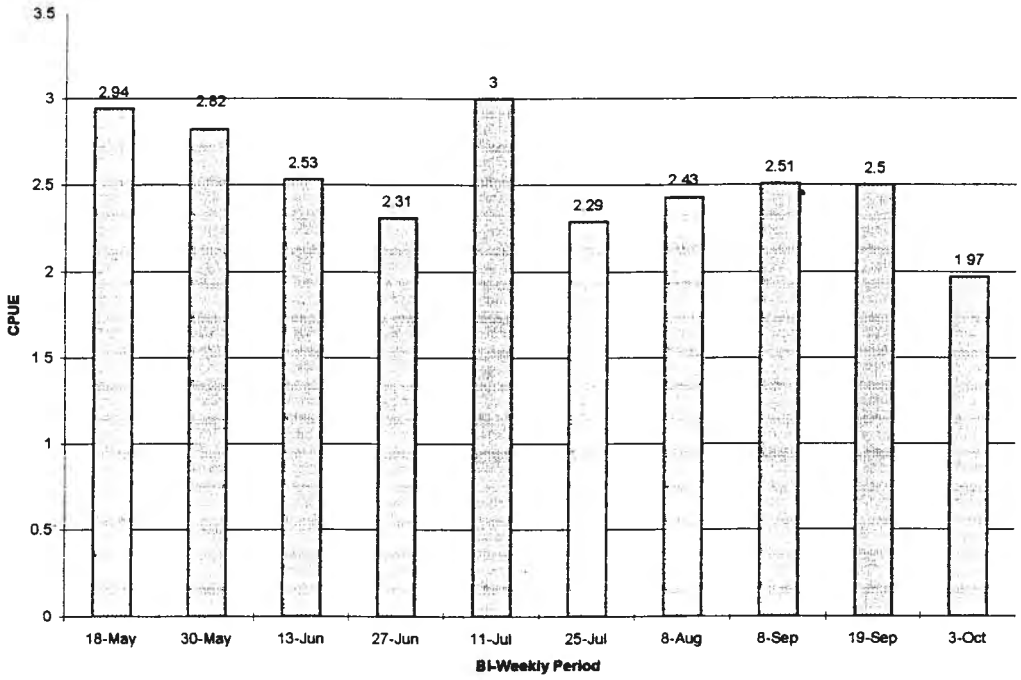


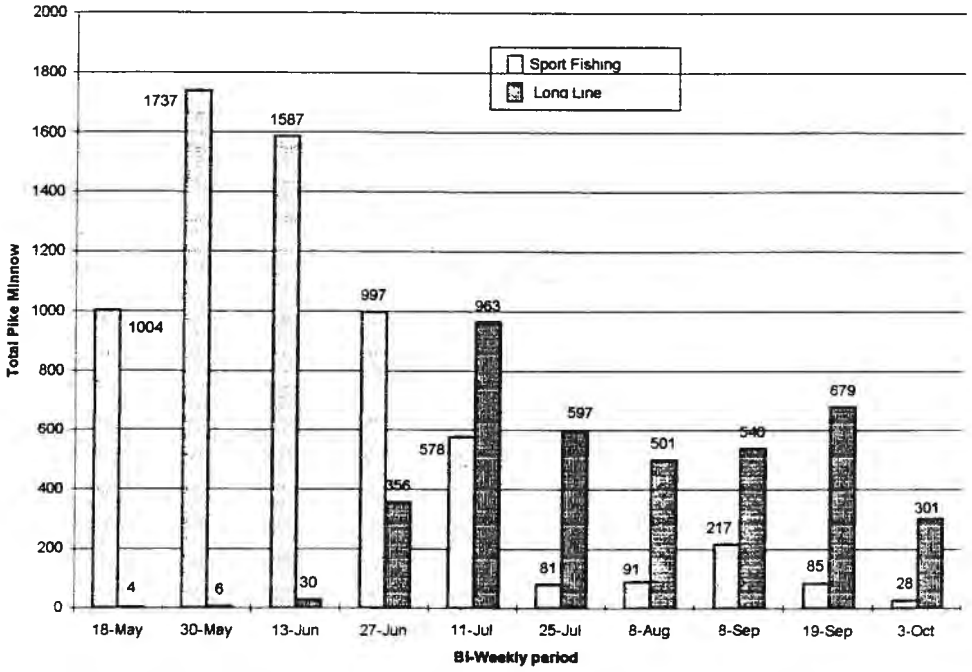
Figure 5
Bi-Weekly CPUE (Hook & line and Long Line)



During the initial months of May and June, anglers experienced a high degree of success while sport fishing the immediate Wells tailrace. The west bank, east bank, and Wells hatchery outlet in the immediate tailrace area were the most productive hook and line fishing locations. May and June also marked the highest degree of angler participation. During this time period pikeminnow were concentrated in the immediate Wells tailrace and easily accessible to the sport anglers. Angler participation decreased in mid-July as pikeminnow became more difficult to catch. Only the most experienced fishermen were participating in the removal fishery by the first of August. A majority of these individuals possessed extensive experience in both sport fishing and long line removal techniques, enabling the crew to maintain adequate catch levels. As sport fishing gear catch effectiveness dropped, anglers began setting increased numbers of long lines. By mid-July, weekly long line catch totals had surpassed that of hook and line catch (Figure 5). This marked a shift from a spring fishery based on hook and line removal techniques to a fall long line fishery. Over 85% of the pikeminnow captured from July 25 to the end of the program were caught on long line gear. High long line catch levels were a result of anglers ability to leave baits for several hours at different locations throughout the tailrace area.

Angling attempts at fishing the Wells reservoir and Okanogan River locations met with limited success. The only productive location to speak of within the Wells reservoir was the mouth of the Methow River near Pateros, Washington. Over 90% of the 888 fish captured in the Wells Lower reservoir location were captured at the Methow – Columbia River confluence area. An individual angler who had extensive angling experience in that area captured the majority of these pikeminnow.

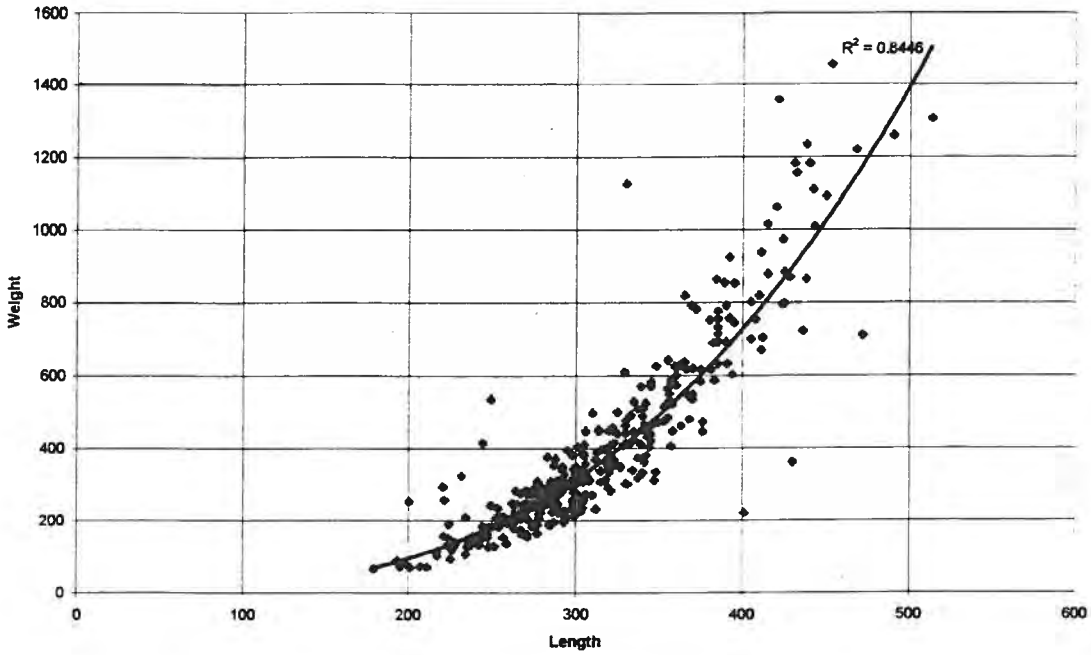
Figure 6 Bi-Weekly Catch
(Sport fishing vs. Long Line)



Sport fishing anglers experienced the highest degree of success still-fishing baits below the Wells hatchery outlet and along the east bank below Wells Dam. Anglers also concentrated efforts on pools and eddies below the immediate Wells tailrace. The most productive baits used by anglers were smolt, crickets and crayfish. These baits alone accounted for over 90% of pikeminnow captures. Three anglers used downriggers in the immediate Wells tailrace during the productive spring fishing period. This method also proved to be an effective pikeminnow removal technique.

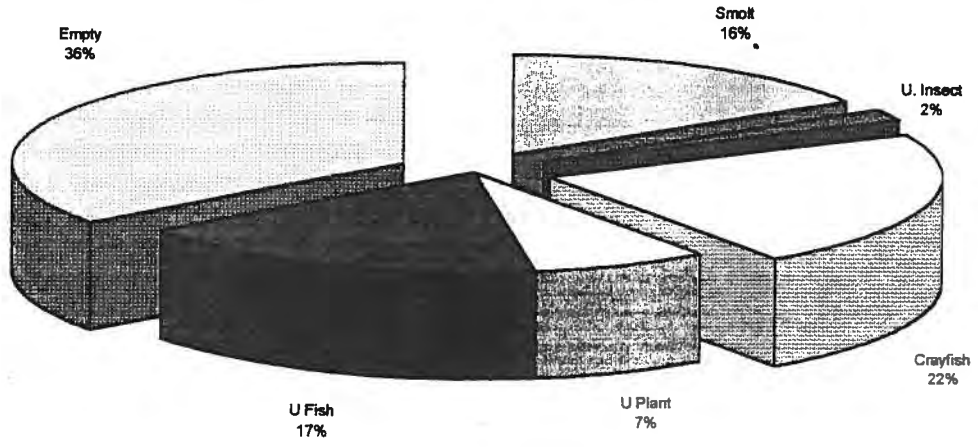
A total of 407 northern pikeminnow were sexed. A 60% majority of these fish were female. Fork length and weight were recorded on 528 northern pikeminnow A fork length-weight curve, fitted to the data resulted in a high r2 value of .84 (Figure 6). On average, males weighed 240 grams (.53 lbs) and measured 278 millimeters (10.95 inches) in fork length. Females were larger, averaging 458 grams in weight (1.01 lbs) and 328 millimeters (12.91 inches) in fork length. The overall northern pikeminnow length average was 306 millimeters (12.05 inches) and overall weight average was 366 grams or .81 lbs, translating into an estimated total of 8409.42 lbs of pikeminnow biomass removed in 1999.

Figure 7
Length/Weight Relationships



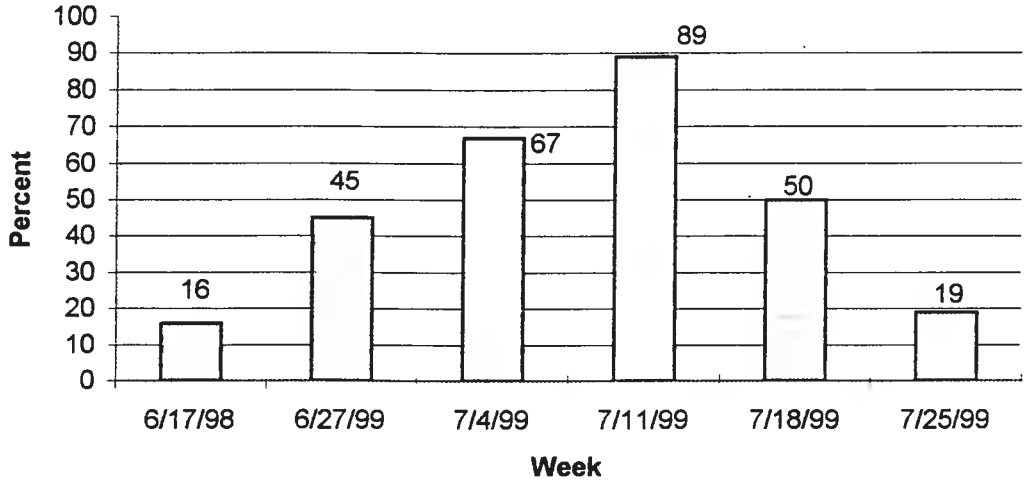
A 40% majority of dissected pikeminnow stomachs were empty (Figure 8). The main prey items identified in pikeminnow gut analysis consisted of crayfish (22%), unidentified fish matter (17%), and smolt (16%). Unidentified plant material, unidentified insect, and sculpin were also found in relatively small proportions.

Figure 8
Stomach Contents



Gonad analysis indicated 1999 northern pikeminnow spawning efforts took place in July (Figure 9). The peak spawn period occurred during the week of July 11, at which time 89% of the sub-sampled fish were classified as ripe.

Figure 9
Gonad Maturity (Percent of Weekly Subsample Classified as Ripe)



Incidental catch consisted of 10 separate species with a total of 1379 non-target fish captured. Gear types appeared to be selective for northern pikeminnow as incidental fish captures only accounted for 12% of the overall catch. Peamouth (*Mylocheilus caurinus*), burbot (*lota lota*), bridgelip suckers (*Catostomus columbianus*), and walleye (*Stizostedion vitreum*), were most frequently encountered by hook and line anglers (Figure 10). Smallmouth bass (*Micropterus dolomieui*), sculpin (Cottus sp.) Columbia River chub (pikeminnow – peamouth hybrid), and brown bullhead catfish (*Ictalarus nebulosus*) were encountered to a lesser extent. An estimated 10 sturgeon were incidentally hooked during the removal efforts, however, these fish were not included as incidental catch as the lines were immediately cut when these fish were hooked. A majority of the incidental catch was captured on the long line gear. Long line incidentals were comprised mostly of bridgelip suckers with 957 fish or 92% of the long line total incidental catch (Figure 11). Other species recorded consistently on the long line gear consisted of peamouth, burbot, walleye and sculpin. Smallmouth bass, chiselmouth (*Acrocheilus alutaceus*), columbia river chub, channel catfish and brown bullhead catfish were infrequently encountered. All incidentals were released in a live-healthy state. No anadromous salmonids were encountered during the 1999 removal efforts.

Figure 10
Sport Fishing Incidental Catch
(Total Number Caught)

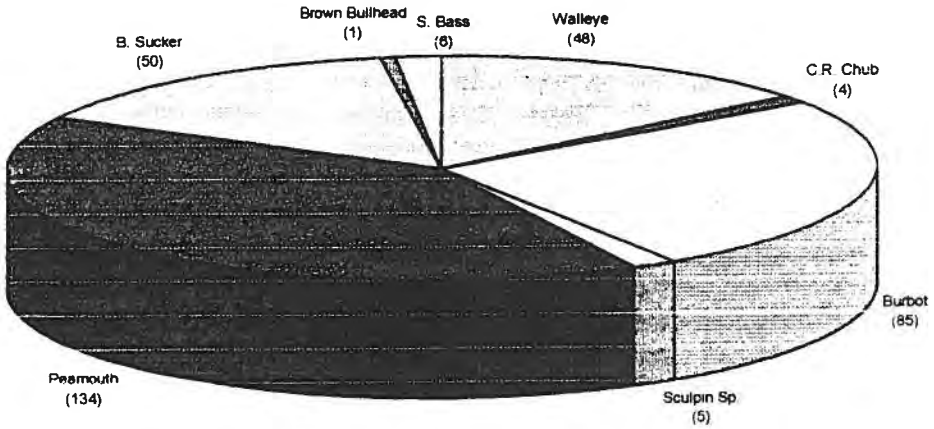
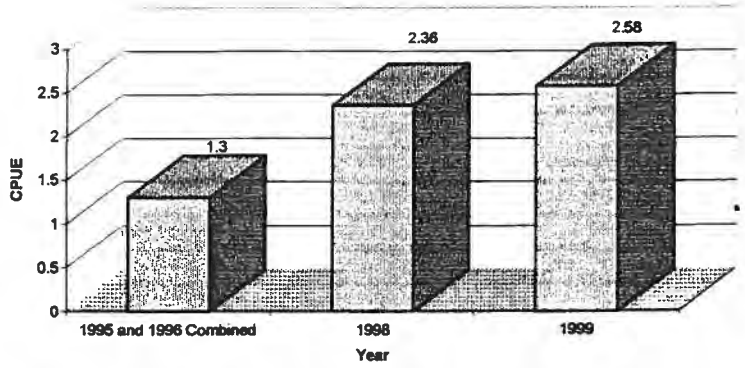


Figure 13
DCPUD Yearly CPUE Comparison



Although pikeminnow catch levels were high around Wells Dam, removal efforts within Wells reservoir and Okanogan River have met with limited success over the past few years. Anglers fishing these locations typically experience CPUE rates near 1 fish per hour, with the exception of angling effort near the mouth of the Methow River where catch rates were relatively high in the spring of 1999. It is probable that pikeminnow congregate near the location during the early spring feeding on the outbound smolt migrants passing through the confluence area. Angling attempts in summer and fall near the mouth of the Methow river met with limited success. Because anglers were compensated on an incentive per fish basis, a majority of the effort was then transferred to the more productive Wells tailrace area.

Attempts at long lining within Wells reservoir also met with limited success. The largest problem encountered in reservoir long lining attempts was the fact that fishing locations would become fished out after one or two long line sets (long lines placed in tailrace areas could often be fished for four or five days before the location was fished out). The vast surface area of water within Wells reservoir also made it difficult for anglers to locate structure and areas of pikeminnow abundance. However, it should be noted that the long line fishing techniques were still in a state of trial and error throughout 1999. To our knowledge, a commercial long line fishery has never been successful within a relatively small river system. Great advances have been made in gear construction over the last two years. Anglers have also obtained the ability to "read" areas within the reservoir that could be productive fishing locations. It was shown that a successful reservoir fishery could be conducted, when in 1999 anglers at Columbia Research successfully participated in a pikeminnow removal program sponsored by Chelan PUD (Jerald, 1999 draft). The fishery was conducted within Rocky Reach reservoir and Rock Island reservoirs with a total of 6496 pikeminnow removed during 2466.25 hours of effort resulting in an overall CPUE of 2.63. With the gear advances and extensive experience of long line anglers it may be feasible to effectively capture pikeminnow within Wells reservoir during the year 2000.

Pikeminnow research has determined that these fish congregate in tailrace areas and hatchery outfalls during times of peak smolt out migrations (Bickford et al. 1996, Burley et al. 1994, Li et al. 1987). These trends have been witnessed over the past two years during the months of May and June when anglers experienced high catch rates within the Wells tailrace area (Jerald 1998). Anglers have also reported high catch rates near the mouth of the Wells Hatchery outfall during smolt releases. Anglers fishing the tailrace at that time witnessed large numbers of pikeminnnow regurgitating smolt. It has been shown in radio tagging experiments conducted by DCPUD that pikeminnow migrate in mid summer to spawn in gravel beds located in reservoir areas (Bickford and Skillingstad, 2000). This trend was also observed in 1999 as anglers fishing in the immediate Wells tailrace found pikeminnow increasingly difficult to capture as the summer fishing period progressed. On August 17 Columbia Research began conducting pikeminnow research and removal activities within the Rocky Reach reservoir (this reservoir is located directly below Wells tailrace). Anglers experienced high catch rates in the 10 mile reservoir stretch below Wells Dam (Jerald, 1999 Draft). This lends evidence to support the suggestion that pikeminnow within Rocky Reach reservoir dissipate into reservoir areas after spending spring months congregating near the tailrace of Wells Dam.

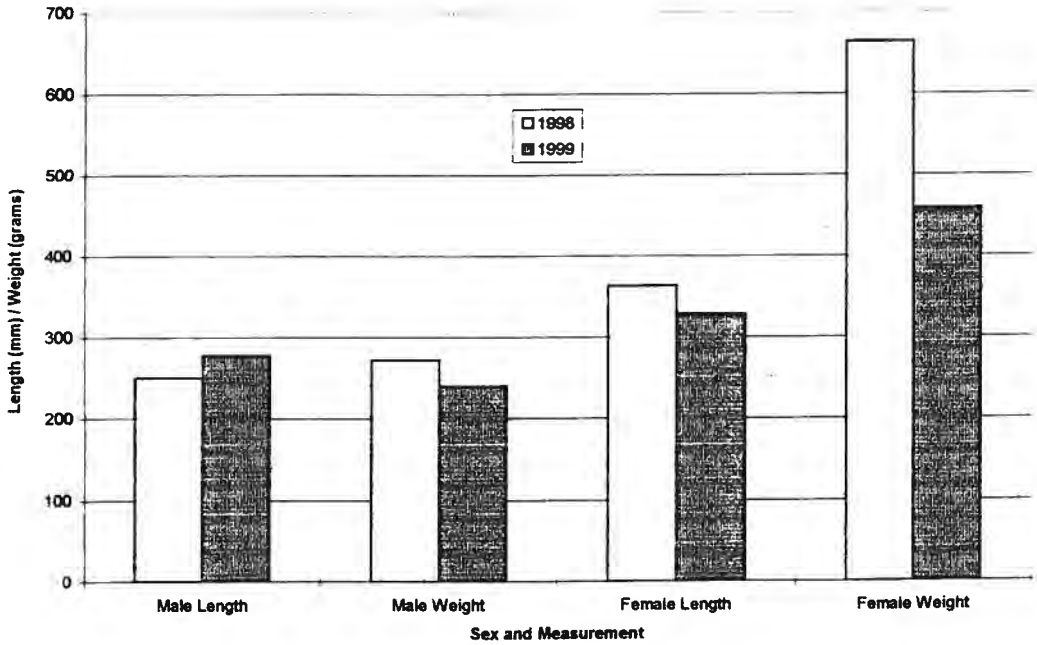
A high incidence of smolt and crayfish were identified in pikeminnow gut contents. Together, crayfish, smolt, and unidentified fish matter were found in 55% of the analyzed stomachs. It is evident that these two items are the main prey source for pikeminnow within the study area, as they were also recorded in abundance during the 1998 research and removal activities (Jerald 1998). A majority (over 90%) of the smolt found in stomach analysis were recorded during the months of May, June, and July. Conversely, a majority of crayfish were recorded during the months of July, August, and September. The stomach content data provides evidence that pikeminnow utilize a predation strategy of feeding on smolt at the Wells tailrace in early spring and dispersing throughout the reservoir to feed on crayfish during the summer months.

Although 1999 marked the highest catch values for any of the DCPUD sponsored pikeminnow removal projects, it should be noted that it took anglers approximately 5 months to capture these 10,096 fish. In 1998 anglers captured 7347 pikeminnow in half that time (approximately 2½ months). During 1999 it took much longer for pikeminnow to recruit back into the heavily fished areas (specifically below Wells dam). This forced anglers to "rest" fishing spots for days or weeks while pikeminnow returned to the heavily fished areas. The inability of the fish population to restock productive habitats is a further indication that the removal efforts are effecting pikeminnow population dynamics.

Initiating removal efforts in the early spring of 1999 was beneficial to angler crews as they could prepare for the peak fishing period in June. This early start date also reduced smolt predation in the Wells tailrace area during the peak spring smolt migration. Catch and CPUE values were consistently high during the early season period. Future removal efforts focused on these productive fishing areas and periods would result in increased catch levels and decreased smolt predation.

Continued evaluation of the pikeminnow fishery from a biological standpoint will be important in determining the effects which removal efforts have on pikeminnow population dynamics in future years. Sub sampled data have already shown physical changes within the makeup of the pikeminnow population. Average weights and lengths for female pikeminnow were smaller in 1999 versus those measurements taken in 1998 (Figure 14). Vigg et al. (1990) suggested that northern pikeminnow population numbers and size (age) structure analysis could predict and quantify the effects of a northern pikeminnow control fishery. A decrease in size and in age structure of a pikeminnow population should result in decreased salmonid predation mortality. Anglers fishing in the immediate Wells tailrace observed this trend. In 1998, a high incidence of large female pikeminnow were caught in that area (this was the first time the intensive fishery had been conducted). In 1999, anglers noticed a marked decrease in the large hens while fishing the tailrace.

Figure 14
Average Lengths and Weights (1998 vs 1999)



A tagging study conducted by DCPUD could quantify the effects of the pikeminnow control fishery. Properly conducted, the study could determine exploitation rates and population estimates within Rocky Reach reservoir and

Wells tailrace. Until recently, an intense tagging study was not economically feasible as typical tagging studies on pikeminnow within the Columbia River system have focused on marking fish using electroshocking boats. This approach also present a problem regarding the inability to obtain an electroshocking scientific collection permit due to endangered species concerns. However, with the recent success experienced using the long line gear, it may be feasible to mark a segment of the pikeminnow population within each mile or section of the reservoir area. This could be accomplished at relatively little cost to the District. Pikeminnow would then be randomly captured during the summer fishery. Chelan PUD has also expressed interest in the evaluation study. A joint study between the two Public Utility Districts would allow for the marking and evaluation of pikeminnow from Chief Joseph Dam to Rock Island Dam, encompassing approximately 92 miles of reservoir area.

Economical assessment of the pikeminnow fishery should also be considered. The most adequate way of evaluating the fishery from an economic standpoint would be to analyze the monetary value of juvenile salmonids saved by the removal efforts. During peak feeding periods one large squawfish is quite capable of consuming 5 or more smolt per day. Anglers participating in the removal efforts commonly observed pikeminnow regurgitating 2 or 3 smolt when landed. Conservatively, it could be estimated that, on average, each pikeminnow caught in 1999 would save .5 smolt per day during the upcoming year 2000 spring and summer smolt migrations. Peak smolt outmigrations generally last 90 days at Wells Dam. Multiplying the 10,382 pikeminnow removed in 1999 by .5 smolt per day by 90 days estimates a total of 467,190 smolt saved. Estimating that each smolt costs .50 cents to raise and release provides a net program value of $233,595.

Recommendations

Continue pikeminnow removal/research efforts in year 2000, contracting on a per-fish incentive basis.

Begin obtaining scientific collection permits, section 10 permits, and contracting agreements in January / February of year 2000 to provide for an early spring start date.

Continued use of sport fishing and long line removal techniques in Wells reservoir and tailrace locations.

Increased long line removal effort within Wells reservoir, possibly paying anglers higher bounty amounts for pikeminnow collected from the less productive fishing location.

Initiate a joint tagging study (Douglas PUD and Chelan PUD) in Wells reservoir, Rocky Reach reservoir, and Rock Island reservoir to determine exploitation rates and population estimates of the pikeminnow fisheries.

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MINUTES OF THE WELLS COORINATING COMMITTEE FOR 1999

APPENDIX I

WELLS COORDINATING COMMITTEE
MEETING SUMMARY
JANUARY 13, 1999

Agreements Reached:

1. **The committee agreed to support Grant PUD's application for a Section 10 Permit for a survival study at Wanapum and Priest Rapids Dams in 1999.**

NOTE: Bob Heinith asked for a short caucus of the Joint Fisheries Parties committee representatives at the beginning of the meeting, prior to the discussion of the 1999 Survival Studies. The meeting reconvened at 10:05 A.M.

I. GENERAL MID-COLUMBIA ISSUES

A. Survival Study Updates

Hammond distributed a paper by John Skalski which details options for survival studies at Priest Rapids and Wanapum in 1999. This matter was discussed at an earlier coordinating committee meeting and Hammond had agreed to present the options developed by Skalski. Hammond reviewed the study design options and explained that Grant PUD was interested in taking advantage of the fish tagged under the survival studies planned by Chelan PUD for Rock Island Dam to assess survival through the Grant PUD projects. In response to Woodin's question concerning the number of tagged fish which would be released at each of the planned release sites, Hammond said 250 would be released at each site along with 20 additional tags that would be released at each site on dead fish. There was discussion concerning the double antenna arrays that would be used and Hammond explained that it isn't important to avoid overlap in detection from the two arrays, what was important was to avoid opportunity for mortality between those arrays. Hammond explained that the proposed survival study would not provide route specific survival estimates like the Chelan PUD study, but they did expect to have project survival blocked by powerhouse and spillway although they did not expect those estimates to be very precise.

Hammond said they have determined that tag could be available for the study although firm orders have not been placed, as yet. Since the proposed study relies on Chelan PUD's tailrace release at Rock Island, Grant PUD feels it is important that the tags and tagging protocol be closely coordinated. An alternative would be for Grant PUD to make their own Rock Island tailrace release. Peven explained the tagging protocol Chelan PUD would be using for the survival study. The fish will be tagged and placed on the release barges where they will be held 40 to 48 hours before release.

Hammond said what he needed today was support from the committee for going ahead with a survival study at Priest Rapids and Wanapum, in which case they will go ahead and order the necessary tags and develop an application for a Section 10 Permit. At the same time they will instruct John Skalski to complete and finalize the study design for committee review.
Woodin asked if aerial antennas would be adequate for the tag detection required. Peven assured him that, based on previous information developed at Rock Island and Rocky Reach, he is

confident that aerial antennas are more than adequate. Hammond said their previous experience with radio tag studies at Wanapum indicate the aerial antennas will be adequate. Woodin remarked that maybe, with the addition of underwater antennas, they could get close to 100% detection. Hammond said they don't have enough detection equipment to add underwater antennas. The committee felt that, given the importance of Wanapum detection to the Chelan PUD survival study, effort should be made to acquire additional receivers from the Corps of Engineers to allow as high a detection rate at Wanapum as is possible.

Brown asked why PIT tag studies were included in the Skalski paper on study design options, to which Hammond responded that this grew from HCP discussions and was included in the paper Grant PUD had asked Skalski to prepare. Dach asked if it wouldn't be worth considering using PIT tags in the Grant study along with radio tags to ensure that usable survival data would be available following the 1999 season. He said that NMFS would look at telemetry survival results with skepticism until all of the protocol assumptions have been substantiated. Peven pointed out that Chelan and Douglas PUDs are both including PIT tags and radio tags in their studies. Dach pointed out that the Corps of Engineers is also planning to conduct comparative PIT and radio tag studies in 1999 and they hope to have a suite of studies to review at the conclusion of these studies to assess the efficacy of radio tag use for survival studies.

Following the discussion the committee agreed to support Grant PUD's application for a Section 10 Permit for a steelhead survival study at Wanapum and Priest Rapids in 1999.

Peven reviewed the protocol to be used for the Rocky Reach and Rock Island survival study in 1999. He said they will be taking fish from a common source, the Rocky Reach juvenile collection sampling facility, or the hatchery to three separate tagging locations. The fish will be tagged directly into holding vessels on the barges at the release sites. The radio tagged fish will be held in five gallon buckets prior to release. Peven said the major change in the study plans since the November meeting was their decision to develop route specific survival data at Rock Island. This will not require additional tag releases but will make maximum use of the detection equipment installed. Peven clarified the fish handling protocol and explained that all the hatchery steelhead, which will be used primarily for the PIT tag portion of the study, are on Turtle Rock and will be moved from that location to the three tagging sites.

Bickford reviewed the status of the 1999 Wells survival study. He reported that the Section 10 Permit has been published in the Federal Register and should be issued within 30 days. This application was considered a modification of the existing research permit and as such has a shorter time frame for approval.

Bickford reported that additional holding/release vessels were being acquired for the study. They have also held several coordination meetings with the Wells Hatchery personnel. Brown asked how many fish they could handle at a time. Bickford said fish for each replicate release group would be transported to a raceway where they would be held a day prior to moving to the tagging trailers. Following tagging, the fish will be held in the release vessels for up to 40 hours at the hatchery before they are transported to the release sites and loaded onto the release barges.

Heinith asked for an extension of time for comment on the report Survival Estimates of the Passage of Juvenile Chinook Through Rocky Reach and Rock Island in 1998. Dach also requested an extension of time for comment. The committee agreed to extend the period for comment on the report to the date of the next coordinating committee meeting, which will be February 10.

B. Adult Steelhead Radio Telemetry Study

Hays discussed some logistical problems the PUDs had identified that could effect the number of adult steelhead that would be available to tag in 1999 and compromise the assessment of steelhead passage at Wells Dam. The PUDs desire to minimize the impact of adult steelhead trapping at Priest Rapids on adult passage. Given the long lead time necessary to secure a new Section 10 Permit, as opposed to modification of an existing permit, it appears that it would be desirable to attach this study to an existing permit. Part of the problem relates to the steelhead run timing, which has few fish moving early or late in the run, and a limit on the number of fish that can be tagged in a given day during peaks in the run. Brown said it appears NMFS would like to amend the WDF&W Section 10 Permit to cover this study but in that case, WDF&W would be expected to assume liability for the study and he doubts that his agency would be willing to do that. The committee discussed ways that the WDF&W permit could be modified to allow the study to proceed under terms that would be acceptable to WDF&W. One possibility would be for the WDF&W to conduct the study under contract to the PUDs. Brown said he would check with his agency to see what kind of arrangements might be made that would allow the study to proceed in 1999 including modification of the existing WDF&W Section 10 Permit.

Hays said they have been in contact with LOTEK for tags for the study and are confident that tags will be available even though a purchase order has not been issued, as yet.
Dach said he would like to see adult steelhead passage at Priest Rapids Dam included in the study. This would require transportation, of fish collected and tagged at Priest Rapids, downstream of Priest Rapids for release. Hammond pointed out that spring chinook trapped at Priest Rapids for radio tag studies in the past have included Snake River "overshoots" which are more likely to contribute to "fall back" at Priest Rapids.

Brown asked if the Section 10 Permit for the adult steelhead radio tag study is not included in a modified WDF&W Permit, could the study still go ahead as planned. Hays said there probably would not be enough time to secure a new Section 10 Permit. He went on to say that he feels the PUDs would be more comfortable with a responsible fishery agency conducting the study because of overall fish passage implications.

Dach asked if there would be separate steelhead adult radio telemetry study proposals developed by each PUD. The answer was yes. Dach pointed out that the overall study plan refers to comparison of steelhead passage with previous information on other species. He said he was uncomfortable with that kind of comparison. There was discussion concerning how steelhead passage would be evaluated and what criteria would be used. Hays pointed out that these studies were passage optimization studies.

It was pointed out that there were three issues to consider at this meeting. These were:

1. Would passage into the tributaries be monitored by the PUDs?
2. What trap modifications were necessary for completion before trapping begins?
3. How would high water temperature be dealt with during the trapping period?

Brown said he feels that since the fish are going to be tagged they should be monitored onto the spawning grounds. Bickford pointed out that aerial flights are the best method to determine the location of the tagged fish on the spawning grounds. The PUD representatives agreed to discuss the monitoring question and to report back to the committee at the next meeting with a proposed schedule or plan for monitoring tagged fish in the mid-Columbia tributaries.

Hammond reported that people had been meeting on the adequacy of the Priest Rapids adult trap and what kinds of things might be done to make the trap operation more reliable. They

also considered what kinds of improvements might be made in the long-term to upgrade the trap. Hammond said he needs to know what should be scheduled for a fish ladder outage on the left bank ladder to install necessary improvements. The month of March has been identified as the window for trap modification. Woodin said it would be preferable to extend the current outage to accomplish the modifications rather than having a second outage in March. Hammond pointed out that there are certain lead times that are necessary and he isn't sure those could be met in time to extend the current shut-down. Hammond said Brown had previously submitted an extensive list of possible trap modifications and these have been discussed with Chelan and Douglas PUDs for possible shared funding of the improvements. No decisions have been made in this regard. Hammond said the decision that the committee needs to make is support for the ladder outage to make the improvements this spring. The committee expressed a desire to see the work done as early in the year as possible and with the shortest ladder shut-down necessary. Hammond said this issue will be discussed at the next Detail Fisheries Operations Plan meeting at Wanapum Dam on January 20. This issue will be placed on the agenda for the February 10 coordinating committee meeting.

The committee discussed the problem that could be encountered with water temperatures during trap operation. It was reported that water temperatures during the steelhead passage period in 1998 were higher than normal. Concerns were expressed regarding trapping of adult steelhead if there was a re-occurrence of high water temperatures in 1999. The committee felt that the matter could be left to the discretion of Brown who will have direct responsibility for developing Priest Rapids adult trap operation criteria for the steelhead trapping period.

C. Interim Protection Plan Consultations

Hevlin reported that NMFS hopes to have the Interim Protection Plans completed by March. He said they are waiting for a Biological Assessment from FERC on the Grant IPP and the biological analysis of spring chinook from Chelan and Douglas PUDs. Hevlin suggested a meeting with the mid-Columbia PUDs (informal consultations) should be scheduled for February. It was suggested that this could be tacked on to a Quantitative Analytical Report meeting scheduled in conjunction with the next coordinating committee meeting on February 10. The committee agreed to meet from 3 PM to 5 PM on February 9 at the West Coast Sea/Tac Hotel.

D. Spring Chinook Captive Brood Stock Program Update

Hammond showed slides of the AquaSeed facilities at Rochester which were set up to accommodate the mid-Columbia spring chinook captive brood program. He also distributed a set of tables detailing the results of the first two months of rearing of the captive brood at that station. Hammond said he visits the facility on a monthly basis and invited anyone on the committee to feel free to join him or visit the facility on their own. Heinith asked Hammond what costs Grant PUD had incurred as a result of the captive brood program. Hammond said their administration had set a limit of $350,000 for support of the program through June 1999. Based on the costs to date, Hammond didn't think that budget would be exceeded. He said he had been impressed by the innovative and cost effective approach shown by the people at AquaSeed. Hammond stressed the need for early discussion on the future of the captive brood program since the Grant PUD commitment for funding only runs through June 1999.

II. WELLS DAM

A. Review of Okanogan Sockeye Habitat Study

Klinge reported on the study of Okanogan sockeye habitat in Canada. He stated that they may have a draft report available within a month or two. He said they have about sixteen options to consider which will be discussed in the report. Klinge said the process has included, and actually stresses, close coordination with the various interest groups in Canada. Spawning channels and off-channel spawning/rearing areas are two examples of options being considered. He also said water temperature modification is being considered for review. Klinge went on to say that he hoped to have the contractor, Chris Bull, available to meet with the Wells Coordinating Committee sometime this spring. He said Chris has been working closely with the British Columbia and Canadian governmental agencies and tribal interests and he will solicit their review of the draft report, early on, to make sure what is available to the PUD will not contain objectionable options. Klinge said Douglas PUD has actually contracted with the British Columbia Conservation Foundation for Chris Bull's involvement in the study. Klinge feels the review will be thorough and the intent is to have a list of options, acceptable to the Canadian interests, that can be considered by the Wells Committee, and others, for future Okanogan sockeye enhancement.

B. Cassimer Bar Sockeye Program

Klinge reviewed the background on the decisions made concerning the 1997 brood sockeye currently at the Cassimer Bar Hatchery. He reported that there has been a severe BKD epizootic which has reduced the number of fish down to an anticipated release of about 24,000 fish. These fish are currently running about 10 fish per pound with approximately four months left till release. Klinge said there needs to be serious consideration of what, if anything, should be done concerning the 1999 brood. Heinith expressed the feeling that Marco needs to be present for discussions regarding future plans for Cassimer Bar sockeye operations.

C. 1998 Adult Sockeye Radio Tag Study

Heinith asked Bickford to briefly summarize the results of the 1998 sockeye study. Bickford reviewed the information, previously reported to the committee, regarding problems with the tags used for the 1998 study which compromised the collection of data. Apparently the tags used for the study had 5 to 10 percent battery failure so the actual number surviving to the spawning grounds couldn't be accurately estimated. In addition, there was a receiver which malfunctioned at the worst possible time at a key location, Zosel Dam. While preliminary data based on information collected at Zosel looked disastrous, surveys on the spawning grounds confirmed the problem with the receiver at Zosel and it was determined that more fish made it to the spawning grounds than originally indicated. Bickford said the spawning ground surveys and aerial detection of tags accounted for approximately 20 percent of the tagged fish on the spawning grounds. If "bad tags" are considered, about 24 to 27 percent of the fish made it to the spawning grounds. The distribution of tagged and untagged fish on the spawning grounds appeared to be comparable. Fewer fish were observed outside the index areas than was noted in 1997.

The next meeting of the Wells Coordinating Committee will be February 10 at the West Coast Sea/Tac Hotel.

ATTENDANCE LIST

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WELLS COORDINATING COMMITTEE
MEETING SUMMARY
MARCH 15-16, 1999

Agreements Reached:

1. The committee agreed to support the 1999 adult steelhead telemetry study pending modification of the study plan as agreed at the meeting with the understanding that project specific elements of the study would be developed for approval by the committee.

2. The committee approved the spill representatives for Rocky Reach, Rock Island, Wanapum and Priest Rapids.

3. The committee approved the juvenile bypass representatives for Wells Dam for 1999.

I. GENERAL MID-COLUMBIA ISSUES

A. 1999 Survival Studies

Bickford gave a status report on the Wells Survival Study. He said they have received the PIT tags and radio tags and the radio tag receivers have been tested for Y2K compliance. Douglas PUD is working with Chelan PUD on PIT tag detection provisions at Rocky Reach. Woodin asked when the first tags would be released. Bickford said the first fish would be collected on April 9 with releases scheduled to begin on April 15 for PIT tagged fish and April 20 for radio-tagged fish.

Bickford gave a run-down on the status of their Section 10 Permit process. His contact with NMFS indicated the permit would be issued by the end of March. Hammond said he had heard from NMFS that the Permits would be combined and issued with the Biological Opinion in late April. There was discussion concerning what options would be available if the Permits are not received prior to the scheduled start of the study. No conclusions were reached.

McDonald reported on the status of the Chelan Survival Study. He said the first releases would be made April 28 at the Wells tailrace site with a two day lag between the Wells tailrace releases and the releases in the Rocky Reach tailrace with the Rock Island releases following one day later. McDonald reported there were challenges faced in developing the Rock Island tagging site and access to the barge below Rock Island. These challenges were being worked out and they were making progress.

McDonald said the Rock Island survival study will start with the collection of fish at Turtle Rock Ponds on April 10, tagging on April 12, and release on April 14. For the Rocky Reach study, the run-of-the-river component will be taken from the sampling facility at the Rocky Reach juvenile bypass. The first fish collections for tagging will be April 25, tagging will commence on April 26, and the first release scheduled for April 28. McDonald said the run-of-the-river fish will be released in the afternoon at the same time every release day. Dach asked how a twenty-four hour bias would be dealt with if all the releases were made at the same time of day. Peven responded by saying they will be comparing the fish released under the Chelan study with the fish released under the Wells study which, coming from further upstream will undoubtedly be passing Rocky Reach and Rock Island around the clock. Peven went on to

explain the logistical difficulties associated with the survival studies at Rocky Reach and Rock Island. He said they feel it would be extremely difficult to try to accommodate releases over a twenty-four hour period during the study. Dach raised concerns regarding the possibility of fish passing Rocky Reach or Rock Island at one time of the day and applying that result to 24 hour passage. This may or may not be valid, Dach said. It was pointed out that this concern could be addressed in the discussion of the data or assumptions in the report that will be prepared.

Dach expressed concern regarding the differences between run-of-the-river fish and hatchery fish in relation to how they might pass the projects. Peven said this has been discussed extensively in the past. There doesn't appear to be any way of determining what group of fish most adequately reflect run-of-the-river fish. Dach said he is concerned that the run-of-the-river fish, collected in the surface collector at Rocky Reach, and the hatchery fish that will be tagged, may not reflect what true run-of-the-river fish may do. He acknowledged that the protocol appears to be adequate for detection of tags at Rock Island but he feels this is questionable for detection at Rocky Reach. Dach said he isn't sure that the comparison to Wells study fish detection at Rocky Reach is adequate to address his concerns. He said it remains to be seen whether or not his concerns can be alleviated by use of tagged fish released for the Wells study. Dach said he is concerned that the fish being used may produce biased results. He said he expects these questions will be addressed in the final report.

McDonald reported on preparations for the collection of fish leaving the Turtle Rock Ponds volitionally. He expressed concerns regarding how fish will move out of the ponds to be available for tagging. If they don't move out at a rate that meets tagging requirements, this could effect the conduct of the study. The committee discussed the disadvantages of varying tag release numbers and any operations that would have the potential of introducing bias in fish quality such as drawing down the pond level to induce migration or physically netting the fish out of the pond. McDonald said he feels the best solution for dealing with the problem, if volitional movement out of the rearing ponds is inadequate, would be to use a seine to move fish toward the exit of the pond.

McDonald reported on arrangements being made for releases of tagged fish in the Rock Island tailrace. There has been close coordination between Chelan and Grant PUD's for the release of tagged fish in the Rock Island tailrace. These fish will be used as the test fish for the Wanapum and Priest Rapids survival studies as well as control fish for the Rock Island study. McDonald said all tagged fish will be held in river water and will have oxygen added to the holding vessels rather than compressed air which was used during the 1998 study. A crew will be monitoring the tagged fish while they are being held, 24 hours per day, seven days a week during the entire study. Care will be taken to handle each release group as close to identically as possible in terms of holding period, release times, transport distance, etc.

Hammond reported on the status of the Wanapum and Priest Rapids Survival Study. He said they are in the process of acquiring and installing equipment. The first Wanapum tailrace release will be two days following the Rock Island tailrace release with the first Priest Rapids release one day later. The fish for the Wanapum tailrace release will come from the Wanapum gatewells and the Priest Rapids fish will come from the Priest Rapids gatewells. Woodin suggested that Grant PUD consider holding fish for a day prior to tagging to cover the possibility that the gatewell dipping operation will be shut down due to high winds. Hammond said their study protocol called for fish to be held one day after collection before tagging and then for the fish to be held two additional days before release. He said they are expecting to find a window of

time each day to dip the small number of fish needed for tagging. If they miss a gatewell dipping day it would throw the schedule off so they will make every effort feasible to dip the required number of fish each day.

Dach raised a question concerning the ability to assess the effect of 80% spill at Priest Rapids on juvenile migrants. Hammond said he had talked to Giorgi and Stevenson regarding the availability and timing of data that would be available to assess 80% spill relative to survival. Hammond said there will be regular reporting of what is being observed. It was recognized that telemetry is an unproven survival assessment tool but it should indicate whether high mortality is taking place relative to the 80% spill. Hammond said it would be desirable to have a pre-determined plan for how an in-season adjustment in spill might be made based on in-season assessment of the telemetry study. He went on to say that the "trigger" for in-season adjustment of spill should be included in the NMFS Biological Opinion. Dach said it may be more appropriate to use indicators of survival rather than survival estimates in-season. He said he would be reluctant to have a survival level included in the Biological Opinion.

B. Adult Steelhead Telemetry Study

The chairman reported on his conversation with Heinith who was unable to be at the meeting. Heinith left a list of three issues relating to the adult steelhead telemetry study which he asked to be considered by the committee. These items were;

1) Adequacy of the survey effort on the spawning grounds including distribution of fish and egg retention.
2) Installation of additional receivers in problem areas at the adult passage facilities at the dams such as junction pools, etc.
3) Installation of instrumentation to measure hydraulics at the passage facilities, especially in problem areas.

There was some uncertainty regarding Heinith's interest in determining egg retention. The committee acknowledged that recovery of radio tagged steelhead would be improved over recovery of untagged fish but, since these fish will be spawning during the spring freshet, any carcass recovery would be questionable at best. Brown suggested that egg retention could be addressed by looking at radio tagged fish collected for brood stock. Woodin said that the question could also addressed indirectly by observing the location of tagged fish in the tributaries.

The PUD representatives feel the provisions made for assessing ladder passage will address the suspected problem areas in the passage facilities at each project.

The interest in instrumentation to measure hydraulics in the passage systems was discussed by the committee. A suggestion was made by Woodin that there be a commitment to revisit the hydraulic information available on suspected problem areas at each of the projects in the mid-Columbia.

Brown distributed a memo responding to the latest draft study plan dated February 24. He provided additional comments on the study plan from the perspective of WDF&W who have been asked to assume responsibility for study and to include the study under the WDF&W Section 10 Permit. He said he feels strongly that before the WDF&W assumes responsibility for the study they should feel confident that the study will be as productive and meaningful as possible. He feels there is a lack of commitment to the level of monitoring of tagged fish beyond passage at individual projects. Brown reviewed the specific comments included in his memo dated March 12 and pointed out what he feels are shortcomings in the February 24, 1999 study

plan. He stated that without a commitment to address the shortcomings contained in his memo, WDF&W should not take on responsibility for the study or cover it under their Section 10 Permit. Peven stated that it was his understanding that the PUD's had previously agreed to aerial surveys of distribution in the tributaries and it was his opinion that monthly aerial surveys would be appropriate. The committee discussed the use of fixed monitors at the mouths of the four major tributaries and aerial surveys of the tributaries and the main stem Columbia from below Priest Rapids Dam to Chief Joseph Dam. Bickford suggested two aerial flights per month as an alternative to extended use of fixed monitors. The committee agreed that fixed monitors should be used through November with aerial surveys beginning with one flight in November, continuing with two flights per month through June, unless there is reason to terminate the aerial surveys earlier. The aerial surveys will include the main stem Columbia from below Priest Rapids to Chief Joseph Dam. The committee agreed to support the adult steelhead telemetry study pending modification of the study design reflecting the understanding reached on the acceptable level of monitoring. It was recognized that the project specific passage elements of the study still need to be developed and the committee will consider those plans as they are developed.

C. Report on Governors Salmon Recovery Board

Bob Bugert gave the committee a report on the establishment of a Salmon Recovery Board by the Washington Governors office. This board was given the task of coordinating recovery efforts on threatened and endangered salmon species in the State of Washington. They have established a three step process involving statewide, regional, and individual watershed activities. The board has divided the state into seven regions based upon ESU and threatened and endangered listings. There are six or seven watersheds within the upper-Columbia region. Bugert said in referring to salmon, he is including both anadromous and resident species. It has been proposed that there be a salmon recovery board established for the upper-Columbia region which would be made up of federal, state, tribal, and local governments and watershed councils. They have been contacting the various entities concerning participation and have received favorable response. Hammond pointed out that Grant PUD was not included in the list of local government entities and said it is likely that Grant PUD will be asked to fund some of the measures which might be identified for implementation. He asked if Grant PUD participation in the process could be accommodated, to which Bugert responded yes. Bugert said Hammond could be helpful in having Grant PUD participation considered.

It was pointed out that the areas designated for upper-Columbia and middle-Columbia do not follow the ESU for upper-Columbia listed steelhead. Bugert explained that the Regional Recovery Boards were the ones who established the areas shown on the map of the salmon recovery regions and these were in somewhat of a state-of-flux.

Ward asked about the legislative provisions for moving ahead with the activities Bugert discussed. Bugert said that legislation has been introduced in the current legislative session. He said it is probably too late in the session for passage in 1999. He is confident, however, that there will be legislation passed in the future.

Bugert stated that the Governors strategy is that local entities can get the job of salmon recovery done more effectively that the federal government. He pointed out the need to have the local governmental entities "buy into" the process to make it effective. The establishment of the recovery boards are a way to bring local governmental entities into the process.

Bugert said that the recovery board is planning to develop Habitat Conservation Plans for each of the counties in the upper-Columbia recovery region which would have common formats and protection elements along with county specific elements. He pointed out that recovery boards receive statutory authority since they would be the HCP applicants. If not, counties or municipalities could be the applicants. Bugert said the advisory boards would also have an advisory role to the other H's, i.e. Hatcheries, Harvest, and Hydropower. Bugert said he would keep the coordinating committee informed on progress toward meeting the expectations of the recovery board process.

D. Brood Stock Protocols

Brown said he would be sending out proposed brood stock protocols for spring chinook, summer chinook, sockeye, and steelhead in the near future. He said the spring chinook escapement estimate is extremely low and it is expected that all spring chinook arriving at Wells Dam will be collected for brood stock.

II. WELLS DAM

A. Okanogan Sockeye-Review of Cassimer Bar Program

Klinge stated the objective of this meeting was to review the history of the Okanogan sockeye program, discuss preliminary plans for the 1999 brood year, and to consider the preliminary findings of the project, funded by Douglas PUD, which is attempting to identify Okanogan sockeye opportunities in the Canadian Okanogan which would receive support from Canadian agencies and tribal interests. He introduced Byron Louis, Okanagan Nations Fisheries Commission and Chris Bull from Glenfir Resources. Klinge distributed a series of tables which had been prepared based on information provided by personnel from the Cassimer Bar Hatchery. He reviewed the history of the program beginning with the 1991brood year which were taken to the Wells Hatchery for holding, spawning, and egg incubation. Beginning with the 1992 brood, the program has based at the Cassimer Bar Hatchery for adult holding, spawning, incubation, and rearing.

Marco reviewed similar information which he had received from Cassimer Bar Hatchery personnel which included additional information on performance standards. He explained the complications surrounding the 1997 brood year program where the fish were initially scheduled for rearing in net pens in Lake Rufus Woods. When the arrangements for net pen rearing fell through, the committee decided to rear the fish to yearling size at Cassimer Bar. This resulted in fish reaching a larger size than would have been expected from a net pen program due to the warmer water temperatures at the hatchery. Marco pointed out that the 1998 brood year survival from green eggs to hatch was lower than experienced previously and appears to mirror green egg to hatch survival for other stocks which may be related to elevated water temperatures during holding. Marco also pointed out the improving adult holding survival of adults over time until the 1998 brood year, which saw survival drop to 53%.

Louis asked Marco about earlier discussion they had concerning the potential move of the net pen rearing program from the south basin of Lake Osoyoos to the north basin. He called attention to a letter that had been sent from his organization to the coordinating committee regarding their support for such a move. Bickford pointed out that letters had also been received from the Federal/Provincial transplant committee opposing transfer of adults, eggs, fingerlings, or smolts across the border into Canada.

Marco reported that the Colville Tribe had sponsored a proposal for risk assessment of the reintroduction of sockeye in Skaha Lake under the Power Council's Fish and Wildlife Program. He explained that the proposal needs to be reviewed by several entities before it could receive funding. He said Phase I would be a risk assessment. He stated there are similarities between Skaha Lake and Lake Okanagan, such as the presence of Mysis shrimp, so they would expect results of a Skaha evaluation to also apply to Okanagan Lake.

Klinge reviewed the results of outmigration sampling for the four years fish were actually released into Lake Osoyoos. The percentage of marked juveniles collected in outmigration sampling was 3.2%, 0.52%, 14.5%, and 0.0% for the 1994, 1995, 1996, and 1997 brood years He went on to review the results of CRITFC sampling at Bonneville Dam for 1995 through 1998, carcass sampling from spawning ground surveys on the Okanagan River above Lake Osoyoos, and other sampling done at Tumwater Dam. Very few fin clipped adult sockeye were recovered in these sampling efforts. Klinge said there were other potential sources of information on adult returns such as the fishery at Chief Joseph Dam tailrace and the gill net fishery in the Okanogan River. Marco said few sockeye are taken in the Chief Joseph fishery and the managed gill net fishery in the Okanogan River has only operated in the last three years. No fin-clipped adults have been reported in the gill net fishery.

Cates said he was expecting John Morrison, USFWS pathologist, to come to this meeting to report on his observations on the Cassimer Bar sockeye program.

B. Review of Possible Sockeye Measures in British Columbia

Klinge introduced Chris Bull, Douglas PUD contractor, who is working on a study to identify ways to protect and improve sockeye habitat and or production in the Canadian Okanagan River Basin. Klinge explained that the PUD was expecting the study to identify measures that could be taken for Okanagan sockeye in Canada that would have the support of Canadian interests. Bull gave the committee an historical overview of Okanagan sockeye habitat and the present and historical range. He pointed out the habitat modification that had taken place in the Okanagan basin over time. Sockeye access to areas upstream of McIntyre Dam has been restricted since the early 1920's. Bull reviewed the remaining natural river area available to sockeye spawning and pointed out that the majority of this area is tribal land. He said his study team believes the most important consideration should be protection of existing habitat. Bull displayed a chart showing ownership of the remaining critical habitat. He pointed out a critical area where private land encroaches on the river. He stated that opportunities exist for purchase or otherwise put into place measures to protect the remaining natural areas from further encroachment. Bull identified several sockeye measures which his study team had looked at. These included:

- Restoration of the channeled portion of the Okanagan River above Osoyoos Lake by breaching the dike in selected areas.
- Restoration of the channeled portion of the Okanagan River above Osoyoos Lake by modifying the dike.
- Construction of a spawning channel.
- Natural ground water channel development.

The committee also discussed other issues associated with Okanagan sockeye production including the status of water rights in British Columbia, the carrying capacity of Osoyoos Lake, organic loading of the system, and Osoyoos Lake water temperature.

Byron Louis explained the relationship of the Okanagan Bands and the Provincial Government regarding fisheries issues as a result of the Sparrow Decision (similar to the Boldt Decision in the U.S.). He reviewed recent discussions between the Bands and the Province and decisions concerning possible reintroduction of sockeye into Skaha Lake. The committee discussed the Okanagan Technical Working Group and acknowledged that this group could be instrumental in providing guidance for further consideration of sockeye measures in British Columbia. Klinge reported that he had attended a meeting of this group in Kamloops, B.C. earlier in the year. He said it was his opinion that there appeared to be some commitment from the Canadian agencies to work cooperatively to look at what kinds of activities might receive support from those agencies.

C. Moving from a U.S. to a Canadian based sockeye program

Klinge said Douglas PUD is interested in having discussion regarding how the PUD's responsibilities might be viewed if the sockeye program is moved north of the border. He said Douglas PUD is hoping to have a list of measures, supportable by the Canadian parties, available as early as May of this year. He said at this point the PUD isn't interested in long-term monitoring of implementable habitat type measures in British Columbia. Klinge said if a list of measures are received, say by May, the PUD is prepared to move quickly toward implementation. What would be necessary would be agreement among committee members on how the existing Douglas PUD compensation program could be converted from a poundage based program to a protection based responsibility. Louis said his people would like to keep the issue out of the Pacific Salmon Treaty forum since he questions whether, in that forum, any measures would likely be implemented.

Heinith asked if Douglas PUD is looking at sockeye responsibilities under the Wells Settlement Agreement or the HCP. He said he feels Douglas PUD has sockeye responsibilities beyond the effects of the Wells Project on juveniles. Adult losses between Wells Dam and the spawning grounds is, in part, effected by the Wells Project. Klinge said Douglas PUD is looking beyond the responsibilities for sockeye compensation provided in the settlement agreement and recognizes there may be some responsibility beyond juvenile migration.

Woodin asked Klinge if he had talked to Chelan PUD about participation in measures which might be possible above the U.S. - Canada border. Bickford said Chelan PUD is aware of the work that Chris Bull is doing for Douglas but they are probably not ready, at this time, to be actively involved.

Woodin pointed out that a major shift in what sockeye measures are being considered could have a major effect on the HCP agreement. He suggested that these measures should be considered right away since the EIS is being prepared and meetings will be held. Klinge explained that Phase II of Bull's effort would be to look at acceptable measures in more detail. Klinge went on to say that he is hoping for some communication from the Okanagan Technical Work Group on which measures identified in Phase I would be considered acceptable by the Canadian interests. It is recognized that there would have to be further discussion, in the Wells Committee, of any measures deemed supportable by the Canadian interests. Klinge said that, ultimately, the Douglas PUD Commission would have to approve funding for any measures agreed upon by the Wells Committee.

There was discussion of the potential of production measures, i.e. egg boxes, net pens, etc. in the Phase I report. Klinge and Bickford said they were reluctant to include those types of measures in the Phase I report based on previous discussion with Federal and Provincial agencies

and the feeling that those entities may back away from the Phase I identification of acceptable options in Canada. There was interest on the committee to not preclude considerations of production measures.

D. Preliminary plans for the 1999 brood year.

The committee discussed the options for the 1999 brood year and decided to put off determination of brood stock collection plans until a later meeting.

E. Plans for the 1998 brood fish.

Klinge said he feels the best option for 1998 brood fish, currently being reared at the Cassimer Bar Hatchery, would be to release the fish in the Wells Reservoir in May 1999. Marco suggested that the fish be held for yearling release using net pens in the upper end of the Wells Reservoir. He said they could hold fish at Cassimer Bar Hatchery until conditions were suitable in the Wells Reservoir in terms of total dissolved gas, water temperature, etc. No consensus was reached regarding disposition of the 1998 brood fish.

F. Wells Bypass Operation for and Bypass Representatives for 1999

Klinge reviewed the operating plans for the Wells Juvenile Bypass including the hydroacoustic monitoring of run timing. The monitoring effort is not expected to change from the last several years and will consist four single beam transducers in the forebay which will provide an index of run timing to guide bypass operations. Dach expressed concerns regarding the hydroacoustic monitoring and the possibility that the information could be misused in the future. He agreed that the data collected could denote the presence or absence of fish as needed to trigger the start or end of bypass operations. Aside from this use Dach said he didn't feel there was a need to collect information inseason. Dach said his "specific concern was that fish milling behavior in the forebay could lead to multiple counts giving unreliable estimates of the population and passage behaviors(i.e. spatial distribution)". Klinge explained that the inseason data is not used for any other purpose and he said he didn't see that it would be a problem and that there was value in maintaining a consistent data base over time. Dach said he would prefer to see the single beam transducers replaced with split or multi-beam transducers if Douglas PUD continues to collect inseason data. Klinge said transducers would not be change in 1999.

Klinge said it was time to appoint bypass representatives for the Wells Bypass for the 1999 juvenile migration. The committee agreed to appoint Marco, Cates, and Klinge as bypass representatives for the 1999 juvenile migration.

There will be no Wells Coordinating Committee meeting in April. The next meeting of the committee will be May 11-13 and will include tours of project activities and a possible meeting with Canadian entities interested in Okanogan sockeye.

ATTENDANCE LIST

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WELLS COORDINATING COMMITTEE
MEETING SUMMARY
MAY 12, 1999

Agreements Reached:

I. GENERAL MID-COLUMBIA ISSUES

A. Proposed 1999 Brood Stock Protocol

Brown reviewed the status of spring chinook passage at Bonneville Dam. The run has exceeded the projected number for Bonneville and has passed 30 thousand through May 6. Spring chinook passage at Priest is over 1000 fish and over 100 have passed Rock Island. Brown said he expects the number reaching Wells Dam will be no more than 140 fish. According to provisions in the HCP, the entire run will be collected at Wells Dam when the run is this small.

Brown said he expects Icicle Creek to account for approximately 90% of the mid-Columbia spring chinook run. He said the biggest question that needs to be addressed at this time, is what to do about the Chiwawa River run. He said he predicts 100 naturally produced and 40 hatchery fish returning to the Chiwawa this year. In the past, several different protocols have been used. Woodin said Craig Busack, WDF&W geneticist, feels there is a risk of having inadequate population size in both the natural and hatchery populations if the wrong protocol is chosen. Burnheisel remarked that in the Methow River in 1996, the decision was made to collect all the fish for hatchery brood stock. He pointed out that the results, over the last several years, fail to show an advantage in taking fish into the hatchery compared to leaving them to spawn naturally. He said the protocol calling for all the fish to go to the hatchery when the expected population is below a certain level, may be flawed. He said he is asking that the committee be open to rejecting that philosophy if the results in the future fail to show an advantage of hatchery rearing over natural production. A one to one adult to return ratio should be achieved to continue the present practice of taking all of the fish into the hatchery when the run size is below a certain level. Klinge said Bernheisel's points were well taken, however, he feels at this point in time with the run expected to be as low as projected, we should take our best shot at making the most of the few fish returning. Brown pointed out that the HCP deliberations resulted in agreement to intervene when numbers are as low as projected. Woodin suggested trying to trap fish at the Chiwawa weir seven days a week, retaining half the fish and releasing the other half upstream of the weir. Brown pointed out that the NMFS Biological Opinion restricts brood stock collection to no more than one third of the escapement. Brown said if there aren't 20 fish in the hatchery by August 8, all the fish should be released to the wild above the weir. A bare minimum population for hatchery production is about a dozen pairs. Hays said, from Chelan PUD's perspective, he would support a one to two trapping effort with evaluation in mid-July concerning whether the fish should be released to the wild or not. Heinith said from the Tribes' perspective, he would opt for 100% collection. Hays pointed out that 100% collection is not possible at the Chiwawa weir. Brown remarked that he doubts that a Section 10 Permit will be received in time to determine any changes from the draft Biological Opinion. The draft BO includes three options for

consideration by the coordinating committee. The committee acknowledged the continuing conflict between the tribal and agency position concerning the policy to be followed in spring chinook management on the Wenatchee River. This conflict has been evident in the U.S. vs. Oregon proceeding and was argued in the mid-Columbia HCP discussions. In spite of the ongoing disagreement over Wenatchee River spring chinook management, the suggested operation of the Chiwawa weir to collect up to one half the returning adult spring chinook, with evaluation in mid-season, is expected to be followed.

B. Survival Study Updates

Hammond said the last release of radio tagged steelhead at Priest Rapids and Wanapum Dams will be Thursday, May 13. He said Grant PUD would continue to monitor for radio tags as long as tags are being detected at those projects.

McDonald reviewed the status of the run-of-the-river and hatchery components of the Chelan PUD survival studies. The releases have, for the most part, gone according to schedule with few problems. They have used a seine in the rearing pond at Turtle Rock to move fish toward the outlet pipe and estimate the number of fish exiting into the trap for removal to the tagging site.

Klinge reported that the last release of the radio tag portion of the Wells survival study was completed on Monday, May 10. This week they are making the thirteenth of fifteen releases of PIT tagged fish for that portion of the survival study. They have reports of detection of PIT tagged Wells survival study fish all the way down the Columbia River system to Bonneville Dam.

Dach asked if PUD radio tags were being detected at Corps of Engineer projects. Hammond said the Corps isn't set up to monitor the frequencies used in the PUD radio tag studies. In addition, the battery life on the radio tags is quite short and it is doubtful that the tags would still be functional when they reached the Corps projects.

Peven reported that Chelan PUD is experiencing very little pre-release mortality or tag shedding on the PIT tagged steelhead this year. He said this had been a problem in 1998 and they appear to have overcome the problem this year.

C. Adult Steelhead Telemetry Study

Hammond said he would like to have a representative of each of the parties on the committee at Priest Rapids sometime in May to review procedures and equipment that will be use for the adult steelhead telemetry study. The committee set Tuesday, May 25, 1999 as the date for review of facilities and procedures to be used. The meeting will begin at 9:30 AM. Bob Dach said he would notify Rudy Ring, from the University of Idaho, about the meeting and try to have him present. Hammond reported that tagging will commence on July 13.

Brown said the Section 10 Permit process is running but he isn't sure when the permit will be received. This is the third revision to the Section 10 Permit WDF&W previously applied for.

Heinith asked about project specific study plan. Dach said he had received a study plan from Chelan PUD but not from Douglas or Grant PUD's. Hammond reviewed the project specific provisions that will be in their study plan. Brown reviewed the previously discussed provisions being made for monitoring tagged fish in the tributaries and how radio-tagged fish collected for brood stock can be monitored for success of spawning and egg retention compared

to untagged population. Brown said as long as monitoring continues to June, there will be some assessment of kelts following spawning.

D. Chief Joseph Spill Study

Dach reported on the Corps of Engineers spill study planned for Chief Joseph Dam beginning in late May. There will be two days of evaluation of TDG at various spill levels followed by a two day assessment period before the final two days of TDG evaluation. There will be two hours of spill followed by two hours of no spill for each test. The Corps will monitor movement of the TDG plume through the Wells Reservoir. The Department of Ecology has been notified of the tests and the Corps will attempt to restrict the TDG at the Wells forebay monitoring site to no more than 120%. The assumptions are that degassing will take place at the Brewster Flat in the upper Wells Reservoir and the Okanogan and Methow Rivers will be discharging high flows and will provide a degree of dilution. If these assumptions are correct, the study should proceed on schedule. The decision will be made on May 25 whether to proceed with the test as scheduled, to modify the test, or to terminate the test. Dach said he feels the test protocol, using two hour test windows and provisions for modification or termination will prevent impact to fish populations. Heinith said he would prefer to see the test conducted at a different time. The committee discussed the schedule for similar tests at Wanapum and Rock Island. Dach said there will be a final coordination conference call, on May 20, to review the TDG, projected flows, etc. If the Chief Joseph forebay TDG is above 125%, the test will not go forward. In addition, there is concern regarding the Rocky Reach forebay TDG.

E. Quantitative Analytical Review(QAR)

Hevlin distributed two documents concerning the QAR analysis needs. He said NMFS needs the analysis for use in the Section 7 consultation process in order to determine that the proposed actions do not appreciably reduce the likelihood of survival and recovery in the wild. He said they are making progress on the QAR process, and at the last meeting they identified three areas of involvement. Sub-groups were formed to cover these three areas of involvement. These were:

The Biological Requirements Sub-Group chaired by Chris Toole
The Data Gathering Sub-Group chaired by Tom Cooney
The Analytical Sub-Group chaired by Tom Cooney

Hevlin said the Analytical Sub-Group will develop a life cycle model but he was quick to point out that this effort will not duplicate what the PATH group worked on and the intent is to simplify the life cycle model. Hevlin went on to explain that the QAR would be used to evaluate proposed actions.

Hevlin said they would like to get Grant PUD involved on one of the sub-groups. He said Bickford would be involved on the Analytical Sub-Group and Peven would be involved on the Data Gathering Sub-Group.

II. WELLS DAM

A. Wells Dam 1996 Adult Spring Chinook Count

Brown explained the need to correct the 1996 Wells Dam adult spring chinook count in the Corps of Engineers data base. He said this is the only instance he is aware of where hatchery brood stock collections have been included in passage numbers. Apparently a decision was made to include the fish collected for brood stock in the passage report for 1996. Brown said it is

important for future uses of the data to make sure that the passage numbers shown have actually passed the project. It was pointed out that people use the Corps data for different purposes. For those using the data for escapement numbers, the way the 1996 spring chinook counts have been recorded indicates there were 400 plus fish that escaped to the spawning areas above Wells Dam when in actuality all of those fish were collected for brood stock. There was no spring chinook escapement above Wells Dam in 1996. Dach said he would contact the Corps and see if the change can be made on the basis of a phone request. If not, Dach will inform the chair as to what will be required and the chair will see that this is done.

B. Wells Dam Spill Study Proposal

Klinge distributed a summary of the Hydroacoustic Index of juvenile salmonid passage at Wells Dam and the juvenile bypass operation for 1999. He also distributed a plan for testing and monitoring spill and total dissolved gas. Klinge explained that the spill/TDG monitoring plan he presented will run for six weeks and will utilize forced spill rather than a fixed volume of spill provided for study purposes. Klinge said he was looking for committee approval to close the side entrances of the fish ladders and approval to deviate from the "crowned spill" pattern at forced spill volumes less than 60 kcfs. Woodin said he wasn't necessarily opposed to the study but would prefer to see more controlled conditions during the study. He suggested using pondage to test more controlled conditions during 12 hour test periods. Feldman said he tended to be in agreement with Woodin on his interest in seeing more controlled test conditions. He said that without careful planning there could be a mish-mash of information that would be difficult to evaluate and which could erroneously drive management decisions. Nordlund will discuss the proposal with Dach and get back to Klinge on their (NMFS) position.

C. Okanogan Sockeye

Klinge reported that the process Douglas PUD has initiated with Canadian entities regarding sockeye activities in British Columbia. He referred to a meeting he had attended in B.C. with Canadian entities discussing what might be done in B.C. for sockeye salmon. They had indicated interest, at that time, in an holistic sockeye approach. Klinge said that progress had been slow in developing actions for sockeye improvements in British Columbia that would have the support of Canadian interests. He said he was hopeful that there will be something to bring to the committee in the next couple of months. Marco said he thinks it will be helpful to distribute the draft Bull report to the committee for review at this time. Klinge said that given the slow progress on the Bull effort, it would be premature to distribute the draft report to the committee. He feels the earliest a report might be available would be the end of June. Feldman observed that we have come a long way in discussion with the Canadians in the past several years. Brown asked where this all leaves us in regard to the 1999 brood year. Woodin said it doesn't appear there will be any Canadian-based program for the 1999 brood.

Marco said he had talked to the First Nations in British Columbia about sockeye activities. He has also talked to the Colville Hatchery people about what might be done with the 1999 brood fish such as net pens in Lake Rufus Woods or Wells Reservoir or a yearling program.

No conclusions were reached at this meeting regarding what to do with the 1999 brood year.

No date was set for the next Wells Coordinating Committee meeting.

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WELLS COORDINATING COMMITTEE
MEETING SUMMARY
June 9, 1999

Agreements Reached:

1. The committee agreed to modify the broodstock collection protocol for Methow River spring chinook by releasing a portion of the fish collected and reducing the collection rate for the remainder of the run.

2. The committee agreed to release the 1998-99 brood sockeye in Lake Osoyoos in the fall.

I. GENERAL MID-COLUMBIA ISSUES

A. Broodstock Collection

Woodin reviewed the status of the upper-Columbia spring chinook run and broodstock collection at Wells Dam. The run is substantially improved over early run projections. Through June 6, 1167 adults and 132 jacks have passed Rocky Reach. The current estimate is for 1200 adults at Rocky Reach of which 65% are expected to reach Wells Dam. The committee had previously agreed to collect 100% of the run at Wells Dam for broodstock. Woodin suggested that since the run is substantially higher than earlier predicted, the committee might want to consider modifying the collection protocol. Woodin reviewed three potential modifications for consideration. These were:

Option A: Continue to collect 100% of the spring chinook run at Wells Dam and separate Carson stock at the time of spawning.

Option B: Continue to hold all collected fish and make a major reduction in the trapping effort at Wells Dam to just two days per week.

Option C: Release to the wild 80 of the fish being held and collect 20 of the estimated 40 fish holding below the trap in the Wells fish ladder. Reduce the trapping effort to three days per week.

Woodin reviewed provisions in the HCP agreement regarding how spring chinook might be managed depending on the number of fish in the run. Heinith asked if WDF&W had a preferred option. Woodin said he would rather not say and wanted the committee to discuss the matter and arrive at a decision. He did say that, before agreeing to option A, there would have to be considerable in-house discussion. Scribner said he would not agree to option A. The committee discussed the advantages and disadvantages of options B and C. Scribner pointed out that it is common in supplementation programs to have more broodstock collected than required. He said if option C is selected, it is important to try to gain information on re-release of broodstock into the wild. Westerhof said he would like to see some of the early fish released. Scribner suggested releasing fewer than eighty fish to the wild. It was pointed out that it is difficult to collect more than about 10% of the carcasses in the wild so the amount of information that could be gained by marking the re-released fish would probably be minimal.

Woodin said there have been no mortalities at the hatchery, to date and the fish are currently healthy. Westerhof mentioned several examples in the Snake River Basin where broodstock had been re-released into the wild. He said he had always been uncomfortable with 100% collection and would like to see fish returned to the wild. Woodin summarized the

discussion and observed that the committee appears to favor a modified option C which would include the following components:

1) Fifty fish will be re-released to the wild.
2) No re-released fish will be marked.
3) The fish currently holding below the trapping facilities, at Wells Dam, will be allowed to proceed upstream
4) The traps will be operated Monday through Wednesday next week. Trapping after that time will be adjusted based on the collection rate.

No opposition to the modified protocol was expressed.

Woodin reported that no fish have been collected at the Chiwawa weir thus far. Cates said that trapping at Leavenworth Hatchery is behind normal due to the cool weather and delayed run-off. Westerhof said they expect to use the coordinating committee for technical discussion related to broodstock protocols which will be included in their Biological Opinion.

Scribner asked for an update on the spring chinook captive brood program. Woodin pointed out that the effort to identify Twisp River fish by elemental analysis has been abandoned. They are currently separating Twisp fish based on return of marked adults from previously trapped known Twisp River fish. Hammond said developmental costs of the captive brood program are about $120,000 with monthly costs of approximately $20,000 for O&M. Grant PUD has agreed to support the program for an additional two years.

There was further discussion on the tribal position regarding the Twisp River spring chinook captive brood program. Scribner said that since the meeting at the Cle Elum Hatchery, there has been further tribal discussion concerning the captive brood program. They remain less than enthusiastic about this program and believe it is contrary to the understanding they feel was arrived at in the HCP discussions concerning Methow spring chinook management. Hammond pointed out that the captive brood program is not related to the HCP but is Grant PUD's attempt to do the "right thing" leading toward their long-term settlement (Biological Opinion or Section 7/10 Permit). Hammond went on to say that it is Grant's intent to pursue programs that have broad regional support.

B. Production Funding Priorities

Scribner raised the issue of the development of production funding priorities outlined in Steve Parker's letter of February 12, 1999. He said his people are interested in seeing this issue move forward in the coordinating committee. Hammond said Grant PUD is also interested in pursuing consideration of this matter. He said it would be helpful to Grant PUD to have the Joint Fisheries Parties come to them to open these discussions, especially if they were able to come to Grant PUD with resolution of some of their differences. Westerhof said there had previously been a meeting scheduled for the JFP's to get together to resolve some of the thorny issues that are still evident in JFP positions. Scribner suggested a meeting of the JFP's on this matter and the committee agreed that July 12, 1999 would be an appropriate date. Westerhof will check on availability of a NMFS conference room and will be the point person in organizing the meeting. Woodin said his understanding is the meeting will focus on Grant PUD compensation measures. Marco expressed some concerns regarding possible "side-deals" that might be made as a result of agreement to proceed with the captive brood program.

C. Update on NMFS Biological Opinion

Dach gave an update on the NMFS Biological Opinion process. He said it isn't their intent to have this process drag out all summer. He said they are especially concerned about having consistency between the BO and the HCP agreements. Heinith pointed out that the BO is supposed to be out before the HCP goes through the ESA process. Dach reviewed the various activities NMFS was involved in concerning the preparation of the BO and processes associated with the HCP. He said their intent was to have the HCP published in the Federal Register by mid-June but they had expected to be able to meet with the tribes to discuss the No Net Impact issue. Since they haven't met with the tribes, as yet, the schedule for publishing the HCP in the Federal Register has slipped.

D. Update on OAR

Hevlin introduced Tom Cooney and Chris Toole and gave a review of progress on the QAR since the last meeting. Toole provided an overview of activities of the Bio-Requirements work-group and said they had been working closely with the NMFS Protected Resources Group. Peven has been providing mid-Columbia information. They have just put out a scoping document QAR Group. Heinith asked if the production levels being considered included provision for tribal harvest. Cooney said harvest would be included in the modeling that his work group will be doing. Peven reported on activities of the data gathering work group. They are attempting to put together spring chinook redd counts and steelhead information for each tributary including wild and hatchery components. He will be reporting to the full committee and Cooney has agreed to supply a summary of how the data gathering group information would be used by the modeling work group. Cooney said they have proposed using a life-cycle model similar to that used in PATH. He explained the general strategy they plan to use in the modeling effort. They will model the effects of the 4 H's on the Wenatchee, Entiat, and Methow Rivers. He said they will not be able to develop the level of detail used in the Snake River evaluation but it will be a similar approach although a simpler analysis. He said his idea is to have a modeling process developed by the end of summer. They won't be able to have all the runs done by that time, however. He said there are other exercises going on (e.g. Forum Process, and NMFS Internal Process) which he hopes the QAR can "piggy-back" on.

Cooney said one of the factors they have to deal with is how to treat background climate or environmental effects in the analysis. In addition they have to determine what survival rates were associated with the adult returns used in the analysis. He said his group will use U.S. vs. Oregon harvest rates in their analysis. One of the questions they will have to address will be can you meet the recovery objectives and have U.S. vs. Oregon harvest rates?

Heinith asked if there would be any independent review of the work group effort. Cooney said that would be a good idea but the timing of such a review might be a problem.

II. WELLS DAM

A. Douglas PUD Adult Steelhead Telemetry Study

Bickford previously distributed a draft Wells Steelhead Telemetry Study Plan. He reviewed previous adult passage studies for chinook and sockeye and said their intent is to proceed with the steelhead study in the same way. The study will involve closing the side entrances. Woodin said he had no suggested changes to the draft plan. Dach said he have a response to Bickford late next week (June 18). Heinith said he would try to have any comments

to all three PUDs on their individual passage study plans before the end of next week. There was discussion of the 1094 Section 10 Permit modification process and Westerhof said they are including a number of actions under this process. There is a question whether this modification will be completed by the time the steelhead telemetry study is scheduled to begin. Hammond suggested a conference call on June 30 to finalize approval on the telemetry studies. The committee agreed.

B. Okanogan Sockeye

Klinge reported that the process Douglas PUD is working on to develop Canadian consensus is not moving along as quickly as they had hoped. He said they are hopeful of having Phase I completed by the end of July. Phase II will follow.

Klinge gave a report on the workshop he had attended in Nanimo, B.C. which was organized by the Department of Fisheries and Oceans for coordination with the First Nations. He pointed out the trans-boundary efforts between the Canadian agencies and the State of Alaska. When Klinge inquired as to how that was possible he was told it was associated with Salmon Treaty actions. Klinge said one thing he heard at this workshop was "stay away from yearling sockeye programs". Cates distributed a memo from John Morrison, USFWS pathologist, which basically said the same thing.

Marco said that following receipt of Morrison's memo they developed a way to deal with a 80,000 fish program if they had three or four rearing vessels so that fish could be segregated according to BKD status. Marco pointed out that the fish last year were not expected, at this time of the year, to be used for a yearling program. This year the fish are much smaller than they were last year.

Klinge said he is of the opinion that the best action to follow is to attempt to release the fish in Lake Osoyoos. If approval can't be achieved to put the fish into the north end of Lake Osoyoos, then he would like to see the fish released in the south basin. Marco said since the fish are about 400 fish per pound now, it might be better to release the fish this fall after the lake cools down. Klinge said he would strongly suggest that the fish be put on a 0-age schedule and plans made to release the fish either immediately or early fall at the latest.

Heinith pointed out that Byron Lewis said all he needed, to pursue Canadian involvement for access for a sockeye program, is a letter from the committee that he could use to solicit support in Canada.

Woodin said he supported the Colville proposal to proceed with a program for the 1998-99 broods with a target of releasing the fish in Lake Osoyoos in October or early November, preferably in the north basin but in the south basin if necessary. The committee agreed to support release of these fish in Lake Osoyoos in the fall.

The next meeting of the Wells Coordinating Committee will be July 14 at Sea/Tac

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WELLS COORDINATING COMMITTEE
MEETING SUMMARY
July 14, 1999

Agreements Reached:
1.

I. GENERAL MID-COLUMBIA ISSUES

A. Adult Steelhead Telemetry Study

Brown reviewed the status of the adult steelhead telemetry study. He said trapping operations actually started about 10:45 AM on July 13. Grant PUD and LGL personnel had previously tested the release process in the Hanford area near Vernita Bridge with the tank truck filled with water. Brown said only two steelhead were trapped the first day and both of these were late in the day after the tagging crew had left. He reported 119 adult chinook and 132 sockeye were trapped the first day. He said they identified several problems with the trap facilities and they will be working with Grant PUD to rectify those problems. Dach said he would like to observe the operation early on and asked when the best time would be to see steelhead being tagged. Brown said the steelhead didn't cooperated yesterday but as we get further into the run there shouldn't be a problem seeing fish. Dach said the first week in August is when he would plan to be there.

B. Production Update

Brown said 291 adult spring chinook were being held at the Methow Hatchery after 50 were release back to the wild as agreed at the June Mid-Columbia Coordinating Committee meeting. Brown said his best estimate of the total spring chinook run past Wells Dam was 649. Brown said some fish have passed Tumwater Dam, on the Wenatchee River, but he didn't have a count. He said WDF&W had put the Chiwawa weir into operation last week but with the weather turned warmer the flows picked up and they weren't able to keep the weir up. He said he wasn't sure if they had been able to trap any fish yet this year.

Westerhof said a problem they are trying to deal with on the Snake River is how to handle the fish that will be returning from the Nez Perce Hatchery releases. The Nez Perce Tribe doesn't want to adipose clip those fish and NMFS is at a loss to know how to deal those fish if they stray into non-target production areas. He said the fish in the Clearwater system seem to be more prone to stray into other streams including streams in the mid-Columbia, e.g. the Methow River.

C. Biological Opinion for Wells Hatchery Steelhead Study, Survival Study, and Steelhead Telemetry Study

Westerhof said the letter of transmittal was signed after review by the NMFS Science Center and attorneys. The draft BO was sent on to the NMFS Headquarters in Washington D.C. The BO will be finalized after Headquarters review.

Westerhof reviewed the steelhead study portion of the modified BO. The sample size requirement for comparison of returns from HxH and HxW parents is 700 fish. These groups were cheek CWT on the right or left side. Bickford expressed concern regarding the potential for operating the adult traps at Wells Dam for longer periods of time in order to reach a 700 fish sample size. There was interest expressed by the committee for finding a better way to mark the fish so that adult trapping and handling could be reduced. Brown said the study is currently set up to run three consecutive years, 1998-2000, with the use of cheek CWT.

Westerhof said the spring chinook BO is still in the developmental process. He said this BO will, hopefully, be finished sometime in 1999. This BO covers the Wenatchee and Methow River captive brood program.

D. Survival Study Updates

Bickford reviewed the 1999 Wells Project steelhead survival study. As of July 5, detection of PIT tags at downstream recovery sites were as follows:

Rocky Reach	22%
McNary	12%
John Day	22%
Bonneville	12%
Estuary	1%

Theses detection rates exceeded expectations and should result in the precision goals of the study being met.

Bickford reported that 4000 of the PIT tagged fish were handled at the fish sampling station at Rocky Reach and another 1100 were handled at the bypass trap at Rock Island. Additional fish were handled at the Federal projects listed above. Bickford anticipates a draft report being available around the middle of August.

Bickford also reviewed the pilot steelhead survival telemetry study. This data is still being extracted and it is too early to determine results at this time.

McDonald reported that the last PIT tag detection for the Rock Island steelhead survival study was on July 3. The detection rates at downstream recovery sites were as follows:

McNary	12.2%
John Day	23,0%
Bonneville	6.9%
Estuary	< 1.0%

McDonald said the preliminary Ricker estimate of survival was 97.2% with 2.42% error. He said it appears that the timing of the test and control groups was homogeneous. They are just starting the formal analysis so these results are preliminary. He said the data from the pilot telemetry survival study is still being retrieved so there was no data to report.

Hammond said he didn't have anything to report on the Wanapum/Priest Rapids steelhead survival study, at this time. Data is still being retrieved and analyzed.

Hays said that future survival studies are a big enough topic that it would seem desirable to hold a mid-Columbia survival study workshop. Dach said he agreed that would be a good idea. Peven said it is important to begin this dialog as soon as possible after the 1999 data is available. Dach said they would need time for the NMFS Science Center to review the 1999 data prior to a workshop.

E. Draft 7Q10 Guidance

Maynard explained that the terminology "7 Q 10" is a water quality standard terminology that refers to 7 days of a high (1 in 10 year) flow event. He explained that setting this standard for the Columbia River was difficult because it is such a controlled system. He has developed draft guidelines for setting 7 Q 10 standards. He said he will accept comments on the draft guidelines through August 31. He said the data base used was 1974 through the present. Hammond asked if 1974 was used as a starting point due to Canadian storage considerations. Maynard said that it was.

Hays questioned the powerhouse flow portion of the draft guidelines. He said he assumed this was meant to address the "practical" powerhouse flow, during 7 Q 10 conditions, that would represent what portion of these flows would be spilled. Dach commented that actual conditions should be used to determine powerhouse capacity (i.e., number of units expected to be operating given normal maintenance and expected turbine unit outages based on a history of powerhouse operations and maintenance), not necessarily the maximum nameplate or over generation capacity of each turbine. Hays said historical powerhouse flows wouldn't necessarily be applicable in the future given de-regulation and changing market conditions. The committee recognized the objectives the guidelines were meant to address. Dach said he assumed the guidelines would not be cast-in-concrete but would be dynamic and implementation could change as conditions change. Dach asked if these guidelines were expected to be applied to individual projects or would they be applied system-wide. Maynard said they would apply to both.

Maynard said water temperature is becoming more of an issue, driven by the ESA. He said they are in the process of changing how they look at water temperature standards. They will be looking at water temperature standards, by species. They have a Preliminary Review Draft of a discussion paper dealing with water temperature concerns. He will make copies available to the committee for review. Maynard referred to an EPA document which concludes that water temperature effects are primarily caused by reservoirs. He said he will attempt to let the committee know where that report is available in electronic form.

II. WELLS DAM

A. Okanogan Sockeye

Ward reviewed a meeting held in Canada concerning Okanogan sockeye. He stated that issues discussed included carrying capacity of Lake Osoyoos, harvest allocation, adult sockeye migration delays at the mouth of the Okanogan River, and passage above McIntyre Dam. A report by Kim Hyatt detailed the limiting factors to sockeye rearing in Lake Osoyoos.

Bickford reported that Chris Bull has distributed the final draft of his phase I report to the Canadian Department of Fisheries and Oceans, the Department of the Environment, and the Canadian Bands. He said Klinge will be meeting with the Okanogan sockeye "Task Force" next week and will report to the committee at the next coordinating committee meeting.

Marco reported that broodstock collection began on July 12 and, to date, they have 14 fish. He said their trapping schedule is set to coincide with the WDF&W summer chinook broodstock collection schedule. He said they plan to collect 140 fish for broodstock as was agreed at the last coordinating committee meeting. The 1998 brood year fingerlings are being reared with a planned release into Lake Osoyoos this fall when water temperatures are considered suitable.

B. Corps of Engineers Adult Fish Passage Count Correction

Dach said he had talked to the Corps of Engineers about corrections to their official adult fish counts for Wells Dam to account for broodstock collections. This matter had been discussed at the June coordinating committee. Dach said the Corps agreed to make the necessary corrections beginning with the 1999 report. The requested changes were too late to be included in the 1998 report.

C. Wells Bypass and Hydroacoustic Index

Bickford provided information on the 1999 Wells Juvenile Bypass operations. He showed that the spring bypass operations were terminated on July 6 at 2400 hours. The summer bypass operation began at 0000 hours on July 7.

D. Wells Adult Steelhead Passage Study

Bickford reported that antenna deployment for the adult steelhead telemetry study at Wells Dam, had been accomplished during the winter ladder maintenance period. He said their entire system is composed of very efficient dipole antennas. Each antenna location has been fitted with triple redundancy to ensure that debris or hydraulic perturbations will not reduce detection efficiency. He went on to say that the entire Wells Dam telemetry system will be operational by July 19. The tributary monitoring stations will be operational before July 25.

E. Wells Pikeminnow Removal Project

Bickford reported that 5449 pikeminnows have been removed from the Wells Project area thus far in 1999. Total angling effort and catch per unit of effort is 2071 hours and 2.61 fish per hour. Set lines became more effective than angling during the past week.

The next meeting of the Wells Coordinating Committee will be August 25 at Sea/Tac.

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WELLS COORDINATING COMMITTEE
MEETING SUMMARY
August 25, 1999

Agreements Reached:
1.

I. GENERAL MID-COLUMBIA ISSUES

A. Adult Steelhead Telemetry Study

Brown reported on progress on the adult steelhead telemetry study through August 19. A total of 127 tagged fish have been released below Priest Rapids (near Vernita Bridge). Eight of these fish have been recaptured and released at Priest Rapids. The recaptured fish have generally been recaptured at Priest Rapids within two days of release. Brown said a maximum of eight fish have been transported to the release site for each release. The transport tanks are very large and could accommodate many more fish but Brown said they have chosen to be conservative. He reported that approximately 5% of the fish shed their tags prior to release. Bickford remarked that steelhead are notorious for shedding radio tags.

Brown said they are slightly behind schedule in the number of fish tagged and released, to date. He said this reflects the fact that the run also appears to be late this year. He said there are enough fish that they could catch-up in tagging but they have chosen to tag according to the run timing and they would expect to get on schedule as the run increases.

Brown also report on an interesting phenomena which they have observed at the Priest Rapids adult trap this year. The number of mini-jacks which they have counted this year is much higher than observed in past years. Brown said these fish, most of which are adipose clipped and coded-wire tagged, have been shown to be from yearling summer chinook hatchery programs. He said all of the yearling summer chinook programs appear to be represented. Although they have not sampled the fish this year Brown said he was confident that they would find the same to be true with the increased number of mini-jacks this year. He said to put the increase into perspective, the number of mini-jacks seen during each of the last five sampling days have exceeded the season totals for the previous two years. Brown said he isn't sure what the large increase in mini-jacks means, but it could be an indicator of increased survival and a possible large jack return in 2000

B. Update on NMFS Biological Opinion on the Interim Protection Plans

Dach said that the Biological Opinion is being finalized today and should be sent out today or tomorrow. This draft will be discussed at meetings with the mid-Columbia PUD's on September 9 and 24. He was hopeful that written comments, from the PUD's, would be available by the 24th. After that meeting they will distribute a revised draft around mid-October. If there are no comments at that time it would be finalized.

C. Juvenile Survival Update and Survival Workshop

Peven, Bickford, and Hammond said they were not able to present the results of the 1999 Juvenile Survival Studies at this meeting. They will distribute the information to the committee as soon as possible in preparation for discussions at a proposed survival workshop. It was agreed that for a workshop to be productive the data from the 1999 studies would have to be made available at least two weeks in advance. Bickford said the data from the Wells study will probably be ready by the middle of September. Peven said the most important data to review would be the data from the telemetry studies since the PIT tag study methodology is pretty well established. He said he would not like to see the discussion on the efficacy of telemetry survival studies delayed too long since it cuts into the lead time necessary to do a telemetry survival study in 2000. Dach said a minimum of two weeks would be necessary for NMFS to review the data before a workshop to consider that methodology for survival studies. Dach suggested setting a date for such a meeting in early October to give the Science Center a target to shoot for. The committee agreed to set October 7 as the date for a mid-Columbia Survival Study Workshop. Dach said we should recognize that the data from the Snake River survival studies may not be available by that time. Even so, it may be possible for Science Center people to attend the mid-Columbia survival study meeting.

D. Production Issues

Brown reported that there have been two days of spawning at the Methow Hatchery thus far in 1999. He said that the 1995 brood year Methow fish are showing surprisingly strong. For the first two days of an estimated six total spawning days these 1995 brood fish are running four to one over the parent year females spawned.

Brown said they are currently managing three stocks in the Methow Basin. These are the Twisp River stock, the Methow stock, and the Federal Hatchery stock. He said there appears to be a strong over-run of Entiat Hatchery returns represented in the broodstock collected. There was discussion concerning the "surplus" Federal Hatchery stock and what should be done with these fish. Cates said that the Entiat Hatchery had surplus adults this year and the USF&WS has decided not to take Entiat fish into the Methow. It was pointed out that the Methow/Winthrop Hatchery broodstock was almost all collected at Wells Dam and could have resulted in more Entiat "overshoots" than would have been collected at the hatcheries. Cates also pointed out that the 1995 brood Entiat Hatchery fish were 100% Coded-wire tagged at release. This phenomena of Entiat Hatchery fish in the Methow Basin may not be unusual but undetected in previous years.

There was strong sentiment among some committee members to avoid destroying the Entiat Hatchery fish present in the Methow/Winthrop Hatcheries brood stock. Several suggestions were made for transferring the progeny from these fish to other locations. The Entiat River, Lake Chelan, Salmon Creek, and Omak Creek were mentioned as locations where these fish could possibly be transferred. It was also suggested that the progeny could be transferred back to the Entiat River for release as fry or fingerlings. Brown said that out of the first 56 females spawned this year, eleven were Entiat Hatchery fish. Klinge pointed out that the Methow Valley is currently undergoing severe difficulties as a result of ESA listings. Irrigation withdrawals for farms in the area are being threatened due to these listings. He said that destroying spring chinook at the hatcheries in the Methow Basin, even if they are from outside the basin, would not send a very good message to the communities in the area. Woodin said that he feels since the fish have already been transferred to the federal hatchery at Winthrop, they are

technically within the federal hatchery program. What the USF&WS decides to do with them is up to them to determine. Westerhof said that NMFS and the F&WS consider these fish as unlisted strays which do not belong in the Methow River and should be destroyed unless a good research program can be developed to utilize them.. Allowing these fish to spawn in the Methow would not be consistent with the Mid-Columbia HCP Hatchery Program, Fed 1 Plan, and NMFS ESA policy. The strategy for the Methow Basin is to slowly transition Carson spring chinook stock out of the basin while increasing the Methow Basin endemic stock collected at Wells Dam.

Cates reported that the Entiat Hatchery had 231 spring chinook in excess of program needs. At the Leavenworth Hatchery, there were 719 excess spring chinook, at the Hatchery rack, in addition to the fish caught by the sport and tribal fisheries in the Icicle River. Cates said the excess fish were given to the Colville Tribe. Westerhof said the issue of Entiat Hatchery fish showing up in Methow Basin hatchery broodstock is something he (NMFS) will have to address in the spring chinook Biological Opinion they will soon be preparing. NMFS might have to require the Entiat Hatchery to mark 100% of the fish they release.

Brown provided the following summary of spawning at the Methow Hatchery for the first two spawning days:

Number spawned		Wild	Methow brood	Winthrop H.	Entiat H.
Females	57	23	27	1	6
Males	35	13	14	3	5
Total	92	36	41	4	11

Entiat Hatchery fish as percentage of total	12%
Entiat Hatchery fish as percent of females	11%
Entiat Hatchery fish as percent of federal hatchery fish	73%

The committee agreed to continue the same protocol as used previously where coded-wire tags are read at spawning and the Winthrop/Entiat/Leavenworth Hatchery fish are transferred to the Winthrop Hatchery.

Brown reported that the upper Wenatchee spring chinook run will be very close to what was predicted, about 140 fish. There was an attempt to operate the Chiwawa weir, as agreed earlier in the year, for broodstock collection. Due to high flows in the Chiwawa River throughout the planned trapping period, they had difficulty keeping the weir up. When they did get the weir to stay up, the next morning they found some bull trout mortality on the weir. Fifteen adult bull trout mortalities were found on the weir with three additional fish released alive below the weir. WDF&W shut the weir down immediately as required by the agreement between WDF&W and NMFS for operation of the Chiwawa weir. Brown said they checked above the weir for evidence of a fish kill that would have resulted in the weir collecting dead fish. They have found no evidence of such an event in their investigations. They also sent samples of the dead fish to a lab for analysis to try to determine if there was any evidence that would suggest a fish kill above the weir. Brown said they also found one dead bull trout in their smolt trap below the weir one day after shutting down the weir.

Brown reviewed the WDF&W strategy for managing the Twisp River spring chinook stock. Known Twisp River spring chinook are spawned separately when identified during spawning operations. The intent of WDF&W is to also extract approximately 50 eggs from each spring chinook redd located in the Twisp River to hold at the AquaSeed facilities at Rochester for continuation of the captive brood program. The Yakama Tribe is currently surveying the Methow Basin for spring chinook spawning under contract with Douglas PUD. No redds have been located in the Twisp River thus far in 1999.

Brown said that this year in Nason Creek they are preparing to extract eggs from half the redds identified. They will cap all of the redds identified and compare fry emergence from the redds which had eggs extracted and from the undisturbed redds. Westerhof said the information collected would be useful but they also have to consider the possible impacts to the stock from redd capping. He said that NMFS has identified Nason Creek as a logical site for this kind of study. There was discussion of the pros and cons of such a study and potential alternatives. Woodin said he was uncomfortable with capping all the redds necessary to do the study. Ward pointed out that the main question may not be the study design for such a study but the efficacy of the captive brood program per se. Woodin said WDF&W would discuss the matter, in-house, and report back to the committee at the September meeting.

F. Committee Housekeeping Matters

The chairman referred to a letter received from Lee Bernheisel, Okanogan Wilderness League. Bernheisel had raised an issue concerning potential extraction of eggs from Twisp River spring chinook redds and whether this action required ESA review. He also lodged a complaint regarding failure to receive committee correspondence, i.e. meeting notices and agendas, and meeting summaries that he had been promised. The chairman reported that a letter had been sent to Bernheisel which explained that there had been a misunderstanding regarding who would be sending correspondence to Bernheisel and was not a deliberate attempt to withhold information from him. This misunderstanding has been resolved and the chairman will include Bernheisel in future information distribution.

A question was raised concerning who should receive draft meeting summaries. It has not been committee policy to distribute draft meeting summaries to people outside the committee. Bernheisel complained that by the time final summaries were distributed it was old news and not particularly helpful to him. He asked that he be placed on the list for receipt of draft summaries. The committee discussed the matter and there was support for continuing the present policy of distributing draft summaries only to committee members. Bernheisel stated that he had been advised by legal council that the Freedom of Information Act required that this information be made available to whoever requested it. Peven and Dach said they would ask for a legal opinion from their respective legal councils and report back to the committee. The chairman suggested that it may suit Bernheisel's needs if the committee would direct the chairman to distribute draft meeting summaries to the committee within two weeks of the meeting and that members provide prompt review of the draft summaries so that the final summaries could be distributed prior to the next meeting. The committee felt that it would be desirable to accelerate the distribution of the final meeting summaries. The matter will be reviewed at the next committee meeting.

G. Schedule for September and October meetings

The committee set the dates and location for the next two Mid-Columbia Coordinating Committee meetings as follows:

September 21 at Wenatchee
October 20 at Wenatchee

In addition, a tentative date of October 19 was set for an Okanogan sockeye meeting with Canadian interests which will be held in Oroville, WA or Oliver, British Columbia.

II. WELLS DAM

A. Okanogan Sockeye - Phase I Study

Klinge distributed a draft of the Phase I Okanogan Sockeye Report prepared by Chris Bull on options for protection and restoration of sockeye habitat in the Okanogan River. This report covers all the measures for sockeye which were considered during Bull's analysis. Of the measures listed, nine were considered supportable by the Canadian interests. After reviewing the report the Canadian entities developed a summary of measures into these three general areas:

1. Flow related measures
2. Water temperature related measures
3. Habitat related measures

Klinge said Chris Bull has been given direction to develop information on the measures in the three general areas shown above to show which might be most effective. The intent of the Canadian interests is to develop a list of measures, they could support, by February of next year. The three party Canadian group is interested in meeting with the Wells Coordinating Committee to avoid spending a lot of time and effort on measures that weren't supportable by the Wells Committee. Woodin asked about cooperation among the Canadian parties. Klinge said it appears there is good representation from DFO, BC Environment, and the First Nations.

Klinge said there are several measures included in this review that receive support from several different entities or individuals. Spawning channels are supported by some who are interested in sockeye management. Oxbow restoration is supported by some but not by others. There is, however, fairly universal belief that the habitat is probably capable of supporting the run but it is spawner limited.

Woodin said that K. Hyatt's work on Okanogan sockeye production indicates the existing system could support around 250,000 spawners and Lake Osoyoos appears to be capable of rearing the progeny of that number of spawners. Hyatt's report is supposed to be out, following in-house review, around the middle of September.

Klinge said the First Nations are interested in seeing harvest opportunities developed. DFO is mandated to work with the First Nations so there is considerable pressure to move the program forward.

B. Cassimer Bar Sockeye Program

Klinge reported that 140 fish had been collected at Wells Dam for Cassimer Bar brood stock. The 1998 brood fish on station are doing well and are running about 70 to 140 per pound. These 20 thousand fish are scheduled to be released into Lake Osoyoos this fall when the water temperature decreases and will migrate in the spring of 2000.

C. Wells 1999 Juvenile Bypass Operation

Klinge reported on the Wells juvenile bypass operation in 1999. He said the spring operation began on April 8 and ran through June 25. During this 79 day operation, bypass spill represented 7.7% of the project discharge. The summer operation began on June 26 and is still running (61 days). Approximately 7% of the project flow during the summer operation was bypass spill. Klinge pointed out that there usually has been a break between the spring and summer bypass operation. In 1999 this did not occur. He said they usually fyke net toward the end of the summer migration to establish a cut-off date. They have fyke netted twice recently and found the percentage of chinook in the catch was too high to terminate the bypass operation. They will be fyke net sampling again this evening.

Woodin asked Klinge about cost accounting for the Wells juvenile bypass operation. He said it seems to him that during periods of forced spill, there should be no cost for bypass spill shown on the annual FERC report. Klinge said he would look into the matter and see if it would make sense to show this on the annual report.

D. Total Dissolved Gas Monitoring

Klinge reported on results of TDG monitoring at Wells Dam in 1999. The TDG ranged from 106 to 126% over the season. They will be monitoring through September 15. He said they have had difficulty this year in the auto system for report the TDG data to the Corps. The expect the problem to be eliminated by the spill season in 2000.

Klinge said they have been working on development of the 7 Q 10 figure for Wells Dam. He said he understood that the Corps has established a 7 Q 10 figure of 230 kcfs for Chief Joseph Dam so they expect the Wells figure will be in the neighborhood of 250 kcfs.

E. Wells Ladder Operation, Broodstock Collection, and Wells Hatchery Evaluation

Klinge and Woodin reported that this matter had been resolved and the parties were satisfied that the adult steelhead telemetry study and the hatchery evaluation would not be compromised.

The next meeting of the Wells Coordinating Committee will be September 21 in Wenatchee.

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WELLS COORDINATING COMMITTEE
MEETING SUMMARY
September 21, 1999

Agreements Reached:
1.

I. GENERAL MID-COLUMBIA ISSUES

A. Adult Steelhead Radio-Tag Study

Brown gave an update on the trapping operation at Priest Rapids. During the previous week, September 14 and 16, 149 steelhead were trapped including 22 wild and 127 hatchery fish. Four fish which were previously radio-tagged were recaptured and excluded from the random sample. The total number of steelhead sampled to date, includes 547 hatchery and 118 wild. Thirty-four hatchery and ten wild steelhead were tagged and transported to the release location near Vernita Bridge and released. Through September 18, 306 steelhead have been fitted with radio tags and released near Vernita Bridge. This represents 93% of the 328 fish objective through this week. Brown said the steelhead run has shown improvement over the last two years. The latest in-season estimate of the steelhead run size, based on 1991-97 passage data, is 9238 fish with a range of 7724 to 11746.

Brown reported that about twice as many adult chinook have been trapped this year compared to what they normally trap during the their trapping operations at Priest Rapids. Mini jack chinook also continue to show abnormally strong. Over 600 mini jacks have been collected this year which is over ten times the previous annual totals.

Hammond reported on passage of tagged steelhead at Priest Rapids and Wanapum. He said 201 out of 220 tagged steelhead detected at Priest Rapids had passed that project, thus far. A total of 262 tagged steelhead had been released below Priest Rapids through September 9. Of the 193 tagged steelhead detected at Wanapum, 190 have passed that project. Hammond emphasized that these data are preliminary. Hammond said there is some evidence that as many as 10 to 12 tags may have been regurgitated after release. He said this will be investigated by boat surveys over the next several weeks.

Mosey reported on passage of tagged steelhead at Rock Island and Rocky Reach. He said that 160 out of 173 tagged steelhead detected at Rock Island had passed upstream. At Rocky Reach, 99 out of 117 fish detected have passed upstream.

Bickford said that 72 out of the 90 tagged steelhead detected at Wells Dam have passed upstream and 16 additional tagged fish have been collected as brood stock at the Wells Hatchery. Eight of the fish collected as brood stock have been released by the hatchery crew upstream of Wells Dam.

Peven reported that they have received two tags recovered by individuals, one a NMFS employee at a Snake River dam and another from a local angler who had been fishing below Priest Rapids. There was discussion of the pros and cons of trying to inform anglers of the presence of radio tagged steelhead this year. The committee discussed the possibility of posting notices at key locations, such as boat launching sites, to inform anglers that tagged steelhead

could be encountered. Bickford agreed to coordinate an appropriate public information effort at key locations from Rocky Reach downstream to the Vernita Bridge area (open for fall chinook fishing) and tribal fishing locations in the mid-Columbia.

B. Pike Minnow Removal Programs

West distributed a summary of the pike minnow removal program at Rock Island and Rocky Reach for 1999 and previous years. This year, roughly half the number of fish were captured compared to what was captured in previous years. The reduction is not due to less effective fishermen this year compared to previous years. He said he had also examined the fish counts at Rock Island and Rocky Reach Dams and has noted a decreasing trend of pike minnow passage at those projects. He said he feels the program has been effective in reducing the pike minnow population at their projects. West said their pike minnow removal program is at a crossroad and they are evaluating the program for future direction. They are considering moving to a reservoir fishery similar to what is being done at Priest Rapids and Wells Dams. They have contracted with Columbia River Predator Control to fish the Rocky Reach and Rock Island reservoirs through October 1999. This contract is based on a per fish caught basis with a limit of $50,000 for the current years effort.

Woodin pointed out that this contract represents a change in the predator removal project which the coordinating committee had previously approved. He said this change should have been brought to the committee for approval. He said approval probably would not have been difficult but the proper protocol would include committee approval prior to executing the contract. Peven said this was an oversight and he agreed they should have brought the proposal to the committee for approval.

Pock distributed a summary of the Wanapum/Priest Rapids pike minnow removal program for 1999. This is the third year they have contracted for pike minnow removal. The 1999 program began on April 12 this year and ran through August 30. During this period a total of 11,304 pike minnows were removed from the waters of the Priest Rapids Project in 2375 angler hours for a cpue of 4.76 fish per angler hour. He said that several very productive new fishing sites were located this year in addition to those sites that had previously been productive. Suckers and chubs dominated the 542 incidental species captured. The one steelhead caught was well below the "take" allowed by the permit issued for the pike minnow removal program. A draft report is due the middle of October and the contract calls for a final report in December.

Bickford summarized the Wells Project pike minnow removal program for 1999. He said the program has recently resumed after being suspended for a period of time. He said this fishery is similar to that reported by Pock for the Priest Rapids Project and is primarily a bait fishery. They have found the same bait used in the Priest Rapids program, Mormon crickets, crayfish, and chicken livers, are most effective. Since mid-July, long-lines have been used to effectively remove pike minnows.

C. Mid-Columbia Juvenile Survival Studies Update

Hammond said if Grant PUD has not received the necessary data from their contractors they would not be able to participate in the Survival Workshop scheduled for October 7. He said he would probably attend the workshop, even if their data is not available, but they would not be able to contribute to the discussion. Peven said Chelan PUD and Douglas PUD would present PIT tag study data today but the radio-telemetry studies data are not available, as yet. He said they are expecting to have radio-telemetry data available by the end of next week. Dach said the

NMFS Science Center people would have their data available to present at the workshop. While the committee agreed it would be desirable to have all the data available for review prior to the meeting, they considered the value of getting all the researchers together to review the data and to ask questions and discuss results made it worthwhile to proceed with the workshop on the scheduled day.

Bickford distributed a summary of the results of the 1999 steelhead juvenile survival study at Wells. He reported that survival from the Methow release site to below Wells Dam, based on 15 replicate releases, ranged from 0.859 to 1.110. The weighted average of the replicate survival estimates was 0.943. Bickford said he had just received the PIT tag/radio-tag comparisons yesterday(September 20). He will prepare a summary of this comparison as soon as possible and distribute it to the committee prior to the October 7 workshop. Woodin asked why the Okanogan River releases were excluded from the PIT tag summary. Bickford responded that these were part of the PIT tag/radio-tag comparative study and will be included in the summary.

Bickford handed out a proposal for a PIT tag survival study at the Wells Project in 2000. He said Douglas PUD would like to concentrate on a PIT tag study of survival from the Methow to Wells tailrace using yearling chinook or steelhead. He said this stretch is where any problems would be expected to occur and it is important for Douglas PUD to pin that survival rate down. He said they would then plan to compare survival from the Okanogan release site to the Methow release site in 2001. He said his purpose in presenting this proposal, at this time, is to let the committee know what survival studies Douglas PUD would like to pursue over the next two years. Westerhof said he would expect to see the research fish (listed species) taken from production releases, rather than over and above production fish, with adjustment for expected research mortality.

Peven handed out a summary of the 1999 Rock Island PIT tag steelhead juvenile survival study. He said the "bottom-line" is 95% survival from Rocky Reach tailrace to the Rock Island tailrace and, using Wells tailrace releases from the Wells study, 95.6% survival from the Wells tailrace to the Rocky Reach tailrace. Peven said he isn't ready to present any mortality study proposal for 2000 or 2001. He said they may be only considering radio-tag studies for 2000 but they are not prepared to present a specific study plan, at this time.

Hammond said they have not received the data from the radio-tag pilot survival study for Wanapum and Priest Rapids and, consequently, he is not able to address future studies at Priest Rapids and Wanapum at this time.

D. Coordinating Committee Meeting Schedule for November and December

The committee agreed to meet on November17 and December 15 at Sea/Tac. The committee had previously agreed to meet on October 20 in Wenatchee following an October 19 Okanogan sockeye meeting.

II. WELLS DAM

A. Okanogan Sockeye

Klinge reported on discussions he had with Canadian parties concerning a joint meeting with the Wells Coordinating Committee. He asked the committee if they would travel prefer to travel to the meeting together so as to expedite site visits to locations covered in Chris Bull's report. He said he was hopeful that the Canadian representatives could join the committee for the site visits. The meeting will be held on October 19. Klinge said he would expect the Canadian

representatives to discuss their viewpoints on sockeye measures in the Okanogan. He stated that the main purpose of this joint venture is informational and there will be no negotiation of viewpoints. He sees the potential for a joint understanding of possible alternatives to the existing Cassimer Bar Program. The joint meeting was suggested by Bill Green who stated that it was important to identify measures that were unacceptable to both the committee and the Canadian parties so time and effort isn't wasted on measures that did not have broad acceptance. The committee feels the meeting will be worthwhile and Klinge agreed to make the necessary travel arrangements and will provide details to the committee when the details are finalized.

B. Methow Basin Spawning Ground Surveys

Klinge reported on information received from Joel Hubbell, from the Yakama Nation, on the results of spring chinook spawning ground surveys in the Methow Basin. The Yakama Nation is operating under a contract with Douglas PUD. He said they had identified twenty redds this year, located as follows: Lost River 3, Methow River 13, Chewuch River 2, and the Twisp River 2. In addition, they have recovered 14 carcasses, three of which were adipose clipped hatchery fish. He said the data received from Larry Brown indicated 121 adults and 151 jacks should have been available for natural spawning. The number of natural redds observed is disappointing, stated Klinge.

Brown asked if the surveys are continuing and Klinge replied that it was his understanding that Hubbell was not planning additional surveys. Brown asked if they had identified any new redds during their last survey. Klinge said he thought they had seen four new redds. Brown said the surveys should be continued until there were no new redds located. He feels it is critical that these surveys be continued until no new redds are found. Klinge agreed to contact Hubbell and make arrangements for the surveys to continue. Bernheisel suggested that the committee contact U.S. Forest Service personnel for any information they may have Methow Basin spring chinook spawning.

Klinge said jack returns this year indicate there should be an increase in Methow Basin spring chinook escapement in 2000. He said if there is any interest, on the part of the committee, to return to tributary brood stock collection next year he needs to as soon as possible. Brown said he sees no reason to return to tributary collection and that the HCP is clear on the composite brood stock program for the Methow Basin. Westerhof agreed that there was no compelling reason to return to tributary brood stock collection.

Brown discussed possible complications from Entiat Hatchery strays in brood stock collection at Wells Dam. He pointed out that 36 adult and 6 jacks had been included in the brood stock collected at Wells Dam this year. These fish were not included in the egg take for the Methow Hatchery. Woodin suggested that, next year, there be closer coordination between WDF&W, FWS, and NMFS concerning spawning protocol for the brood year 2000 and disposition of strays, particularly Entiat Hatchery strays.

C. Wells Bypass Operation

Klinge handed out a summary of juvenile bypass operations at Wells Dam in 1999. Dach asked if the information distributed states that the bypass operation covered 95% of the juvenile migration. Bickford said that, based on 16 years of historical data, they feel closer to 98% of the migration was covered but that isn't stated in the summary distributed. Bickford said he would supply an estimate of the percent of the migration covered by bypass operation following the

lunch break. After lunch, Bickford reported that their best estimate of the coverage of the juvenile migration by bypass operations at Wells Dam in 1999 was 98.2%.

The next meeting of the Wells Coordinating Committee will be October 19 at Oroville, and October 20 in Wenatchee.

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SUMMARY
WELLS COORDINATING COMMITTEE
OKANAGAN BASIN TECHNICAL WORK GROUP
JOINT MEETING
October 19, 1999

INTRODUCTION:

Rick Klinge, Douglas County PUD, welcomed the group to this meeting of representatives from both sides of the border who are interested in the wellbeing of Okanagan sockeye. He expressed his appreciation for each one in attendance and especially representatives from the Okanagan Bands. Klinge reviewed the background of U.S./Canada discussions concerning the Okanagan sockeye issue. He said it was the hope of individuals involved in those discussions that this meeting would help clarify viewpoints of those on both sides of the border. He said it was important that areas of mutual interest and agreement be identified and, where common support is lacking, those areas be identified and eliminated.

Klinge introduced Clarence Louie, Chief of the Okanagan Bands who addressed the group. Chief Louie pointed out that the Okanagan Bands have had a keen interest in Okanagan sockeye for many years. He said that, in the past, they have not had meaningful participation in matters pertaining to Okanagan fisheries issues. He expressed his pleasure in seeing all of the entities represented at this meeting and said he is looking forward to cooperative efforts to improve conditions for sockeye salmon in the Okanagan Basin. He reviewed the relationship between his people and Okanagan sockeye and their importance to the bands historically. He said it is time to set aside any hostilities and work together in a cooperative effort to reverse the declines that have taken place, over time, and to look at the efforts and resources that will be required to revive the Okanagan sockeye fisheries and other fishery resources in the Okanagan Basin. He said jurisdictional conflicts, which have been impediments in the past, must be put aside to allow meaningful progress toward the goal of increasing fisheries resources in the Okanagan River Basin.

POSITION STATEMENTS FROM PARTICIPANTS

Ian McGregor, British Columbia Ministry of the Environment, said it was good to get together to discuss common interests relating to improvement of Okanagan fisheries resources. He pointed out the large geographical area that his agency is responsible for and reviewed the respective duties of the Victoria and Kamloops offices. He said the Kamloops office is involved, primarily, with inland species and steelhead and cutthroat trout. McGregor said their mandate to preserve native fish stocks and their habitats. He feels the Okanagan Basin Technical Work Group is a group his agency can work with to move forward on fishery and habitat protection. He went on to say that his agency doesn't want to focus only on sockeye, but all the fisheries resources in the basin. McGregor said he realizes that there is a lot of work to be done and they want to be actively involved in the process. The first priority of the B.C. Ministry of the

Environment is restoration of the environment with enhancement to follow. McGregor said that they recognize it may not be possible to return the stock to historical levels but he believes there are important opportunities that may exist that make it important to move forward in a cooperative effort.

Ted Downs, British Columbia Ministry of Fisheries, explained his offices involvement in fisheries issues in B.C. They are involved in stock assessment, hatchery issues, and trans-boundary issues. He said their office is in a position to provide meaningful input into the kinds of measures that might be considered for Okanagan sockeye through the efforts of this group. He said they are pleased to be involved in this process.

Byron Louis, Chair of the Okanagan Nations Fisheries Commission, stated that the issues at hand go much deeper than just a matter of aboriginal rights. He said aboriginal peoples are faced with health problems as a result of changing from a primarily fish based diet to something different. Lewis is concerned that the efforts of this group not be just a short-term effort to meet some mitigation responsibility but that it move toward a sustainable increase in the resources that have historically been the life-blood of aboriginal peoples. Salmon are natural resources that were effected the most severely. He pointed out that coastal aboriginal peoples were dependant upon Columbia River salmon resources which are no longer available. Lewis said he believed that water resources are some of the most mismanaged resources in British Columbia. He said there are other resources besides salmon, e.g. chinook and lamprey, that were formerly important to his people that no longer are available to them. If some of these resources aren't restored there could be massive litigation. They would not be looking at litigation for one generation but three or four generations.

Elmer Fast, Fisheries and Oceans Canada, expressed his appreciation for the informative tour of the Okanagan area that had been arranged for the group. He gave a brief overview of the DFO involvement in southern B.C. He said the issue of fisheries and various fisheries interests in the area are quite complex. He said he wanted to zero in on conservation and management of anadromous fisheries. He went on to say that his agency has clear judicial responsibility to provide for ceremonial and subsistence use of the anadromous fisheries resources. They are keenly aware of those responsibilities. They also have responsibility to other parties regarding their interests in the anadromous fisheries resources. He called attention to previous TWG activities and said they see this working group as the principal entity to develop recommendations, on fisheries rebuilding efforts, to Douglas County PUD. He said they recognized that sockeye salmon are the focus of this effort but they are unwilling to set aside the interest in other fisheries resources. They feel they are making progress toward developing a consensus position regarding recommendations for fisheries rebuilding efforts. He said the stocks in the Okanagan Basin are not at a level of abundance that would make improvement not possible.

Rod Woodin, Washington Department of Fisheries and Wildlife, expressed his appreciation to Douglas PUD for setting up the tour and meeting. He reviewed the Wells Project FERC license provisions regarding fish and wildlife mitigation, and summarized the activities leading up to the Wells Settlement Agreement . He stated that mitigation levels in the settlement agreement were based on an assumed 14% mortality to juveniles. The settlement agreement anticipates increased production, in the future, as a result of the mitigation programs and activities called for in the agreement.

Jerry Marco, Colville Confederated Tribes, stressed the interest of the Colville Tribes in Okanagan sockeye. Marco reviewed the development of the Cassimer Bar sockeye hatchery and

said this is a pilot facility established to determine if sockeye salmon could be effectively cultured. He described the facilities and the operations that had been conducted over the past seven years. He handed-out a summary of the fish cultural operations at that facility, and pointed out the changes that had taken place over the period of operation. He discussed the fish cultural results and explained the differences between the yearling programs followed for the 1998 and 1999 broods.

Rick Westerhof, National Marine Fisheries Service, expressed his interest in being on the tour and at the meeting. He said he hopes that this will be a successful effort that will make an ESA listing for sockeye unnecessary. Westerhof reviewed the Douglas PUD and Chelan PUD HCP agreements, pointing out that the HCP doesn't really deal with coho and sockeye salmon. He said it is much better to work with efforts to increase populations before it becomes necessary to rely on hatchery programs. He said NMFS is concerned about the effects of hatchery returns on the spawning grounds. They are trying to balance hatcheries and ESA concerns. Habitat concerns are also being addressed by NMFS as well as hydropower issues. Westerhof said he appreciated the opportunity to participate and stated how pleased he was to see "wild" sockeye spawning without hatchery programs.

Kim Hyatt, Fisheries and Oceans Canada, reviewed the historical record of the Okanagan sockeye run. He pointed out the low returns in several of the recent years. The first he addressed in his study was, what are the bottlenecks to production? His approach was two-fold, spawning habitat availability and juvenile rearing capacity. He reviewed his evaluation of spawning flows and available gravel (good spawning gravel). He said their assessment was 135,000 spawners compared to the 80,000 plus spawners that Meekin and Allen came up with. He pointed out that his assessment was only for spawners in the best spawning gravel areas. His conclusion is that spawning habitat is not limiting at any level of escapement over the last thirty-five years. Regarding summer rearing, he stated that Osoyoos Lake is considered the warmest lake in British Columbia. It is definitely not a typical sockeye rearing lake. High summer temperatures limit south and middle basin production. Oxygen conditions create additional constraints to rearing, even in the north basin. He said the usual sockeye rearing assessment is based on nutrient conditions and when they evaluated Osoyoos Lake phosphorus levels it indicated the north basin of Osoyoos Lake is one of the most productive sockeye lakes in the world. To evaluate the smolt production potential of Osoyoos Lake, Hyatt reviewed the size of smolts for evidence of density dependence. This review showed that the size of Osoyoos smolts is consistently large. He said they looked at smolt production in terms of smolt size. He said until you decide what size smolts you want, he can't say how many adults are required for a certain level of production. The range of escapements run from 117,000 adult spawners for Lake Wenatchee sized smolts to 58,000 adult spawners for normal Osoyoos-sized smolts. In summary, Hyatt said that even under the most conservative estimates, Osoyoos Lake could accommodate 58,000 spawners. Hyatt reported that Mysis, which weren't present in Osoyoos in the 1970's, are now showing up. Hyatt said his Osoyoos paper resulted in DFO setting an escapement goal of 58,000 sockeye.

Chris Bull, Glenfir Resources, reviewed the objectives of his contract with Douglas PUD. He stressed that direction for this effort comes from the Okanagan Basin Technical Work Group which is made up of representatives of the First Nations, Provincial Government, and Federal Government. Bull emphasized the need for broad overview rather than focusing on a single species or project. The OBTWG has adopted an ecosystem approach that would consider all species. McGregor reviewed the list of options which had been developed. These are:

1. Habitat restoration including re-establishment of oxbows, etc.
2. Spawning channel development
3. Control of river flows
4. Control of water temperature by means of siphon, etc.
5. Irrigation water screening
6. Trap and haul adult sockeye to reduce pre-spawning mortality

Since time was running short, at the meeting, Bull's discussion was limited to the habitat and spawning channel options. For habitat restoration, Bull reviewed the upper portion of Okanagan, the middle portion, and the lower portion. He said the upper portion is in good shape and he said if it isn't broke, don't fix it. The middle portion is mainly urbanized and provides little opportunity for restoration. He said the lower portion, which has been channelized, has the most opportunity for restoration. He said putting the river back in the old channel would restore oxbows and result in an increase in habitat diversity. He said this could result in increased sockeye spawning potential and provide additional benefits for kokanee and whitefish. Bull pointed out that since Hyatt's work indicates spawning and rearing habitat isn't limited, it leads to consideration of survival improvements, i.e. screening irrigation diversions, as important potential gains. Also, modern spawning channels are "natural" in nature and could be acceptable to Canadian interests that are stressing wild fish and habitat protection and restoration.

Rick Klinge, Douglas County Public Utility District, reviewed the beginning of the current Okanagan sockeye process and said this actually began as an attempt by the Wells Coordinating Committee and Douglas PUD to meet Wells Project sockeye mitigation obligations. Douglas PUD is assessing actual survival of smolts passing Wells Dam and indications are that the Wells Settlement Agreement assumptions of a 14% juvenile mortality is too high. Klinge said they are interested in pursuing sockeye mitigation measures that are sound biologically and which would meet Douglas PUD's obligations in a meaningful, cost effective manner. He said they looking forward to development of a list of measures which would receive broad support north of the border and which could be taken to the Wells committee as a potential replacement for the current mitigation program at the Cassimer Bar Hatchery. When measures are identified that have support on both sides of the border, these will be taken to the Douglas PUD Board of Commissioners for consideration for funding. Klinge said he feels there has been a major advancement of the momentum toward identifying measures which would be considered for meeting Douglas PUD mitigation obligations and which would be consistent with the interests of the Canadian parties for an ecosystem approach which would benefit all species.

DISCUSSION:

Fast emphasized that the OBTWG would clearly be the group that would develop the recommendations for consideration by the Wells committee. Flynn shared Fast's optimism that there are measures being considered which have the potential for making an important contribution to the improvement in sockeye numbers. Green said he recognized the momentum that appears to be developing but is concerned that consensus on measures, developed north of the border, may not be endorsed by those south of the border. McGregor said he shares Green's uncertainty about how the decision will be made south of the border. What process will be used to make decisions concerning the options developed and the consensus developed by the OBTWG, McGregor asked? Woodin replied that, from his perspective, if the options developed meet credibility standards he doesn't see a problem in arriving at a joint position regarding acceptable measures for meeting Douglas PUD sockeye mitigation responsibilities. McGregor

asked if a long-term measure was proposed, such as restoring X kilometers of river to productive condition, would this be something the Wells committee would consider even though measurable benefits might be hard to quantify? Woodin said the Wells committee is composed of professional biologist who recognize biological uncertainty. Hyatt said he understands that they would be looking for more than just a "warm fuzzy feeling" and would expect development of a professional assessment of potential benefits of any measures proposed and the rationale for those measures.

Clubb mentioned that Douglas PUD's Wells Project is only one of five non-Federal projects in the mid-Columbia that will have Okanagan sockeye mitigation responsibilities under the HCP process, which is currently undergoing environmental review, or a similar process in the case of Grant PUD.

Marco urged the OBTWG to do the best they can to identify and quantify benefits that could be realized by the measures suggested. Hyatt said that they could develop an assessment of benefits from suggested measures but there also could be some "softer" benefits that would be identified but less certain in terms of quantifiable benefits.

Woodin asked how opposed the OBTWG was to artificial measures since it appears to him that it would be difficult to quantify potential benefits from habitat measures that could begin to approach 25% which is what he feels the effects of the five non-Federal, mid-Columbia dams are on sockeye stocks. Green pointed out the adult transport option which has been considered by the OBTWG as a means of addressing adult losses between Wells Dam and the spawning grounds resulting from high water temperatures in the Okanagan River. He said that benefits from such a measure might be hard to quantify but would be clearly a survival enhancement measure. Feldmann asked, if trap and transport was accepted by Douglas PUD as a mitigation tool, would the OBTWG be ready to go along with that or is there another process or review that would be necessary? Hyatt replied that there isn't consensus on the OBTWG regarding the trap and transport at this point in time.

Down referred to Hyatt's discussion concerning "bottlenecks" to sockeye production and asked what the bottom-line was. Are ocean conditions such that they are the bottleneck? He said it isn't clear to him how freshwater survival is related to ocean conditions in terms of overall production. Hyatt replied that ocean conditions for sockeye have been relatively constant for some time.

Klinge expressed his appreciation for the participation of each one who came to the meeting. He said the discussion was very helpful. Green asked if it would be appropriate to forward copies of the Phase II report to the Wells committee for review and comment. He said he feels that would be helpful to their efforts in developing a list of options which would meet the needs of the OBTWG participants and have a chance of meeting the Wells committee's goals for sockeye mitigation. The participants agreed that that would be an appropriate thing to do.

Klinge began to summarized the results of the tour and meeting. The following points were offered by the participants:

- The tour helped familiarize the participants with the area of interest
- The Wells Coordinating Committee's position was clarified
- Improved coordination between parties on both sides of the border was fostered
- Options being considered by the OBTWG were identified
- Need for benefits analysis of options was identified
- An ecosystem approach was endorsed by the participants

Klinge said there are several things that remain to be done in the future as a result of this meeting. Pointed out were:

- Possible peer review of the Phase II report.
- A "full-blown" technical session next year has the support of the participants.

Matthews cautioned the Wells committee regarding consideration of measures based on assessment of benefits since habitat based measures may be harder to quantify than some other types of measures. Fast pointed out that all of the measures will have benefits to sockeye which may be a wide range of effects but also have benefits to other species. Woodin said that although the Wells committee and Douglas PUD are the entities attempting to resolve the question of acceptable sockeye measures, Douglas PUD's responsibilities for sockeye mitigation are smaller than the future responsibilities of Chelan PUD for Rocky Reach and Rock Island and Grant PUD for Wanapum and Priest Rapids.

McGregor said he feels a joint technical session would be appropriate following review (on both sides of the border) of the Phase II report. Down said this could also be a time when supporting information and rationale could be presented. Bull expressed a desire to have feed-back from the Wells committee, in addition to the OBTWG, during development of the Phase II report. The participants felt this would be an appropriate thing to do.

Klinge thanked the participants for coming and said he feels this was a worthwhile effort that will help point the way toward meeting Wells Project sockeye mitigation goals while addressing the concerns of the parties in Canada.

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WELLS COORDINATING COMMITTEE
MEETING SUMMARY
November 20, 1999

Agreements Reached:
1. The committee agreed to support the 2000 Wells Juvenile Survival Study as detailed in the revised study plan.

I. WELLS DAM

A. Wells Dam 2000 Juvenile Survival Study

Bickford reviewed the timing of the 2000 study proposal. He said that the original survival study plan had been distributed in September. The original plan was subsequently modified as a result of the discussion during the October coordinating committee meeting and re-distributed following that meeting. Bickford reviewed the elements of the study and summarized the comments received from Woodin and Dach. The comments received expressed an interest in a study plan that contained the following elements:

- Extended study period encompassing more of the migration
- In-year species survival comparison

Bickford reviewed his written responses to the comments received and discussed his analysis of what could reasonably be done in 2000. Bickford went over the pros and cons of various study designs that had been considered. He said they had determined that in-year species survival comparisons have a low probability of success based upon power calculations performed by the University of Washington. As such, in-year survival comparisons were determined to not be feasible in 2000. Bickford commented on survival studies they are considering for 2001. That study would involve releases of PIT tagged chinook yearlings at the Okanogan River, Pateros, and in the Wells tailrace. He said this study design would produce three separate, but interrelated, reach survival estimates, Okanogan River to Pateros, Okanogan River to Wells tailrace, and Pateros to Wells tailrace. He said this study design would have a high probability of success related to the issues of mixing and precision. Woodin said it was too early to be discussing the design of 2001 studies. Bickford said the study design being considered for 2001 would require extensive preparation and he didn't want to put off discussion of the design too long or their ability to conduct the study would be compromised.

Bickford reviewed the modified 2000 study proposal. He said there would be a minimum of 10 and a maximum of 15 replicates. There is a problem with the number of fish available from the Wells Hatchery. He said the fish they have to work with will come from a pond containing 120,000 hatchery-X-hatchery crosses and 50,000 of these fish are scheduled for release from the Similkameen Acclimation Pond. The remaining fish are to be truck planted in the Methow and Okanogan Rivers as they outmigrate from the pond. Careful coordination with the hatchery staff will have to take place to ensure sufficient numbers of fish are available during the later half of the study. If coordination with the Wells Hatchery releases is successful and the release schedule

allows adequate numbers of fish for tagging, Bickford said Douglas PUD would extend the study to include more replicate releases to a maximum of 15 which would cover the bulk of the steelhead migration. The year 2000 releases of PIT tagged fish would take place at the Pateros release site with controls released in the Wells tailrace, basically a repeat of that portion of the 1999 study with the time frame extended to cover the steelhead migration. Brown said his latest information from the Wells Hatchery is that there are 223,000 hatchery-X-hatchery fish in the pond the study fish will come from. Bickford said his discussions with hatchery personnel indicate 120,000 fish in that pond, but, if it turns out that the 223,000 fish number is correct it just increases the probability of 15 replicates rather than 10.

Dach said he didn't see a problem with the revised 2000 study proposal. He said the only issue remaining was the question of precision. Bickford said he had talked to John Skalski and Rich Townsend and they were aware of the question Dach had raised. He suggested that Dach get some clarification on that matter directly from Skalski or Townsend.

The committee agreed to support the 2000 Wells Survival Study as detailed in the revised study proposal.

Brown asked if it was too early to suggest a 2002 study. He said he would like to see the 2001 study Bickford discussed, repeated with steelhead in 2002. Clubb said it was probably appropriate to discuss what Douglas PUD's understanding was regarding responsibilities for survival studies under the HCP. He said Douglas PUD had never agreed to study HCP plan species for three years each. That potential fifteen year commitment is not an element of the HCP as far as Douglas PUD is concerned. Woodin said his understanding of the HCP agreement was to study each species for three years, if necessary. Brown pointed out that sockeye and sub-yearling chinook have not been studied, as yet. He also said that the species that have been studied are large, robust, hatchery fish that are probably the most survival prone fish in the mix of species.

Dach said the question of the number of years of study for each species was an important one. He agreed that this question should not hold up the 2000 study, but, he said he would recommend resolving the issue before the HCP agreement is signed. Dach referred to the draft HCP agreement which says "The Coordinating Committee shall establish the protocol(s) to measure 95% Juvenile Dam Passage Survival and 91% Project Survival for each Plan Species by March 1, 2000. If the Coordinating Committee has not established such protocol by said date, such protocol shall be established through dispute resolution as set forth in Section XI by February 28, 2001. Such protocol shall utilize the best technology and methods available. One of the methods to be considered is mark recapture." Dach said he does not want to see this matter left to the dispute resolution process and therefore, it is important to move toward resolution before the March 1, 2000 date established in the HCP. It was clear there was a lack of consensus regarding what the HCP agreement said regarding the number of years of survival studies envisioned.

Clubb discussed the Douglas PUD position regarding the HCP agreement regarding the question of assessment of adult survival. He said 95% juvenile survival was the focus of the HCP discussions and the 91% project survival did include adult survival but there was no understanding that adult survival studies would actually be pursued, at this time, since no one was comfortable with the tools available to assess adult survival. He said his understanding was that adult survival was not expected to be assessed in the Initial Period. The Initial Period focused on juvenile survival. Clubb said that through the course of the HCP discussions, everyone thought adult survival was very high in the mid-Columbia and the 91% project survival

goal, including adult survival, was a negotiated number. Woodin agreed there was no call for adult survival studies early on in the HCP discussions, but he feels the intent was to leave the "door open" for survival studies if the technology was developed and the information became critical. Dach said where adult survival assessment becomes critical is where that figure is used as a recovery requirement. If 91% project survival is considered necessary for recovery of listed species, it becomes critical to be able to determine if you are meeting that goal. He said his interpretation of the HCP agreement was that adult survival studies were expected to be performed to determine if the 91% project goal was being met. Clubb said there was lengthy discussion of adult survival studies during the HCP negotiations and that it was clear that no one knew how such studies could be done in a manner that would result in accurate assessment of adult survival in relation to project effects. He said the adult telemetry studies were done to try to identify any problems with adult passage at the mid-Columbia dams and it was Douglas PUD's intent to address any passage problems, at Wells Dam, identified in those studies.

There was extensive discussion concerning the purpose for adult survival studies and whether "reach" survival assessments or individual project survival estimates are what needs to be pursued. There appeared to be a general consensus that it would be desirable to have an assessment of adult survival through the mid-Columbia reach. The big question is whether or not it is appropriate to try to apportion mortality or assign responsibility for fish losses given the technology available. Bickford said it is his opinion, after talking to other researchers in the region, that the available technology (i.e. radio telemetry) would not allow reliable assessment of individual project adult survival. Dach said this is an important and timely issue and there should be further discussions in the near future. He said information on adult survival is especially important in developing requirements for recovery of listed species.

B. Wells Dam Juvenile Bypass Operation Plan for 2000

Bickford distributed a draft plan for the operation of the Wells Juvenile Bypass System in 2000. He reminded the committee of the Wells Settlement Agreement provision for annual development of the bypass operation plan. He said questions should be directed to Klinge.

The next meeting of the Wells Coordinating Committee will be December 15 at Sea/Tac.

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WELLS COORDINATING COMMITTEE
MEETING SUMMARY
December 15, 1999

Agreements Reached:
1.

NOTE: Due to travel problems, several PUD committee members were not able to attend the meeting in person. These members participated by speaker phone for a portion of the meeting. Two other committee members were unable to participate due to schedule conflicts.

I. JOINT ISSUES

A. Adult Steelhead Telemetry Study

Bickford reported on the results of the most recent aerial survey of radio tagged steelhead adults above Wells Dam. This was the second aerial survey this fall. Bickford reported that 151 tagged steelhead had been detected passing Wells Dam. The telemetry monitors were removed at Wells Dam the end of November. The distribution of tags above Wells were as follows:

Methow River	82 Total
Mouth of Methow (estuary)	3
Mouth to Carlton	33
Carlton to Twisp	45
Okanogan River	59 Total
Mouth of Okanogan	3
Mouth to Monse	23
Monse to Riverside	27
Riverside to Similkameen	5
Similkameen to Zosel Dam	0

In addition, Bickford said six tagged fish were found upstream of Wells Dam that had not been detected at Wells. Bickford explained that detectors at Wells had been unplugged during ladder cleaning operations and had remained unplugged for several days allowing some tagged fish to pass without being detected exiting the ladder. Bickford also reported that 18 tagged fish were being held at the Wells Hatchery and three fish were removed from the Wells fish ladder during broodstock collection activities and released upstream. These 18 (in the hatchery) and three (released upstream) were not included in the 151 fish mentioned above as having passed Wells. Bickford said the median arrival time (i.e., from tagging at Priest Rapids to arriving at Wells) was 9.1 days while the median project passage time (for the 151 fish passing Wells Dam) was 0.6 days.

There was discussion concerning whether or not there should be additional aerial surveys during the winter months. Brown said he would prefer to see the original schedule adhered to with monthly flights during the winter and more frequent surveys as the spawning season approached. He said he realized that aerial surveys during the winter months are weather limited.

Cates asked Bickford if he thought they would be able to extend the aerial surveys up the Twisp and Chewuch Rivers. Bickford responded by saying that the thought the best opportunity would come in the spring when they planned to use helicopters for some aerial surveys. He said they had tried to utilize ground surveys but found these were inadequate to detect tagged fish in these tributary areas. He said he agreed with Brown that the best approach would be to stay with the monthly flights until spring and then use the helicopter flights for more thorough tributary surveys.

B. Fishway Operating Plan Meeting

Nordlund reported that Larry Basham of the Fish Passage Center had contacted him about setting up a series of meetings with Mid-Columbia project operators to discuss 2000 fishway operating criteria. He said the third or fourth week in January was selected as possible times for the meetings at the individual projects. Nordlund said he would send out a notice of these meetings as soon as the dates are confirmed.

C. Next Mid-Columbia Coordinating Committee Meeting

Woodin pointed out that the date previously selected for a January coordinating committee meeting (January 19), was in conflict with a Lake Chelan re-licensing meeting. The committee suggested January 27 as an alternate date if a January meeting is necessary. The chair said he would contact committee members regarding the alternate date and notify the committee if that date is suitable. The suggestion was made that this meeting be held in Portland.

II. WELLS DAM

A. Okanagan Sockeye

Klinge reported on a meeting he had attended in Oliver, B.C. last week (December) where potential sockeye spawning channel sites were discussed. He reported there was considerable enthusiasm shown by the DFO people who attended the meeting. Klinge said a synopsis of the DFO perspective on potential development of a sockeye spawning channel will be developed. During the meeting they visited two sites that had been identified by Chris Bull. Bull's Phase II report will be distributed to all parties before the first of the year. The Canadian parties recognize that it could be possible to come to agreement, early in 2000, on spawning channel development for meeting the Douglas PUD sockeye mitigation obligations and move quickly ahead on implementing a spawning channel mitigation program. Klinge said the Wells Committee could be holding discussions, in the meantime, to identify how to make the transition from the current program, based on pounds of production, to a spawning channel based program. Klinge reported on recent moves in B.C. to address First Nation fisheries issues. This is a little different than measures previously discussed. Cates asked if this would be included in Bull's Phase II report. Klinge said it probably would not since this is a new effort. Klinge said there appears to be a lot of enthusiasm in British Columbia, at this time, to make something happen. He feels the time is right to move ahead with initiatives to develop a sockeye mitigation program based in B.C. There was discussion concerning what the Wells Committee needs to do in preparation for moving from a pounds of production based program to a channel based program. Klinge said he will attempt to set up a Wells Committee meeting to discuss this issue following distribution of the Phase II report.

B. Juvenile Survival Studies

Bickford gave an update on the 2000 juvenile survival study for Wells Dam. He said that since a question had been raised regarding the number of fish available for the study he met with the Wells Hatchery personnel and came up with the following confirmation on the number of fish they will have to draw from for the 2000 study. He said as of December 14, 223,000 HxH steelhead are in pond number four at the Wells Hatchery. The Wells Survival Study will use 65,000 fish with the remainder going for release in the Okanogan River. Brown asked if it would effect the Wells Survival Study if about 50,000 fish were moved to the Similkameen Ponds early for acclimation. Bickford said he had talked to the hatchery personnel about that possibility and they have agreed that it might be better to not do that. Brown said he feels it might be better to move fish to the Similkameen Ponds as they move out of the rearing ponds at Wells.

Bickford reported that provisions had been made for detection of the isso-tags at Rocky Reach and the tags have been ordered. He said the contracts are in place for the 2000 study and preparations are well along for the 2000 study.

Bickford said it probably would not be productive to discuss the 2001 study, at this time, due to the fact that several of the key committee members were not present at this meeting. He said he has prepared a 2001 study proposal which will be e-mailed to the committee and it can be discussed at a future meeting. Brown said WDF&W will be adjusting yearling/sub-yearling chinook production at Wells Hatchery to stay within the NMFS guidelines and he asked if Douglas PUD was in agreement with what they were planning to do. Bickford said they had discussed this matter, in-house, and were in agreement with those plans.

The next meeting of the Wells Coordinating Committee will be January 27 in Portland, Oregon.

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1999 MEMBERSHIP LIST
OF THE
WELLS COORDINATING COMMITTEE

APPENDIX J

Appendix J

1999 Membership list of the Wells Coordinating Committee

Ron Boyce
Oregon Department of Fish and Wildlife

Mike Erho
Wells Coordinating Committee Chairman

Cary Feldmann
Power Purchasers

Bob Heinith
Umatilla Tribes

Bob Dach
National Marine Fisheries Service

Rick Klinge
Douglas County P.U.D.

Jerry Marco
Colville Confederated Tribes

Paul Ward
Yakama Indian Nation

Brian Cates
U.S. Fish and Wildlife Service

Rod Woodin
Washington Department of Fish and Wildlife

THE LONG TERM SETTLEMENT AGREEMENT FOR THE WELLS HYDROELECTRIC PROJECT

APPENDIX K

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Public Utility District No. 1 of Douglas County, Washington	)	Project No. 2149 Docket No. E-9569

SETTLEMENT AGREEMENT

This Settlement Agreement is entered into this 1st day of October, 1990, by the Public Utility District No. 1 of Douglas County, Washington (the PUD), Puget Sound Power & Light Company, Pacific Power and Light Company, the Washington Water Power Company, Portland General Electric Company (collectively the Power Purchasers), the Washington Department of Fisheries, the Washington Department of Wildlife, the Oregon Department of Fish and Wildlife, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, the Confederated Tribes and Bands of the Yakima Indian Nation, the Confederated Tribes of the Umatilla Reservation, and the Confederated Tribes of the Colville Reservation (collectively the Joint Fishery Parties).

I. GENERAL

A. PURPOSE AND SCOPE

1. This Agreement establishes the PUD's obligations with respect to the installation and operation of juvenile downstream migrant bypass facilities and measures; hatchery compensation for fish losses; and adult fishway operation at least until March 1, 2004, as described in subsection I.C. For purposes of the Wells Project, these measures, in conjunction with existing hatchery

compensation programs, and when carried out pursuant to this Agreement, shall be conclusively considered to fulfill the PUD's obligation to protect, mitigate, and compensate for the anadromous fish resource at least until March 1, 2004. These measures are expected to contribute to the Northwest Power Planning Council's goals of rebuilding the natural spawning populations of salmon and steelhead in the Columbia Basin and providing harvest opportunities.

2. This Agreement establishes the Joint Fishery Parties' obligations in support of this settlement. This Agreement also requires evaluation programs for fishery measures and establishes procedures for coordination between the PUD and Power Purchasers and the Joint Fishery Parties.

3. It is the intent of the Parties that this Agreement shall be the basis for the dismissal of the Mid-Columbia proceeding, Docket No. E-9569, insofar as it pertains to the Wells Project, and for compliance by the PUD with the Northwest Power Planning Council's 1987 Columbia River Basin Fish and Wildlife Program, as amended.

4. The fish passage, mitigation, and compensation measures set out in this Agreement are intended to implement Article 41 of the License for Project No. 2149 issued by FERC to the PUD. The PUD's obligations under this Agreement shall be enforceable as if they were conditions of its FERC license. Notwithstanding any other provision of its FERC license, once this Agreement is approved by FERC the PUD shall be bound by the terms of this

Agreement.

5. For purposes of this Agreement, except under subsections VI.B, VII.B and E, VIII.B and D, the Power Purchasers collectively will be a single Party. For all purposes under this Agreement, except under subsections VI.B, VII.B and E, VIII.B and D, the Power Purchasers shall participate through a single representative, whom they will designate from time to time.

B. DURATION

The term of this Agreement shall commence on the date of execution by all Parties and shall continue for the term of the current license for the Wells Project, plus the term of any annual licenses which may be issued after the current license has expired.

C. MODIFICATIONS TO THE AGREEMENT

1. Notwithstanding subsection I.B, at any time after March 1, 2004, any Party may request all other Parties to commence negotiations to modify the terms and conditions of this Agreement in whole or in part. Any such modification shall be subject to FERC approval, except that the Parties may agree to implement on an interim basis, pending FERC approval, any measure not requiring prior FERC approval. No Party shall file a petition with FERC pursuant to subsection I.C.2 to modify this Agreement without first presenting the proposed modification to all Parties and allowing a reasonable opportunity to negotiate, not to exceed 90 days without consent of all Parties.

2. Subject to the limitation stated in the above subsection, at any time after March 1, 2004, any Party to this Agreement may:

(a) Request the imposition by the FERC of different, additional, reduced or modified fish protection measures;

(b) Bring any cause of action, raise any defense or claim, or rely on any theory related to this Agreement in any appropriate forum;

(c) Petition any appropriate administrative agency or political body for relief, including the deletion or addition of one or more measures otherwise in effect under this Agreement; or

(d) Take other appropriate action relating to any issue or matter addressed by this Agreement or which could have been addressed by this Agreement or that otherwise relates to the fisheries issues of the Wells Project.

3. In any action under this subsection I.C, the petitioning Party shall have the burden of proof. The Parties will continue to implement this Agreement pending final resolution of any modification sought in the FERC, or until the relief sought becomes effective by operation of law, or unless otherwise agreed.

4. With respect to any petition or suit filed pursuant to this subsection I.C and any subsequent judicial review thereof, nothing in this Agreement shall bar, limit or restrict any Party from raising any relevant issue of fact or law, regardless of whether such issue is or could have been addressed by this Agreement. Notwithstanding any other provision of this Agreement, no claim shall be made for damages arising from the failure to provide or the provision of inadequate downstream fish passage facilities or programs, or upstream adult passage facilities, or

both, that might have arisen during the period March 7, 1979, through March 1, 2004.

5. Notwithstanding any other provision of this subsection I.C, any Party may participate in any legislative or administrative proceeding dealing with fish protection or compensation issues provided, that, consistent with this subsection, no Party shall advocate or support the imposition of fish protection, mitigation, or compensation measures at the Wells Project that are different from or in addition to those required by this Agreement until after March 1, 2004.

6. The Parties intend that this subsection I.C shall apply to each and every provision of this Agreement, and therefore the terms of this subsection are hereby incorporated by reference into and shall apply to every other provision of this Agreement as if set out fully in each such provision.

D. RESOLUTION OF DISPUTES

1. Any dispute between the Parties concerning compliance with this Agreement shall be referred for consideration to the Wells Project Coordinating Committee (the Coordinating Committee) established under Section V. The Coordinating Committee shall convene as soon as practicable following issuance of a written request by any Party. All decisions of the Coordinating Committee must be unanimous. In the event the Coordinating Committee cannot resolve the dispute within fifteen (15) days after its first meeting on a dispute, it will give notice of its failure to resolve the dispute to all Parties. Thereafter, if the dispute qualifies

under subsection I.D.2, any Party may request the FERC to refer the dispute to (1) the presiding judge in the Mid-Columbia proceeding; or (2) in the event the Mid-Columbia proceeding is terminated, to the Chief Administrative Law Judge of the Commission; or (3) to the Division of Project Compliance and Administration within the Office of Hydropower Licensing, or its successor (any one of which is hereinafter referred to as the Decisionmaker), in the order listed herein (unless otherwise agreed by the Parties or directed by FERC), for expedited review in accordance with the procedures set forth in this subsection. Any issue in dispute that is not subject to the expedited review process may be referred to the FERC for resolution pursuant to the FERC's Rules of Practice and Procedure.

2. The expedited review process specified in this subsection shall be utilized, unless otherwise agreed pursuant to subsection I.D.5, to resolve any issue(s) in dispute between the Parties that arises under this Agreement where the amount in controversy is less than $325,000 (1988 dollars). For the purpose of this subsection I.D, the amount in controversy shall be determined by calculating the difference between the calculated annual cost of the Joint Fishery Parties' proposal for resolution of the dispute and the calculated annual cost of the PUD's proposal for resolution of the dispute.

3. Under the expedited review process, each Party that desires to present an initial position statement to the Decisionmaker shall file the statement with the Decisionmaker and all other Parties within twenty (20) days of mailing of notice by a

Party that expedited review is requested. Responsive statements shall be filed and served within forty (40) days of the mailing of the notice. The Decisionmaker shall set a date for submission of any briefing, affidavits or other written evidence and a further date for hearing of oral evidence and argument. Except by agreement of all Parties involved in the dispute, the hearing shall be held not later than seventy (70) days after the date of mailing of the requesting Party's notice or as soon thereafter as the Decisionmaker shall be available. The hearing shall be held in Seattle, Portland or any other location agreed upon by the Parties, or mandated, upon a finding of special circumstances, by the Decisionmaker. The Decisionmaker shall decide all matters presented within fifteen (15) days of the hearing or as soon thereafter as possible.

4. All decisions under the expedited review process shall be effective upon issuance and pending appeal, if any. Nothing in this subsection I.D shall limit or restrict the right of any Party to petition the FERC for de novo review of any decision under the expedited review process. All such appeals shall be in accordance with the FERC's Rules of Practice and Procedure.

5. The Parties may agree to refer any issue subject to expedited review to a third party Decisionmaker other than someone within FERC for processing pursuant to this subsection or as otherwise agreed by the Parties.

E. EFFECTIVE DATES

1. Except as otherwise specified in this subsection I.E, this Agreement shall become effective upon the issuance of a final order by the FERC approving this Agreement.

2. Notwithstanding subsection I.E.1 above, the Parties will immediately upon execution of this Agreement, implement the provisions of the Agreement that do not require formal FERC approval.

3. The Parties agree to immediately seek interim approval by the FERC of Section IV of this Agreement in order to implement construction of hatchery facilities.

II. JUVENILE FISH PASSAGE

A. GENERAL SCOPE OF JUVENILE PASSAGE MEASURES

1. Subject to the schedules, criteria, and conditions in this Agreement, the PUD will fund the installation, operation, maintenance, and evaluation of juvenile fish bypass systems and measures at the Wells Project. Bypass systems and measures are those intended to attract and route juvenile salmonids past operating powerhouse generating units.

2. All facilities under this Agreement shall be designed and constructed using quality materials and then current engineering standards for the purpose of obtaining a high quality product designed to require low maintenance and have a long useful life.

B. BYPASS SYSTEM

The PUD will continue to implement a program of controlled spill using five (5) bypass baffles at the Wells Project to meet the criteria set out in subsections II.C, D, and E.

C. NORMAL BYPASS OPERATIONS CRITERIA

1. No turbine will be operated during the juvenile migration period unless the adjacent bypass system is operating according to the following criteria.

2. The five (5) bypass system bays will be Nos. 2, 4, 6, 8, and 10. Operation of the turbines will be in pairs with the associated bypass system bays, as follows:

Turbines Operated	Bypass Bays Operated
1 and/or 2	2
3 and/or 4	4
5 and/or 6	6
7 and/or 8	8
9 and/or 10	10

(For example, if turbines 1, 5, and 6 are operating, bypass systems 2 and 6 will be operating.)

3. At least one bypass will be operating continuously throughout the juvenile migration period, even if no turbines are operating.

4. The bypass systems and spillgates will be operated in configuration K of the 1987 bypass system report (bottom spill, 1 foot spill gate opening, 2,200 cfs, vertical baffle opening) for all bypass system bays.

5. If top spill is shown to be as effective as bottom spill in bypass bays 2 and 10, then top spill will be allowed in these bays.

6. If the Chief Joseph Dam Uncoordinated Discharge Estimate is 140,000 cubic feet per second (140 Kcfs) or greater for the following day, all five bypass systems will be operated continuously for 24 hours regardless of turbine unit operation.

7. If the Chief Joseph Dam Uncoordinated Discharge Estimate is less than 140 Kcfs, bypass system operation will be as follows:

Number Turbines Operating	Minimum Number Bypass Systems Operating
10	5
9	5
8	4
7	4
6	3
5	3
4	2
3	2
2	1
1	1
0	1

D. BYPASS OPERATIONS TIMING CRITERIA

1. Bypass systems will be in place at least two (2) weeks prior to preseason forecasted beginning of juvenile migration.

2. Bypass systems will remain in place for at least two (2) weeks after the juvenile migration period ends.

3. Monitoring of fish runs will begin when bypass baffles are in place and will end when the baffles are removed.

4. Bypass systems will be available to operate continuously, 24 hours per day, during the juvenile migration period.

E. BYPASS PERFORMANCE CRITERIA

1. At a minimum, bypass system operations will be provided as described in subsections II.B, C, and D for the entire juvenile migration period as defined in the annual operations plan under subsection II.F, and subject to the provisions of subsection II.F.3.

2. Bypass operations as described in subsections II.B, C, and D are intended to provide fish passage efficiency (FPE) of at least eighty percent (80%) for the juvenile spring migration, and FPE of at least seventy percent (70%) for the juvenile summer migration. For purposes of this Agreement, FPE is expressed by the following formula:

Where A = Sum of daily migrants successfully passed by the device during the spring or summer migration

and B = Sum of daily migrants passing through the turbine unit intakes during the same migration

$$FPE = \frac{A}{A + B} \times 100$$

3. If bypass operations under subsections II.B, C, and D do not meet the minimum FPE levels specified in subsection II.E.2, the PUD will modify those operations by implementing one or more of the following measures:

(a) Change in configuration or addition of lights or other physical changes.

(b) Change in "normal operation" under subsection II.C to operation of five bypass system bays at forecast flow of 120 Kcfs.

4. Unless and until these modifications are in place to meet the minimum FPE levels specified in subsection II.E.2, or if these modifications are not sufficient to meet the FPE levels specified therein, then the PUD will increase spillbay bypass flow up to two times normal operation (up to a total of 4.4 Kcfs) per bypass at night (1 hour before sunset to sunrise) for the period:

(a) During which 80% of the spring migration pass the Wells Project;

(b) During which 80% of the summer migration pass the Wells Project, or for 40 days, whichever is less.

5. If portions of the runs do not receive protection at the minimum FPE levels specified under subsection II.E.2, then compensation will be provided based on the difference between the minimum FPE levels specified in subsections II.E.2 and 3 and the actual FPE achieved during the evaluation provided under subsections II.H.1 and 2. The appropriate level of compensation will be calculated based on actual loss. The form of this additional compensation (i.e., fish production) will be determined by the Joint Fishery Parties in consultation with the PUD.

F. <u>ANNUAL OPERATIONS PLANS</u>

1. The PUD will develop an annual bypass systems operations plan consistent with the criteria in subsections II.B, C, D, and E in consultation with the Joint Fishery Parties by the December prior to each migration period. The plan will be reviewed and approved by the Coordinating Committee by March 1 of each year. The plan will be developed from inseason projected hatchery release

dates from facilities above Wells and previous passage monitoring data. The plan will contain predicted dates for the beginning and end of the juvenile migration period; criteria for identifying the beginning and end of the spring and summer runs; and procedures for bypass operations within the constraints of subsections II.B, C, D, and E, including dates for installation and removal of spill baffles, dates for run time monitoring, and criteria for initiation and cessation of bypass operations. If unanimous agreement cannot be reached within the Coordinating Committee regarding all items in the plan, disagreements will be resolved by expedited dispute resolution under subsection I.D.

2. A Bypass Team will be established composed of one representative each for the Party fishery agencies, the Party tribes, and the PUD.

3. Notwithstanding the provisions of subsections II.F.1 and 2 above, the Bypass Team may agree to relax the operations and performance criteria of subsections II.C and E for a period between the end of the juvenile spring migration and the beginning of the juvenile summer migration. Such a modification can only be made with the agreement of all of the members of the Bypass Team, and will be limited to one or more of the following measures:

(a) Less than continuous 24-hour operation of bypass systems.

(b) Fewer than one bypass system operated for two adjacent turbines operated.

(c) Less than 1 foot spill gate slot opening.

4. Once the annual bypass plan is adopted, decisions regarding adjustments to the plan will be made by unanimous agreement of the Bypass Team. If unanimous agreement cannot be reached, the decision on such adjustments will be by majority vote of the Bypass Team.

G. ANNUAL PASSAGE MONITORING PLAN

1. The PUD shall develop an Annual Passage Monitoring Plan, in consultation with the Joint Fishery Parties for review and approval by the Coordinating Committee by March 1 of each year. The Plan will include development of inseason indices of relative fish abundance on a daily basis and annual estimates of juvenile migrant production. Estimates of relative abundance will be used to guide bypass operations decisions under subsections II.E.4, II.F.1, II.F.3, and II.F.4. Estimates of juvenile migrant production will be used as the basis for compensation adjustments (Hatchery-Based Compensation - Phase IV) as provided in subsection IV.A.3.

H. FPE EVALUATION PLAN

1. The PUD shall develop an FPE evaluation plan, in consultation with the Joint Fishery Parties, for review and approval by the Coordinating Committee by March 1, 1990. The purpose of the plan shall be to evaluate whether minimum FPE levels set out in subsection II.E are being met. The plan will provide for evaluation beginning in 1990 and continuing for at least three consecutive years after baffles are installed and operating in accordance with this Agreement in all five (5) bypass bays. If physical or

operational changes are made to the bypass systems, additional FPE evaluation under a new or amended plan will be required to provide at least three consecutive years of evaluation after completion of the changes.

2. It is the goal of evaluations under the plan to be able to determine FPE within plus or minus five percent (5%) at the ninety-five percent (95%) confidence level. If the FPE point estimates are equal to or greater than eighty-five percent (85%) for the spring run and seventy five percent (75%) for the summer run, then the accuracy of plus or minus ten percent (10%) at the ninety percent (90%) confidence level is acceptable. If the FPE point estimate for the spring run is between eighty (80) and eighty-five (85) percent, or the FPE point estimate for the summer run is between seventy (70) and seventy-five (75) percent, the PUD will implement one of the following actions:

(a) Take the necessary steps to achieve a FPE accuracy of plus or minus five percent (5%) at the ninety-five percent (95%) confidence level, or

(b) Take steps outlined in subsection II.E.3 to increase the FPE point estimates to eighty-five percent (85%) and seventy-five percent (75%) for the spring and summer runs, respectively.

3. The PUD will fund a biometrician or statistician selected by unanimous agreement of the Coordinating Committee to review the draft plan to ensure that the plan meets the objectives of subsections II.H.1 and 2, and to review results developed under the plan.

III. ADULT FISH PASSAGE

A. GENERAL SCOPE OF ADULT PASSAGE MEASURES

The current operating and maintenance criteria for facilities for the passage of adult anadromous fish over the Wells Project Dam are specified in this Section III. Changes in these criteria must be by unanimous agreement of the Coordinating Committee.

B. WATER DEPTH CRITERIA

The water depth over the weirs of the adult fish ladder will be 1.0 to 1.2 feet.

C. ENTRANCE CRITERIA

1. Head: 1.5 feet

2. Gate Settings:

a) March 1 - November 30

	Side Wing Gate	End Wing Gate
(i) Spill less than 80 Kcfs	4 ft	6 ft
(ii) Spill greater than 80 Kcfs	Closed	8 ft

(iii) Low level fixed orifice entrance to be open whenever side gate is closed.

b) December 1 - February 28

(i) Side and end gates open 2 feet six days per week for 24-hour periods.

(ii) Side and end gates open 4 feet and 6 feet, respectively, one day per week for a 24-hour period.

D. ATTRACTION JET CRITERIA

1. Jets are located in a vertical line immediately upstream of the side wing gates.

2. Lower jet (30-inch diameter) will operate only when the low level fixed orifice entrance is open.

3. Three 24-inch diameter jets (at elevations 700, 708, and 717 msl) will each be discharging when tailwater reaches that level.

E. STAFF GAUGE AND WATER LEVEL INDICATOR CRITERIA

Staff gauge and water level indicators will:

1. Be located upstream and downstream of all entrances, and at convenient locations for viewing along ladder.

2. Be located upstream and downstream of adult fishway exit trashrack.

3. Be readable at all water levels and be kept clean.

4. Be checked against panel board water surface readings to insure proper adjustment of water level sensing equipment.

F. TRASHRACK CRITERIA

1. Visible buildups of debris will be cleaned immediately from picketed leads near counting stations, and from trashracks at adult fishway exits.

2. The staff gauges upstream and downstream of the adult fishway exit trashrack will be monitored for water surface differential, which will reflect buildup on submerged trashrack. The trashrack will be cleaned immediately if the differential reading is greater than 0.3 feet.

G. MONITORING AND EVALUATION OF ADULT PASSAGE

1. In 1990, the PUD, in consultation with the Joint Fishery Parties, will develop a study plan to determine the extent of adult

delay and mortality at the Wells Project. The study plan will be reviewed and approved in advance by the Coordinating Committee. Studies will begin in 1991 and continue for a period of time determined by the Coordinating Committee based on preliminary results.

2. If the study identifies delays and/or mortality, the operating criteria specified in this Section III will be changed to alleviate these problems. If changes in the operating criteria do not alleviate the problems, adult passage facility modifications will be made. Provided, however, that any disagreements over the appropriateness of facility modifications of $325,000 or less (1988 dollars) may be taken through the expedited dispute resolution procedure in subsection I.D. And, provided further, that any disagreements over the appropriateness of facility modifications of more than $325,000 (1988 dollars) may be resolved under the FERC Rules of Practice and Procedure at any time.

IV. HATCHERY-BASED COMPENSATION

The PUD will fund a hatchery-based compensation program (the "Program") as provided in this Section IV. The Program will include the design, construction, operation, maintenance and evaluation of facilities required to implement the elements of a production plan (the "Production Plan") as set forth in this Section. The purpose of the Program is to mitigate for fish passage losses at Wells Dam. The Program is composed of adult collection sites; a central hatchery facility for incubation, early

rearing, and adult holding; and acclimation facilities in the tributaries above Wells Dam for final rearing and release.

A. PRODUCTION PLAN

1. The Joint Fishery Parties have developed the Production Plan to define the requirements of hatchery-based compensation under this Agreement. The Production Plan describes juvenile rearing and release requirements, including species mix and target release sizes; and related broodstock requirements under subsection IV.D.

2. The Production Plan will be reviewed annually by the Joint Fishery Parties, and may be modified by the Joint Fishery Parties in consultation with the PUD. Modifications to the Production Plan may include changes to the species mix and rearing and release strategies as required to accommodate the Joint Fishery Parties' management needs. Modifications to the Production Plan will not require an increase in the rearing capability of the Program beyond that required to satisfy Phases One and Two of the Production Plan as shown in subsections IV.A.3(a) and (b) or Phases Three and Four of the Production Plan to be determined as shown in sections IV.A.3(c) and (d). The Production Plan and any modifications thereto will be consistent with guidelines and procedures developed under the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program.

3. The Production Plan is comprised of four phases of hatchery-based compensation as described below. It also includes related broodstock requirements under subsection IV.D.

(a) Phase One

Phase One will begin in 1991 and will consist of the following compensation elements:

(1) 49,200 pounds of spring chinook yearlings at about 15/pound;

(2) 8,000 pounds of sockeye juveniles at about 25/pound; and

(3) 30,000 pounds of steelhead smolts at about 6/pound

(4) After 1991, space to rear additional steelhead will be provided by the PUD at Wells Hatchery, if such space is available and not needed to meet other PUD fish production responsibilities. The PUD will not be obligated to fund or supply well water to rear the fish.

(b) Phase Two

Phase Two will begin after evaluation of the Phase One Production Plan and will be restricted to the Program required by either the Phase Two A or Two B Production Plan as shown below. At the time of implementation, the Phase Two A or Phase Two B Production Plan may be modified based on other Phase One evaluations described in subsection IV.C, Studies and Evaluations, subject to the provisions of subsection IV.A.2.

(1) Phase Two A

Increase sockeye production from 8,000 pounds to 15,000 pounds of juveniles at about 25/pound.

(2) Phase Two B

(i) Eliminate sockeye production;

(ii) Add 15,000 pounds of summer chinook yearlings at

about 10/pound; and 6,500 pounds of zero-age summer chinook juveniles at about 40/pound.

(c) Phase Three

Phase Three will begin as soon as practicable following Coordinating Committee approval of the results of the Wells Project juvenile mortality/survival study or no later than the third brood year after Coordinating Committee determination of the adjustments required and will consist of the following compensation elements:

(1) Except for steelhead, which shall remain at 30,000 pounds, adjust compensation requirement to reflect the difference between the juvenile mortality rate determined by the mortality/survival study under subsection IV.C.5 and the assumed mortality rate shown in Appendix A; and

(2) Adjust compensation requirement to reflect unavoidable and unmitigated adult losses, as determined by Coordinating Committee approved estimates from studies conducted under subsection III.G, and converted to juvenile production based on adult to smolt ratio estimates as described in Appendix B.

(d) Phase Four

Phase Four will begin at such time as the Coordinating Committee approved five-year rolling average estimate of juvenile run size, estimated as described in subsection IV.C.6 and Appendix A, increases to at least 110% of the 9,034,700 estimated juvenile migrant salmon production used to establish the Phase One and Phase Two compensation levels shown in subsections IV.A.3(a) and

IV.A.3(b). Phase Four will consist of compensation adjustment, if requested by the Joint Fishery Parties, to reflect the percentage increase in juvenile run size, except for steelhead, which shall remain at 30,000 pounds. The Joint Fishery Parties, in consultation with the PUD, will determine the appropriate form of compensation (i.e., fish production) for any adjustments required in Phase Four.

B. COMPENSATION PROGRAM

1. The facilities provided in the Program will be designed, constructed, operated, maintained, and evaluated to produce the hatchery-based compensation set forth in the Production Plan.

2. If the evaluations described in subsection IV.C indicate that the Program is not meeting the production levels called for in the Production Plan, then reasonable modifications to the Program will be made.

3. The PUD will only be obligated to assure the capability of facilities provided under this Agreement to produce high quality juvenile fish at the compensation levels shown in subsection IV.A.3.

4. The Program facilities described in this Agreement are in addition to the existing mitigation program at Wells. The existing mitigation program at Wells consists of annual production of 50,000 pounds of steelhead and 56,500 pounds of summer chinook salmon. Under the 1984 Mid-Columbia Stipulation, which expired in 1989, 400,000 summer chinook at 90/pound have been reared at Wells for release into the Methow River. This production will continue until

Phase One production is initiated. Nothing in this Agreement will affect the annual production of 25,000 pounds of steelhead under the Oroville-Tonasket agreement between the PUD and the U.S. Bureau of Reclamation.

5. Facilities provided in the Program will consist of:

(a) Phase One

Phase One compensation facilities, including satellite facilities, shall be capable of rearing and releasing 57,200 pounds of salmon and 30,000 pounds of steelhead annually.

(b) Phase Two

Phase Two compensation facilities shall be capable of increased production to accommodate the Production Plan as described in subsection IV.A.3(b).

(c) Phase Three

Phase Three compensation facilities shall be capable of production levels to reflect the compensation adjustments which may be required as described in subsection IV.A.3(c).

(d) Phase Four

Phase Four compensation facilities shall be capable of production levels to reflect the compensation adjustments which may be required as described in subsection IV.A.3(d). Facilities for the required adjustments will be constructed by the PUD as soon as practicable and be operational no later than the third brood year following the Joint Fishery Parties request under subsection IV.A.3(d).

6. Production and acclimation facilities used in the Program shall be consistent with planning efforts underway by the Northwest Power Planning Council to the fullest extent practicable. The biological criteria and guidelines described in subsection IV.D shall apply to production and acclimation facilities used in the Program.

C. STUDIES AND EVALUATIONS

1. The PUD will develop and fund studies in 1990, approved by unanimous agreement of the Coordinating Committee, to determine:

(a) Potential for spawning and rearing sockeye in unutilized habitat in the Okanogan and Similkameen systems;

(b) Potential for establishing sockeye populations in the new habitat.

2. The PUD will fund the Joint Fishery Parties' effort to determine the success of Phase One sockeye compensation based on review of smolt production. The Joint Fishery Parties may make this determination after the evaluation of the third brood year's production.

3. The PUD will fund the Joint Fishery Parties to develop and conduct studies to evaluate the adequacy of the Program and the effectiveness and success of the Production Plan subject to the provisions of Section V, Coordinating Committee. The studies will meet standards developed for similar efforts under the Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program. The studies will pass the test of reasonableness with respect to cost and duration.

(a) The studies will involve marking a portion of the juvenile fish produced under subsection IV.B and will involve recoveries of juvenile and adult fish to estimate various parameters such as fish health, fishery contribution, survival, spawning time and spawning locations.

(b) The PUD will fund recovery efforts at Wells Dam and hatchery and tributary spawning areas above Wells Dam. Existing recovery operations, currently funded through different sources, will be utilized to the extent possible. Approved studies may require the PUD's participation in funding a portion of other recovery efforts.

(c) The evaluations provide data necessary to determine the success of the Program to produce the intended compensation levels and the effectiveness of the Production Plan to meet management objectives.

(d) Evaluation of the Production Plan and Program effectiveness will be initiated in Phase One for all species in the Production Plan.

(e) To the extent that the Joint Fishery Parties elect to modify the Production Plan, the PUD will fund studies to evaluate the modifications. The studies will be mutually agreeable and are intended to evaluate only the changes called for in the modification. The studies will be consistent with the provisions of Section V, Coordinating Committee.

(f) The PUD will fund an analysis of annual fish production and adult contribution to harvest and escapement to be conducted

by the Joint Fishery Parties. The analysis will be consistent with the provisions of Section V, Coordinating Committee. Draft and final reports will be provided to the Parties.

5. No later than 1990, a Wells Project juvenile mortality/survival study will be developed by the PUD in consultation with the Joint Fishery Parties and approved by unanimous agreement of the Coordinating Committee. The studies will begin in 1991, after the installation of new turbine runners at the Wells Project, for the purpose of determining juvenile losses.

6. The PUD will provide data from its ongoing, annual adult passage monitoring program that will allow the Joint Fishery Parties to compute the five-year rolling average estimate of juvenile run size which will be the basis for Phase Four compensation, as indicated in subsection IV.A.3(d). Calculation of increases in juvenile run size will be based on fish from existing mitigation programs, natural production and future compensation programs. The method of calculation will be as described in Appendices A and B.

D. PRODUCTION/ACCLIMATION FACILITIES

Production and acclimation facilities under this Section shall be consistent with planning efforts underway by the Northwest Power Planning Council to the fullest extent practicable. The following biological criteria and guidelines shall apply to production and acclimation facilities under this subsection IV.D. Criteria are not to be exceeded. Guidelines are not to be exceeded if practicable.

1. Salmon Criteria

(a) Adult Holding

(i) Density not to exceed one (1) fish per ten (10) cubic feet of space.

(ii) Flow must be at least one (1) gallon per minute per 20 pounds of fish.

(b) Juvenile Rearing

(i) Density not to exceed 0.75 pounds of fish per cubic foot of rearing space for yearling chinook to a size of 10 fish per pound. Maximum density is achieved at release date. The density through out the rearing period is proportionately lower and directly related to fish size.

(ii) Pond or raceway loading rate not to exceed 6.0 pounds of fish per gallon of water per minute inflow for yearling chinook at a size of 10 fish per pound. Maximum loading rate is achieved at release date. The loading rate throughout the rearing period is proportionately lower and directly related to fish size.

(iii) Density for sockeye juveniles in net pens not to exceed 0.33 pounds of fish per cubic foot of rearing space.

(c) Water Supply

(i) Water will be of highest quality practicably available at appropriate sites. Ground water may be required at sites. All water supplies will be pathogen free if practicable. The water source must not preclude transfer of the stocks being reared to their point of origin due to presence of fish disease organisms in the rearing water supply.

(ii) Reuse of water is not acceptable for either egg incubation or juvenile rearing.

(iii) Reuse water is acceptable for adult holding.

(iv) Effluent water from egg incubation may require treatment for fish diseases (e.g., chlorination/dechlorination).

(v) Construction of facilities must accommodate the potential to treat the juvenile rearing and adult holding water for disease pathogens.

(d) General

(i) Facilities must have the capability to maintain stock segregation from adult holding through incubation and rearing.

(ii) Facilities must have reasonable capability to provide for isolation and treatment of diseased fish.

(iii) Protection from mammalian and avian predators must be provided.

2. Salmon Guidelines

(a) Water Temperatures

(i) Egg incubation - no greater than 55°F nor less than 38°F.

(ii) Fry starting - 48-52°F.

(iii) Juvenile rearing - not to exceed 52°F.

(iv) Adult holding - not to exceed 55°F.

(b) Release Size, Time, and Location

(i) Yearling spring chinook - 15 fish/pound in late April.

(ii) Yearling summer chinook - 10 fish/pound in late April.

(iii) Subyearling summer chinook - 40 fish/pound in June.

(iv) Subyearling sockeye - 25 fish/pound in June.

(v) Juvenile fish will be acclimated and released in tributaries above Wells Dam.

(c) Adult Brood Stock

(i) Sufficient adults of the appropriate species and stocks will be trapped and held to meet the egg requirements for each phase of salmon production.

(ii) Fifty percent (50%) of the adults trapped will be females and it is assumed there will be

approximately eighty percent (80%) survival of eggs from trapping of females to ponding of fry.

(iii) Adult brood stock will be collected at the following sites:

a) Spring chinook - Chewack River, Methow River above Winthrop, and Twisp River above river mile 2.0.

b) Summer chinook and sockeye - at Wells Dam

(iv) Tributary brood stock collection facilities will require an annually installed rack and a semi-permanent box trap.

(v) Wells Dam brood stock collection may require a separator/sorter in the left bank fishway. The final design of the left bank trap and any modification of the right bank trap will be approved by unanimous agreement of the Coordinating Committee.

(vi) The adults will be transferred in a water-to-water system from traps to tank trucks to holding ponds.

(vii) The PUD shall provide funds for personnel to separate and sort adult fish in the right bank fishway at Wells Dam and at other required adult collection sites. All brood stock collection shall be conducted in a manner to

minimize delay of non-target species and individual fish.

3. Steelhead Criteria

The goal for this program is to use the existing facilities including well and river water, raceways, rearing ponds, house, shop, freezer, office, etc., in the manner they are being used now. Most of the following criteria and guidelines fit the existing program.

(a) Adult Holding

(i) Density not to exceed 2.5 pounds of fish per cubic foot of water.

(ii) Flow must be at least one gallon per minute for 3.3 pounds of fish.

(b) Juvenile Rearing

(i) Density: Calculated density limit not to exceed Pipers density formula: $W = D \times V \times L$ where

W = Permissible weight in pounds.

D = Density index (.25 for raceways and .03 for rearing ponds).

V = Useable volume in container in cubic feet.

L = Fish length in inches.

ii) Water flow: Calculated flow should not allow weight to exceed Pipers flow formula:

$W = F \times L \times I$ where

W = Permissible weight in pounds.

F = The loading factor from Table 1.

L = Fish length in inches.

I = Water flow in gallons per minute.

Table 1. Load factor as related to water temperature and elevation.

Water Temperature(°F)	Load Factor(lbs/in/gpm) Raceways(1)	Rearing Ponds(2)
40	2.70	3.62
41	2.61	3.53
42	2.52	3.44
43	2.43	3.35
44	2.34	3.26
45	2.25	3.17
46	2.16	3.08
47	2.07	2.99
48	1.98	2.90
49	1.89	2.81
50	1.80	2.72
51	1.73	2.65
52	1.67	2.59
53	1.61	2.53
54	1.55	2.47
55	1.50	2.42
56	1.45	2.37
57	1.41	2.33
58	1.36	2.28
59	1.32	2.24
60	1.29	2.21
61	1.25	2.17
62	1.22	2.14
63	1.18	2.10
64	1.15	2.07

1) From Piper et al. 1978
2) From Wells hatchery

(c) Water Supply

(i) Water supply to be of highest quality practicably available using ground and river water. Any disease contracted because of water source

must not stop release of fish in local watersheds.

(ii) Reuse water not acceptable for egg incubation.

(iii) Reuse water normally acceptable (unless disease problem) for adult holding.

(iv) Effluent water from egg incubation will require treatment for fish diseases.

(v) Adult holding and juvenile rearing water may have to be treated for disease pathogens.

(d) General

(i) Facilities must have reasonable capability to provide for isolation and treatment of diseased fish.

(ii) Protection from mammalian and avian predators must be provided.

4. Steelhead Guidelines

(a) Water Temperatures

(i) Egg incubation: 38°F to 55°F

(ii) Fry starting: 48°F to 54°F

(iii) Juvenile Rearing not to exceed 57°F

(iv) Pre-smolt not to exceed 54°F

(v) Adult holding not to exceed 54°F

(b) Release age, time, size and location

(i) Released as yearlings

(ii) April 10 to May 10 at six to the pound.

(iii) Juvenile steelhead will be released in tributaries or into the mainstem above Wells Dam.

(c) Adult Broodstock

(i) Fifty percent (50%) will be females and assume eighty percent survival of eggs to ponding of fry.

(ii) Adults will normally be trapped at the existing facilities on the right bank, however new trap at left bank may be used sometimes.

(iii) Adults will be transferred in water from traps to holding ponds.

V. WELLS PROJECT COORDINATING COMMITTEE

A. COORDINATING COMMITTEE

There shall be a Wells Project Coordinating Committee composed of one (1) technical representative of each Party to this Agreement. The Coordinating Committee shall meet whenever requested by any two (2) Parties following a minimum of ten (10) days written notice (unless waived), or pursuant to subsection I.D, and shall act only by unanimous agreement of all Parties. Any Joint Fishery Party may, at any time, elect by written notice not to participate in the Coordinating Committee. The PUD shall fund a neutral third party to record and distribute minutes of Coordinating Committee meetings.

B. USE OF COMMITTEE

The Coordinating Committee will be used as the primary means of consultation and coordination between the PUD and the Joint Fishery Parties in connection with the conduct of studies and implementation of the measures set forth in this Agreement and for dispute resolution pursuant to subsection I.D. All study designs and modifications to study designs will be subject to agreement by all Parties.

C. STUDIES AND REPORTS

1. All studies and reports prepared under this Agreement will be available to all Parties as soon as reasonably possible. Draft reports will be circulated through Coordinating Committee representatives for comment, and comments will either be addressed in order or made an appendix to the final report.

2. All studies will be conducted following accepted techniques and methodologies in use for similar studies in the Columbia Basin. All studies will be based on sound statistical design and analysis.

3. Fish passage efficiency tests will be conducted using hydroacoustic means and direct capture methods for species identification.

VI. JOINT FISHERY PARTIES' RESPONSIBILITIES

A. LIMITATION OF MID-COLUMBIA PROCEEDING

The Joint Fishery Parties agree to join with the PUD to request that the FERC terminate the Mid-Columbia proceeding insofar

as it pertains to the Wells Project. The Parties specifically agree to reserve the right to enforce the terms and conditions of this Agreement before the FERC.

B. SUPPORT FOR RELICENSE

The PUD's FERC license for the Wells Hydroelectric Project expires in 2012. The Joint Fishery Parties agree to be supportive of the PUD's new or renewal license application to the FERC, provided that the PUD has adhered to the terms and conditions of this Settlement Agreement, as well as any future terms, conditions, and obligations agreed upon by the Parties hereto or imposed upon the PUD by the FERC. To the extent that the PUD has met such terms and conditions, the Joint Fishery Parties agree that the PUD is a competent license holder with respect to its obligations to anadromous fish resources. Nothing in this paragraph shall limit or preclude any Party hereto from requesting at the time of any license renewal the provision of or supporting different, modified or additional fish protection measures and compensation; or from requiring that the fishery protection measures contained in a competing license application be included as a condition of the PUD's new license, or in the absence of such additional or modified measures in a new license, or in the absence of measures contained in a competing license application requested by the Joint Fishery Parties, from requesting that the PUD's new or renewal license application be denied.

C. STIPULATION OF ADEQUACY

The Joint Fishery Parties stipulate that the performance of the PUD's responsibilities under this Agreement constitutes adequate fish protection and full compensation for all fishery losses caused by the Wells Project at least until March 1, 2004. It is further stipulated that this Agreement satisfies any obligations of any Party relating to the adequacy of fish protection and compensation for fish losses caused by the Wells Project, and arising under applicable laws and regulations, including but not limited to the Federal Power Act, the Pacific Northwest Electric Power Planning and Conservation Act, and the Electric Consumers Protection Act of 1986, at least until March 1, 2004. This Agreement shall not otherwise affect the rights of any Party except as expressly covered by this Agreement.

D. FISH AND WILDLIFE PROGRAM

The Joint Fishery Parties stipulate that the performance of the PUD's responsibilities under this Agreement shall constitute full compliance with the applicable provisions of the Northwest Power Planning Council's 1987 Fish and Wildlife Program, at least until March 1, 2004. The Joint Fishery Parties stipulate that the PUD shall receive full credit for its hatchery production in meeting any requirements that may be established as a result of implementation of Section 203 of the Council's Program.

E. LIMITATION ON REOPENING

The Joint Fishery Parties shall not invoke or rely upon any reopener clause set forth in any license applicable to the Wells

Project for the purpose of obtaining additional fish measures or changes in project structures or operations pertaining to fishery issues until after March 1, 2004.

F. ADDITIONAL MEASURES

The Joint Fishery Parties shall refrain from contending on their own behalf or supporting any contention by other persons in any proceeding or forum that additional fish measures or changes in project structures or operations pertaining to fishery issues should be imposed at the Wells Project until after March 1, 2004.

VII. MISCELLANEOUS

A. COOPERATION

The Parties shall cooperate in conducting studies and shall provide assistance in obtaining any approvals or permits which may be required for implementation of this Agreement.

B. NOTICES

All written notices to be given pursuant to this Agreement shall be mailed by first-class mail, postage prepaid, to each Party at the address listed below or such subsequent address as a Party shall identify by written notice to all other Parties. Notices shall be deemed to be given three (3) days after the date of mailing.

C. WAIVER OF DEFAULT

Any waiver at any time by any Party hereto of any right with respect to any other Party with respect to any matter arising in

connection with this Agreement shall not be considered a waiver with respect to any subsequent default or matter.

D. ENTIRE AGREEMENT -- MODIFICATIONS

All previous communications between the Parties hereto, either verbal or written, with reference to the subject matter of this Agreement are hereby abrogated, and this Agreement duly accepted and approved, constitutes the entire agreement between the Parties hereto, and no modifications of this Agreement shall be binding upon any Party unless executed or approved in accordance with the procedures set forth in subsection I.C.

E. BENEFIT AND ASSIGNMENT

This Agreement shall be binding upon and inure to the benefit of the Parties hereto and their successors and assigns provided, no interest, right or obligation under this Agreement shall be transferred or assigned by any Party hereto to any other Party or to any third party without the written consent of all other Parties, except by a Party:

(a) To any person or entity into which or with which the Party making the assignment or transfer is merged or consolidated or to which such Party transfers substantially all of its assets; or

(b) To any person or entity that wholly owns, is wholly owned by or is wholly owned in common with the Party making the assignment or transfer.

F. FORCE MAJEURE

The PUD shall not be liable for failure to perform or for delay in performance due to any cause beyond its reasonable control. This may include, but is not limited to, fire, flood, strike or other labor disruption, act of God, act of any governmental authority or of the Joint Fishery Parties, embargo, fuel or energy unavailability, wrecks or unavoidable delays in transportation, and inability to obtain necessary labor, materials or manufacturing facilities from generally recognized sources in the applicable industry. The PUD will make all reasonable efforts to resume performance promptly once the force majeure is eliminated.

G. INFLATION CALCULATIONS

All dollars specified in this Agreement are 1988 dollars. Dollar figures shall be adjusted annually for each year after 1988 based on the "Consumer Price Index for All Urban Consumers" published by the Bureau of Labor Statistics of the U.S. Department of Labor. If this index is discontinued or becomes unavailable, a comparable index agreeable to all Parties will be substituted.

H. METHOW RIVER HATCHERY WATER SUPPLY

1. The PUD agrees to cooperate with the Washington Department of Fisheries (WDF) to secure the necessary water rights and permits for facilities to be provided under this Agreement.

2. With respect to the proposed Methow River hatchery, the Parties agree that WDF and the PUD may utilize for the proposed Methow River hatchery facility up to 7 cfs of the water right now

held by the U.S. Fish and Wildlife Service (FWS), and subject to full or partial recall by FWS for any reason. The PUD shall not obtain legal title or ownership of the FWS water right.

3. To the extent that the utilization of water does not occur or is recalled or returned to FWS, the PUD and WDF shall use their best efforts to acquire an alternative source of water that meets applicable State requirements for water rights in order to satisfy obligations under this Agreement.

4. The PUD agrees to cooperate with WDF to secure the necessary permits in order to construct and provide for the operation of the proposed Methow River hatchery. The hatchery will be designed and constructed with the capability of installing pump-back facilities for returning the flow to the point of diversion.

5. If hatchery and/or river water supply requirements dictate the need for installation of a pump-back scheme, the PUD shall install and WDF shall operate the pump-back facilities.

VIII. REGULATORY APPROVAL

A. FERC ORDERS

All Parties agree to join in the filing of an offer of settlement with the FERC based on this Agreement and to request that the FERC issue appropriate orders approving the settlement. All Parties shall refrain from seeking judicial review of the FERC orders approving this Agreement.

B. PERFORMANCE CONTINGENT ON APPROVAL

Performance of all Parties' obligations under this Agreement

is expressly made contingent on obtaining all necessary regulatory approvals, specifically including all FERC orders referred to in subsection VIII.A above, and all applicable federal, state and local permits. It is expressly agreed by all Parties that this Agreement shall be submitted to the FERC as a unit and any material modification of its terms, approval of less than the entire Agreement, or addition of material terms by the FERC shall make this Agreement voidable at the option of any Party.

C. NO PREJUDICE

All Parties stipulate that neither FERC approval nor any Party's execution of this Agreement shall constitute approval or admission of, or precedent regarding, any principle, fact or issue in the Mid-Columbia proceedings, or any other FERC proceeding, including subsequent modification proceedings under Section I.

D. EXECUTION

This Agreement may be executed in counterparts. A copy with all original executed signature pages affixed shall constitute the original Agreement. The date of execution shall be the date of the final Party's signature. Approval of this Agreement must be acknowledged by the Commissioner of Indian Affairs and the Secretary of the Interior, or their delegates, to the extent required by 25 U.S.C. § 81.

E. AUTHORITY

Each Party to this Agreement hereby represents and acknowledges that it has full legal authority to execute this Agreement and shall be fully bound by the terms hereof.

F. ACTION FOR NONCOMPLIANCE

Notwithstanding any other provision of this Agreement, any Party may seek relief arising solely from noncompliance with this Agreement by any Party; provided, all requests for specific performance of any provision of this Agreement shall be filed with the FERC pursuant to subsection I.D.

IN WITNESS WHEREOF, the Parties have executed this Agreement the day and year first written above.

APPENDIX A

JUVENILE MIGRANT LOSS ESTIMATES USED FOR COMPENSATION PLANS IN THE WELLS DAM SETTLEMENT AGREEMENT

1. Steelhead

The number of juvenile steelhead migrants killed by passage through the Wells Project reservoir and dam were not estimated for the purposes of this Settlement Agreement. As an alternative the parties have agreed to continue steelhead production programs and plans initiated under previous Mid-Columbia settlements.

2. Salmon Loss Estimates

The number of juvenile salmon migrants killed by passage through the Wells Project reservoir and dam were estimated as follows:

a. The number of juvenile migrant salmon, by species and race, entering the Wells Reservoir was estimated for natural production by applying sex ratios, egg per female data and theoretical egg to migrant survival rates to the numbers of adults passing above Wells Dam to spawn. These juvenile migrant numbers were computed annually and averaged over the passage years 1975-1984 for spring and summer chinook and averaged over the passage years 1975-1986 for sockeye. The recent average level of hatchery releases at Winthrop National Fish Hatchery were added to the spring chinook migrant estimates. The resulting estimates of average annual numbers

of juvenile migrant salmon entering Wells reservoir are:

Spring Chinook	=	1,504,400
Summer Chinook	=	2,913,300
Sockeye	=	4,617,000
Total	=	9,034,700

b. The total project mortality at Wells, including reservoir mortality, was estimated to be 14%. Applying this mortality rate to the population estimates in Item 1 above results in the following estimates of juvenile migrants killed by species:

Spring Chinook	=	210,600
Summer Chinook	=	407,900
Sockeye	=	646,400
Total loss	=	1,264,900

3. Derivation of Production Plan

a. The Phase I compensation Production Plan and Program is an initial step in production which is not intended to provide full compensation for juvenile migrant losses. The lack of full compensation is due to the experimental nature and developmental aspects of the sockeye Production Plan and Program.

b. To accommodate logistic and per-unit cost factors in Phase I development, about 225,000 (15,000 pounds) spring chinook were substituted for 231,000 sockeye.

c. Items (1) through (3) below describe the derivation of the hatchery-based compensation levels included in the body of the Agreement.

(1) Steelhead production is set at 30,000 lbs./year to continue the successful program initiated under prior Mid-Columbia Settlement Agreements.

(2) Phase I compensation includes a pilot program for hatchery production of sockeye. The sockeye production level is set to allow assessment of Program success rather than provide full compensation for the estimated juvenile losses at Wells.

(3) The Phase II Chinook/Sockeye Production Plan is sized to mitigate for estimated juvenile losses:

	Estimated Annual Losses at Wells	Annual Production Phase IIA or Phase IIB	
Spring Chinook	210,600	450,000	450,000
Summer Chinook	407,900	400,000	810,000
Sockeye	646,400	375,000	-
TOTALS	1,264,900	1,225,000	1,260,000

4. Chelan PUD/Douglas PUD Compensation Exchange

In recognition of the specific requirements for spring and summer chinook rearing facilities and the characteristics of the water supply at the PUD's proposed spring chinook rearing facility on the Methow River, the Joint Fisheries Parties, Douglas PUD and Chelan County PUD have reviewed the respective compensation

obligations of Douglas PUD as set forth in this Agreement, and Chelan County PUD under terms of the Rock Island Settlement. In consideration of biological efficiency and logistical effectiveness, the parties have agreed to adjusted compensation obligations under this agreement and the Rock Island Settlement in the following manner:

a. Douglas PUD will assume responsibility for 19,200 pounds of Methow River sub-basin spring chinook production.

b. Chelan PUD will assume responsibility for 40,000 pounds of Methow River summer chinook production.

The resulting changes in production with the Douglas-Chelan compensation exchange agreement are (number of juveniles/year):

	Douglas Production	Chelan Production
Spring Chinook	Increases 288,000	Decreases 288,000
Summer Chinook	Decreases 400,000	Increases 400,000
Sockeye	No Effect	No Effect

c. The resultant Douglas PUD annual compensation program under this agreement (Phase II Production) is:

Phase IIA

30,000 lbs. of Steelhead @ 6/lb.

49,200 lbs. of Spring Chinook @ 15/lb.

15,000 lbs. of Sockeye @ 25/lb.

OR

Phase IIB

30,000 lbs. of Steelhead @ 6/lb.

49,200 lbs. of Spring Chinook @ 15/lb.

15,000 lbs. of Summer Chinook @ 10/lb.

6,500 lbs. of Summer Chinook at 40/lb.

APPENDIX B

DETERMINATION OF RESPONSIBILITY FOR HATCHERY COMPENSATION

For each year of determination, calculate an average smolt output as follows:

1. Calculate a 5-year running average adult run (by species) for naturally spawned fish (Ays) as follows:

$$\bar{A}ys = \frac{Ay + Ay\text{-}1 + Ay\text{-}2 + Ay\text{-}3 + Ay\text{-}4}{5}$$

Where Ay is the total adult count for each species at Wells minus the hatchery escapement for the species in year y;

Ay-1 = the same in the previous year (y-1) and so on.

2. Multiply Ays by the average expected adult to smolt production factor Kys for each species, where Kys is calculated as follows:

a. Spring Chinook:

Ksp = 0.94 (Wells Dam to spawner survival)
x 0.50 (sex ratio) x 5000 (eggs/female)
x 0.10 (av. survival to smolt) = 235

b. Summer Chinook:

Ksu = 0.94 x 0.50 x 5000 x 0.30 = 705

c. Sockeye:

$$Kso = 0.94 \times 0.50 \times 2700 \times 0.12 = 152$$

3. Add the number of hatchery smolts HSys by species, which is a running average of the same 5 years as in Ays.

$$\overline{HS}ys = \frac{HSy + HSy\text{-}1 + HSy\text{-}2 + HSy\text{-}3 + HSy\text{-}4}{5}$$

4. Total smolts (by species):

$$\bar{S}ys = Kys \times \bar{A}ys + \overline{HS}ys$$

5. Grand Total = Sum of all species:

$$Sgt = \bar{S}sp + \bar{S}su + \bar{S}so + \ldots$$

6. If other salmon species or races, for which the above smolt production factors (Kys) do not apply, become established in the production areas above Wells Dam, appropriate K factors for these fish will be established by consensus of the Coordinating Committee. Juvenile migrant production will be computed for these species or races. These numbers will be included in the grand total for juvenile migrant production and the 5-year running averages.

WELLS PHASE IV THEORETICAL CALCULATION EXAMPLE

NATURAL PRODUCTION

DATA USED IN EXAMPLE CALCULATION OF NATURAL PRODUCTION

Adult Count	Ay	Ay-1	Ay-2	Ay-3	Ay-4	5 Year Average
Spring Chinook	3,000	2,200	3,100	5,000	2,900	3,240
Summer Chinook	2,400	2,800	3,700	4,000	4,700	3,520
Sockeye	40,000	20,000	35,000	15,000	30,000	28,000

Ay = Wells Count Minus Hatchery Escapement for Year Y

Ksp = Calculated Spring Chinook Smolts

Ksu = Calculated Summer Chinook Smolts

Ksoe = Calculated Sockeye Smolts

Spring Chinook $\bar{A}y$

$$= \frac{Ay + Ay-1 + Ay-2 + Ay-3 + Ay-4}{5}$$

$$= \frac{3000 + 2200 + 3100 + 5000 + 2900}{5}$$

$$= 3240$$

Summer Chinook $\bar{A}y$

$$= \frac{Ay + Ay-1 + Ay-2 + Ay-3 + Ay-4}{5}$$

$$= \frac{2400 + 2800 + 3700 + 4000 + 4700}{5}$$

$$= 3520$$

Sockeye $\bar{A}y$

$$= \frac{Ay + Ay-1 + Ay-2 + Ay-3 + Ay-5}{5}$$

$$= \frac{40,000 + 20,000 + 35,000 + 15,000 + 30,000}{5}$$

$$= 28,000$$

Ksp, su, soc = Adult/redd factor x sex ratio x eggs/female x eggs to smolt survival x dam count minus hatchery return

Calculated Average Total Smolts (Natural)

Spring Chinook $Ksp = .94 \times .50 \times 5000 \times .10 \times 3240$
$= 235 \times 3240$
$= 761,400$

Summer Chinook $Ksu = .94 \times .50 \times 5000 \times .30 \times Ay$
$= 705 \times 3520$
$= 2,481,600$

Sockeye $Ksoc = .94 \times .50 \times 2700 \times .12 \times Ay$
$= 152 \times 28,000$
$= 4,263,800$

Average Total Natural Smolts

$= Ksp + Ksu + Ksoc$
$= 761,400 + 2,481,600 + 4,263,800$
$= 7,506,800$

HATCHERY PRODUCTION

DATA USED IN EXAMPLE DETERMINATION OF HATCHERY PRODUCTION

SMOLT PRODUCTION IN MILLIONS BY YEAR

Hatchery	Y	Y-1	Y-2	Y-3	Y-4	5 Year Average
Winthrop	1.5	1.1	1.0	.95	.95	1.1
Methow	.8	.8	.675	.40	.25	.585
Twisp Acclimation	.40	.40	.40	.25	.2	.33
Sockeye Net Pens	.2	.2	.2	.15	.1	.17

Hatchery Smolt Production

Winthrop Hatchery 950,000 $= \dfrac{1,500,000 + 1,100,000 + 1,000,000 + 950,000 +}{5}$

$= 1,100,000$

Methow Hatchery $= \dfrac{800,000 + 800,000 + 675,000 + 400,000 + 250,000}{5}$

= 585,000

Twisp Accl. Pond= $\frac{400,000 + 400,000 + 400,000 + 250,000 + 200,000}{5}$

= 330,000

Sockeye Net Pens* = $\frac{200,000 + 200,000 + 200,000 + 150,000 + 100,000}{5}$

= 170,000

*Need Adjustment Factor For Survival To Migration

Average Total Hatchery Smolts

Winthrop	=	1,100,000
Methow	=	585,000
Twisp	=	330,000
Net Pens	=	170,000
		2,185,000

Average Total Hatchery/Natural Smolts
(5 Year Average for Years Y-4, Y-3, Y-2, Y-1 and Y)

Natural	=	7,779,000
Hatchery	=	2,185,000
Total	=	9,964,000

PHASE IV DETERMINATION

Base Number Smolts Used for Initial Compensation	=	9,034,700
Calculated Average Natural + Hatchery Smolts in Years Y-4, Y-3, Y-2, Y-1 and Y	=	9,964,000
Calculated Average Natural + Hatchery Smolts Minus Base Number Smolts	=	929,300
Difference Between Base Number Smolts and Calculated Natural + Hatchery Smolts X Wells Project Mortality Rate	=	929,300 X .14
= Additional Smolts Possible Under Phase IV		130,102

FOR PUBLIC UTILITY DISTRICT NO. 1
OF DOUGLAS COUNTY, WASHINGTON:

Howard Frey
Commissioner

Michael Gemmen
Commissioner

T. James Davis
Commissioner

FOR PUGET SOUND POWER & LIGHT COMPANY:

_____

FOR PACIFIC POWER & LIGHT COMPANY:

_____

FOR THE WASHINGTON WATER POWER COMPANY:

_____

FOR PORTLAND GENERAL ELECTRIC COMPANY:

_____

FOR THE WASHINGTON DEPARTMENT
OF FISHERIES:

_____

FOR THE WASHINGTON DEPARTMENT
OF WILDLIFE:

_____

FOR PUBLIC UTILITY DISTRICT NO. 1
OF DOUGLAS COUNTY, WASHINGTON:

_____
Commissioner

_____
Commissioner

_____
Commissioner

FOR PUGET SOUND POWER & LIGHT COMPANY:

_____

FOR PACIFIC POWER & LIGHT COMPANY:

_____

FOR THE WASHINGTON WATER POWER COMPANY:

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FOR THE WASHINGTON DEPARTMENT
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FOR THE WASHINGTON DEPARTMENT
OF WILDLIFE:

_____

FOR PUBLIC UTILITY DISTRICT NO. 1
OF DOUGLAS COUNTY, WASHINGTON:

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Commissioner

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Commissioner

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Commissioner

FOR PUGET SOUND POWER & LIGHT COMPANY:

_____

FOR PACIFIC POWER & LIGHT COMPANY:

_____

FOR THE WASHINGTON WATER POWER COMPANY:

_____

FOR PORTLAND GENERAL ELECTRIC COMPANY:

_____

FOR THE WASHINGTON DEPARTMENT
OF FISHERIES:

_____

FOR THE WASHINGTON DEPARTMENT
OF WILDLIFE:

_____

FOR PUBLIC UTILITY DISTRICT NO. 1
OF DOUGLAS COUNTY, WASHINGTON:

_____
Commissioner

_____
Commissioner

_____
Commissioner

FOR PUGET SOUND POWER & LIGHT COMPANY:

_____

FOR PACIFIC POWER & LIGHT COMPANY:

_____

FOR THE WASHINGTON WATER POWER COMPANY:

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FOR PORTLAND GENERAL ELECTRIC COMPANY:

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Commissioner

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FOR THE WASHINGTON WATER POWER COMPANY:

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FOR PORTLAND GENERAL ELECTRIC COMPANY:

_____

FOR THE WASHINGTON DEPARTMENT
OF FISHERIES:

6/11/90

FOR THE WASHINGTON DEPARTMENT
OF WILDLIFE:

Ray Ryan 6/11/90

FOR THE OREGON DEPARTMENT OF
FISH AND WILDLIFE:

_____

FOR THE NATIONAL MARINE
FISHERIES SERVICE:

_____

FOR THE U.S. FISH & WILDLIFE SERVICE:

_____

FOR THE CONFEDERATED TRIBES AND BANDS
OF THE YAKIMA INDIAN NATION:

_____

FOR THE CONFEDERATED TRIBES
OF THE UMATILLA INDIAN RESERVATION:

_____

FOR THE CONFEDERATED TRIBES
OF THE COLVILLE RESERVATION:

_____

FOR THE OREGON DEPARTMENT OF
FISH AND WILDLIFE:

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FISHERIES SERVICE:

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FOR THE CONFEDERATED TRIBES
OF THE COLVILLE RESERVATION:

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FOR THE OREGON DEPARTMENT OF
FISH AND WILDLIFE:

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_____
Marvin L. Plenert, Regional Director
FOR THE U.S. FISH & WILDLIFE SERVICE

_____

FOR THE CONFEDERATED TRIBES AND BANDS
OF THE YAKIMA INDIAN NATION:

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OF THE UMATILLA INDIAN RESERVATION:

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OF THE YAKIMA INDIAN NATION:

Levi George

FOR THE CONFEDERATED TRIBES
OF THE UMATILLA INDIAN RESERVATION:

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OF THE UMATILLA INDIAN RESERVATION:

Edward H. Pitaway

FOR THE CONFEDERATED TRIBES
OF THE COLVILLE RESERVATION:

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OF THE COLVILLE RESERVATION:

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