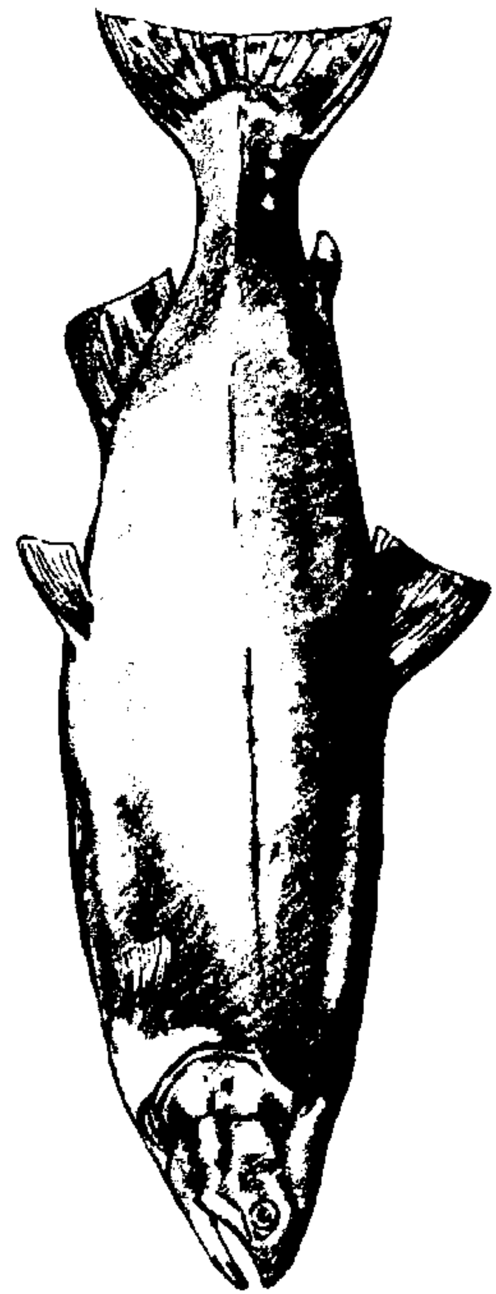

Attachment D—ODFW Documents

Oregon

DEPARTMENT OF
FISH AND
WILDLIFE

OFFICE OF THE
DIRECTOR

December 9, 1993

Mr. Dan Shepherd, Manager
Grants Pass Irrigation District
200 Fruitdale Drive
Grants Pass, Oregon 97527

Dear Mr. Shepherd:

Oregon Department of Fish and Wildlife (ODFW) has worked with Grants Pass Irrigation District (GPID) to find solutions to the long-standing fish passage problems at Savage Rapids Dam. The purpose of this letter is to inform GPID of ODFW's recommendations for resolving this issue. From a fish passage perspective, ODFW believes that the preferred alternative is dam removal. The second alternative, dam and fish passage structure replacement, would be acceptable provided that state-of-the-art fish passage structures were installed and properly maintained and operated. ODFW will not support any alternative that proposes to modify existing structures, because these structures have well outlived their useful lives and modifications would only be expected to result in temporary, partial improvements in fish survival. This letter describes the reasoning that has led ODFW to these conclusions.

The anadromous fish populations in the Rogue River are critically important to the State of Oregon. They provide both a nationally recognized sports fishery and support coastal and ocean commercial fisheries. The south coast of Oregon, including the Rogue River, has been identified by the Governor as a high priority area for restoring anadromous fish (primarily salmon and steelhead) populations. Southern Oregon is also a high priority focal area of the Federal agencies implementing Option 9 of President Clinton's Forest Ecosystem Management Assessment Team Report. ODFW is working to reduce fish losses from all sources, including losses associated with habitat degradation, hatchery practices, harvest practices, and passage at dams. Complete restoration will only occur when all of these problems have been addressed, including losses at Savage Rapids Dam.

ODFW has participated closely with GPID in the technical work group that directed and reviewed the studies conducted as part of a 1990 temporary water right permit issued to GPID by Water Resources Department. Although the major purpose of these studies was to evaluate water use efficiency and options for reducing water use, GPID was also directed to evaluate the following concerns related to fish survival at Savage Rapids Dam:

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"*k. Fish losses caused by Savage Rapids Dam and GPID canal system and the operation thereof. This consideration shall also include identification of options that will reduce or eliminate fish losses that may be associated with the GPID diversion and conveyance system.*

l. Potential improvements and operational measures including removal of Savage Rapids Dam, which would improve fish passage and habitat and decrease fish losses. Identify the cost and benefits of such projects and measures."

Water Resources Department, Permit 50957, issued April 19, 1990

Studies to evaluate these issues were conducted by the U.S. Bureau of Reclamation (Bureau), using both existing and new data. The Bureau's report concludes that the alternative which would result in the least impact to fish is the option in which Savage Rapids Dam would be removed and water supplied to GPID with pumping stations. A second alternative, which results in less benefits to fish, is the replacement option in which the dam would be refurbished, including installation of new fish ladders and screens and spillway. Both the Bureau's analysis and that of the consultant hired by GPID conclude that dam removal is the least cost alternative.

Conclusion

Based on ODFW's review of the subject studies and the long history of fish passage problems at Savage Rapids Dam, ODFW believes that dam removal is the preferred alternative. As stated above, fish passage structure replacement would be an acceptable alternative provided that state-of-the-art fish passage structures were installed and properly maintained and operated. Minor modifications to existing structures are not acceptable to ODFW. We have discussed this with the National Marine Fisheries Service and U.S. Fish and Wildlife Service and understand they also support this position and will document that in correspondence to you.

I understand that this is a very difficult decision for the GPID Board. I hope that this clarification of ODFW's perspective will help the Board in making its decision. I will commit to assist and support GPID in seeking federal funding for implementation of solutions to the fish passage problems at Savage Rapids Dam. In order to obtain this funding, it will be necessary for all involved agencies, districts, and interest groups to work together to acheive our individual and mutual goals. I look forward to this opportunity.

Sincerely,

Randy Fisher
Director

RF/sb

Oregon

DEPARTMENT OF
FISH AND
WILDLIFE

OFFICE OF THE
DIRECTOR

October 26, 1994

Dear Interested Public:

Enclosed is a technical report prepared by Oregon Department of Fish and Wildlife (ODFW) which provides estimates of the impacts of Savage Rapids Dam on salmon and steelhead populations in the Rogue River. In 1979 the National Marine Fisheries Service conducted an analysis which concluded that an additional 26,700 adult fish could be produced if the dam were removed. In response to questions regarding the current applicability of the NMFS estimates, ODFW staff biologists were asked to review current information and make an independent estimate of potential increases in salmon and steelhead populations if the effects of the dam were eliminated by addition of state-of-the-art fishways and screens or by dam removal.

The estimates in this study are based on the "dam removal" alternative. We are in the process of conducting a similar analysis that is based on the "dam retention" alternative, in which the facility would be retrofitted with state-of-the-art fishways, screens, and other modern-day technology to pass fish.

If you are interested in receiving ODFW's analysis of the "dam retention" alternative when it is completed, please request a copy from Stephanie Burchfield, ODFW, 2501 SW First Avenue, Portland, Oregon 97207, or by telephone at (503) 229-6967, extension 441.

Sincerely,

RUDOLPH A. ROSEN
Director

Attachment

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ESTIMATION OF ROGUE RIVER SALMON AND STEELHEAD POPULATION INCREASES FOR THE SAVAGE RAPIDS "DAM REMOVAL" OPTION

Oregon Department of Fish and Wildlife*
2501 SW First Avenue
Portland, OR 97207

October 1994

Background

This report presents estimates of potential Rogue River salmon and steelhead population increases that would be expected if Savage Rapids Dam were removed. These estimates are based upon Oregon Department of Fish and Wildlife's (ODFW) most recent effort to model fish mortality associated with the dam. The assessment incorporates updated information concerning the life history and abundance of anadromous fish species that migrate past the dam.

In 1979 the National Marine Fisheries Service (NMFS) conducted an analysis which concluded that upstream and downstream passage problems at Savage Rapids Dam, as well as loss of fall chinook spawning habitat by reservoir inundation, caused significant losses of Rogue Basin salmon and steelhead (NMFS 1979). The NMFS estimated that if these problems were corrected, the populations would increase annually by 26,700 adult fish as measured at the dam.

In the course of recent discussions concerning the conditions of a temporary water right for the Grants Pass Irrigation District, many people have stated that the NMFS fish loss estimates may be outdated and no longer applicable. Because of the controversy surrounding the NMFS estimate, ODFW staff biologists were asked to review current information and make an independent estimate of potential increases in salmon and steelhead populations if the effects of the dam were eliminated by addition of state-of-the-art fishways and screens or by dam removal.

The following analysis makes use of the best techniques for mathematically predicting population increases given changes at the dam site. These techniques allow rapid and accurate estimates of the population numbers we seek, but without the great expense of extended and time-consuming analysis. Project applicants often legitimately complain about the time and expense of environmental evaluations that frequently yield information only slightly more reliable than can be predicted by the mathematical techniques used in this study. By this technique ODFW biologists are able to compute the lowest possible level of fish loss caused by

* Prepared by Stephanie Burchfield, Michael D. Evenson, Mark W. Chilcote, Franklin R. Young, Michael D. Jennings, and Barry P. McPherson

the facility, as well as the highest level reasonably possible. These high and low estimates are based on generally accepted averages for fish losses derived from studies at dams and water diversions of all possible configurations.

The high and low estimates are used to set the reasonable boundaries, within which the actual population number will lie. Biologists also computed an average estimate which falls within this range. However, because a number of factors influence this number from year to year, the actual population number will vary yearly, but this variation is expected to fall within the high and low boundaries discussed above.

In making a comparison with the NMFS estimate, this technique will tell whether the NMFS estimate was reasonable, because it falls within the estimated range, or will tell if the NMFS estimate was unreasonable, because it falls outside the range of reasonable possibility. For making general decisions, this technique offers quick and accurate results, as well as a wide range within which the actual population numbers will lie. This technique is particularly appropriate for making general estimates of numbers that tend to change from year to year, as do the fish populations at issue here, for example due to factors such as changing ocean and harvest conditions. While great expense and time could be expended to refine the estimate, this only would better home in on a number that would lie somewhere within the range of numbers already predicted by this study, and a number that can change from year to year anyway.

The estimates in this study are based on dam removal. We are in the process of conducting a similar analysis that is based on retrofitting the facility with state-of-the-art fishways, screens, and other modern-day technology to pass fish. While this analysis is not yet complete, such retrofit of the dam will yield somewhat less protection to fish than complete dam removal, because even the best designed fishway of today impedes fish passage to some degree. However, improvements in fish passage using modern technology will offer a significant advantage to fisheries over the current situation.

Approach

Upstream and downstream mortality estimates were assumed similar to generally accepted standards for such mortality as determined through experimental methodology at other dams. In making estimates for the Savage Rapids Dam, present design of the fishway, screens, and spillway and the operating condition of the facilities were taken into account (Franklin Young, July 1994; see attached memo). The fishways are old and designed to engineering standards no longer considered effective for fish passage. Fish facilities at this dam do not meet current design criteria used by ODFW, NMFS and the U.S. Fish and Wildlife Service (USFWS). Low, mid, and high estimates were made in order to bracket the likely range in juvenile and adult passage mortality at Savage Rapids Dam.

Our estimates state the results in terms of additional adult fish passing the dam site, plus contributions to downstream and ocean fisheries. Although the NMFS estimate of 26,700 fish did not include harvest impacts, a subsequent analysis by USFWS predicted that 87,900 additional fish could be harvested based on an increased escapement of 26,700 (USFWS 1990). Adding the NMFS and USFWS estimates results in a total of 114,600 additional fish. Our estimates are generally higher than the NMFS estimate yet lower than the total NMFS and USFWS estimates.

During low return cycles ocean and river harvests are heavily restricted, thus the ratio between the number of fish harvested and those fish escaping to spawn varies over the years. In general, Rogue salmon and steelhead fisheries have been curtailed in recent years to reduce harvest on specific populations in the lower river and in other coastal basins. Therefore, ODFW used lower harvest rates than the USFWS used in its assessments of harvest impacts in order to better reflect current conditions. This explains why ODFW's range of estimates is less than the total USFWS and NMFS estimates of 114,600 additional fish for harvest and escapement.

"Half-pounder" steelhead in the Rogue River are immature steelhead that typically enter the ocean in the spring, reside there three to five months, return to freshwater, and reside in the lower portions of the Rogue River for five to seven months, prior to returning to the ocean. This is a major component of Rogue River steelhead fisheries. While most "half-pounders" generally do not get as far upstream as Savage Rapids Dam, they make a significant contribution to downstream sport fisheries. Because juvenile steelhead production above Savage Rapids Dam contributes to this fishery, the potential increase in harvestable fish resulting from juvenile losses at the dam is accounted for in this assessment.

Details and calculations associated with ODFW's estimate are contained in the attached tables 1 through 19.

Results

Tables 1 through 5 show the assumptions and calculations that were made to estimate annual increases in harvest and spawning populations of spring chinook, fall chinook, summer steelhead, winter steelhead, and coho salmon. These increases, termed "mid range" estimates, use an average upstream fish mortality rate of 15% and an average downstream fish mortality rate of 15%. These estimates fall between the "low" and "high" estimates that will be discussed below. The numbers represent potential increased production of adult fish in the Rogue River if the following fish impacts at Savage Rapids Dam were eliminated: juvenile fish injury and mortality during the downstream migration, adult fish injury, mortality and delay during the upstream migration, and lost spawning opportunities associated with reservoir inundation of historic and potential habitat. The tables cite sources of data and assumptions used in the mathematical computations. The "Literature Cited" section provides full reference information for these sources.

Table 6 is a summary table that lists "mid range" estimates for each species. Based on the assumptions in this model, we estimate that an additional 43,620 salmon and steelhead would be produced annually if Savage Rapids Dam were removed.

Tables 7 through 11 represent "low range" estimates of additional salmon and steelhead production based on upstream and downstream mortality rates at Savage Rapids Dam of 10 and 5 percent, respectively. Table 12 summarizes the "low range" estimates for each species, and shows a combined "low range" estimate for all species of 20,865.

Tables 13 through 17 represent "high range" estimates of additional salmon and steelhead production attributable to Savage Rapids Dam. These tables use the same mathematical model as that shown in detail in tables 1 through 5; however, mortality rates at the dam represent the high end loss estimates of 30 percent for both juvenile and adult passage. Table 18 summarizes the "high range" estimates for each species, and shows a combined estimate of 93,542 for all species.

Table 19 summarizes previous tables and shows the range of additional production for each species. Figure 1 shows this information for each species in graphical form. For all species combined, our estimates range from a low of 20,865 to a high of 93,542, with a mid-range estimate of 43,620 as shown in Figure 2.

Conclusions

The range of numbers obtained, 20,865 to 93,542 fish annually, represents a reasonable range of estimates for expected salmon and steelhead population increases attributable to Savage Rapids Dam removal. As stated above, actual increases will vary yearly, and are highly dependent on run sizes and harvest rates. Coho salmon estimates are primarily based on hatchery fish numbers, and the effects on naturally produced coho are not considered. Potential listing of coho under the federal Endangered Species Act would make such a calculation meaningless, because when populations are listed as either threatened or endangered, the value of each individual fish to recovery efforts becomes significantly higher than its harvestable value.

Two alternatives to correct fish passage problems at the dam are under consideration: dam removal and dam retention with modifications. The calculations in the tables assume that the current loss rates would be reduced to virtually zero in order to produce the estimated fish benefits. These calculations are most representative of the "dam removal" option. The "dam retention" alternative, in which state-of-the-art fish passage facilities would be installed, would significantly reduce existing fish passage mortalities, although some losses of juvenile and adult fish would continue at the dam, and fall chinook salmon spawning habitat in the reservoir area would remain unavailable. We currently are making a series of computations that would provide a reasonable range of population increases expected with improvements at the dam.

The model that we developed predicts population increases in the same range as the NMFS' 1979 estimate of 26,700. As described above, the NMFS analysis estimated potential increased adult fish returns to the dam and did not include harvest increases. The USFWS' 1990 analysis concluded that an increased escapement potential of 26,700 adult fish passing Savage Rapids Dam represents an additional increase of 87,900 fish to commercial and sport harvest (USFWS 1990). Hence, using the NMFS and USFWS estimates, approximately

114,600 additional adult fish could be produced annually if Savage Rapids Dam were removed. This total estimate is greater than the high range estimate predicted in our model. The reason for this discrepancy is that run sizes and harvest rates were higher during the years in which USFWS based its analysis than they are today. If run sizes and harvest rates increase in future years, we would expect total fish population increases attributable to Savage Rapids Dam removal to more closely approximate the 114,600 estimate than our range of 20,865 to 93,542.

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U.S. Fish and Wildlife Service. April 27, 1990. Planning Aid Memorandum, Portland.

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Table 1. Estimated Spring Chinook Salmon Increases Resulting from Savage Rapids Dam Removal - Mid Range

Adult Production = Upper river (UR) returns + River harvest + Ocean harvest

Assumptions:

UR returns =	31,126	Source: Gold Ray Dam counts, 1942 - 93 average
Lower river harvest rate =	28%	Source: Cramer et al, 1985, p. 255 (1964-81); does not include jacks
Ocean harvest =	43,397	Source: Satterthwaite, 1987, p.27, Table 9; catch:escapement = 1:1

Calculations:

River harvest = 0.28(Total fish at mouth) = 0.28(UR return + River harvest) = 0.28 (UR return)/(1-0.28)

River harvest = 0.28(31,126)/0.72 = 12, 105

Upper R. Returns	+ River Harvest	+ Ocean Harvest =	Adult Production
31,126	12,105	43,397	86,628

Upstream adult passage at dam

Assumptions:

SRD adult upstream mortality = 15%(Adults at base of SRD) Source: Young, 1994 (estimated range 10-30% adult passage loss)

Assume no loss between Savage Rapid (SRD) and Gold Ray (GRD) dams

Calculations:

Adults at base of SRD = GRD counts + SRD Upstream Loss = GRD counts + 0.15(Adults at base of SRD)

0.85(Adults at base of SRD) = GRD counts

Adults at base of SRD = GRD counts/0.85 = 31,126/0.85 = 36,619

Adults at base of SRD x SRD adult mortality rate = Adult increase due to eliminating SRD adult passage loss

36,619 15% 5,493

Downstream juvenile passage at dam

Assumptions:

SRD juvenile mortality = 15%(smolts migrating to SRD)	Source: Young, 1994 (estimated average 10-15%, and range 5-30%)
Hatchery smolts produced = 1,458,000	Source: ODFW, hatchery release data, 1986-94
Wild smolts produced = 1,410,000	Source: ODFW unpublished data, mean for 1976-90
Hatchery smolt-to-adult survival rate = 2%	Source: ODFW, hatchery data, includes harvest
Wild smolt-to-adult survival rate = 2%	Source: Satterthwaite, 1994, personal communication.

Calculations:

SRD juvenile loss (hatchery) = 15%(1,458,000) = 218,700

SRD juvenile loss (wild) = 15%(1,410,000) = 211,500

Adult equivalent increase due to eliminating SRD downstream loss = (SRD hatchery juvenile loss x hatchery smolt-to-adult survival rate) + (SRD wild juvenile loss x wild smolt-to-adult survival rate) = (218,700 x 0.02) + (211,500 x 0.02) = 8,604

Adult equivalent increase due to eliminating SRD downstream loss = 8,604

Total Spring Chinook Increase		Upstream Passage		Adult Equiv. Downstream Passage
14,097	=	5,493	+	8,604

Table 2. Estimated Fall Chinook Salmon Increases Resulting from Savage Rapids Dam Removal - Mid Range

Above Savage Rapids Adult Production = Upper river run at mouth + Ocean harvest of fish originating above SRD

Assumptions:

Upper river run at mouth = Spawning escapement + River harvest + lower river prespawning mortality

Spawning escapement = Gold Ray Dam counts + Spawning between SRD and GRD

Gold Ray Dam counts =	3,148	Source: Gold Ray Dam counts, 1942 - 93 average
Spawning between SRD and GRD =	9,350	Source: Satterthwaite, 1992 (500 fish/km)
River harvest =	9.5% (upper river run at mouth)	Source: ODFW, 1992, p.78, 1974-86 average
Prespawning mortality =	20%(upper river run at mouth)	Source: Satterthwaite, personal communication
Ocean harvest =	2(upper river run at mouth)	Source: Satterthwaite, personal communication, assume C:E = 2:1 for upper river fall chinook

Calculations:

Spawning escapement = 3,148 + 9,350 = 12,498

Upper river run at mouth = 12,498 + 0.095(upper run) + 0.20(upper run)

Upper run(1-0.095-0.20) = 12,498

Upper run = 12,498/0.70 = 17,728

River harvest = (0.095)(17,728) = 1,684

Prespawning mortality = (0.20)(17,728) = 3,546

Ocean harvest = 2(17,728) = 35,456

Above Savage Rapids Adult Production = 17,728 + 35,456 = 53,184

Adult spawning habitat increases

Loss of spawning potential = Potential adults that would spawn in channel inundated by SRD reservoir and below SRD

Assumptions:

Potential adults spawning in channel inundated by reservoir =	770	Source: Satterthwaite, 1992;
Potential adults spawning in channel downstream of SRD =	154	based on 1974-81 carcass surveys
Total potential SRD spawning adults =	924	adjusted for prespawning mortality

SRD potential spawners are harvested at same rates as upper river run fish:

River harvest = 9.5%(run at mouth)

Ocean harvest = 2(run at mouth)

SRD potential spawners at mouth = SRD spawning adults + River harvest

Total adult increases if inundated spawning habitat were restored = SRD spawning adults + (river harvest + ocean harvest of SRD spawning adults)

Calculations:

SRD run at mouth = 924 + 0.095(SRD run at mouth)

(SRD run at mouth)(1-0.095) = 924

SRD run at mouth = 924/(0.905) = 1,021

River harvest = 0.095(1021) = 97

Ocean harvest = 2(1021) = 2,042

Total adult increases if inundated spawning habitat were restored = 924 + 97 + 2,042 = 3,063

Total adult increases if inundated spawning habitat were restored = 3,063

Table 2, continued. Estimated Fall Chinook Salmon Increases Resulting from Savage Rapids Dam Removal - Mid Range

Upstream adult passage at dam

Assumptions:

SRD adult upstream mortality = 15%(Adults at base of SRD) — Source: Young, 1994 (estimated range 10-30% adult passage loss)

Spawning escapement = Gold Ray Dam counts + Spawning between SRD and GRD = 12,498

Spawning escapement = 0.85(Adults at base of SRD)

Calculations:

Adults at base of SRD = Spawning escapement/(0.85) = 12,498/(0.85) = 14,703

SRD adult upstream mortality = 0.15(14,703) = 2,205

Adult increase due to eliminating SRD adult passage loss = 2,205

Downstream juvenile passage at dam

Assumptions:

SRD juvenile mortality = 15%(juveniles migrating to SRD) — Source: Young, 1994 (estimated average 10-15%, range 5-30%)

Wild juvenile-to-adult survival rate = 2% — Source: ODFW unpublished data, 1976-90 average

(Juveniles produced each year)(Juvenile-to-adult survival) = Upper river adult run at mouth

Ignore loss to juveniles of potential spawning fish in SRD reservoir

Adult equivalent potential increase = (SRD juvenile mortality)(Juvenile-to-adult survival)

Calculations:

Juveniles produced = Upper river adult run at mouth/juvenile-to-adult survival = 17,728/0.02

Juveniles produced = 886,400

SRD juvenile mortality = 0.15(886,400) = 132,960

Adult equivalent increase due to eliminating SRD downstream loss = (132,960)(0.02) = 2,659

Adult equivalent increase due to eliminating SRD downstream loss = 2,659

Total Fall Chinook Increase		Upstream Passage		Adult Equiv. Downstream Passage		Spawning Increase
7,927	=	2,205	+	2,659	+	3,063

Table 3. Estimated Summer Steelhead Increases Resulting from Savage Rapids Dam Removal - Mid Range

Upstream adult passage at dam

Assumptions:

SRD adult upstream mortality = 15%(Adults at base of SRD) — Source: Young, 1994 (estimated range 10-30% adult passage loss)

Gold Ray Dam counts = 6,016 — Source: Gold Ray Dam counts, 1942 - 93, average

Returns between Gold Ray and Savage Rapids dams = 3624 — Source: Satterthwaite, 1992

Upper river escapement = Gold Ray Dam Counts + Returns between Gold Ray and Savage Rapids

Upper river escapement = 0.85(Adults at base of SRD)

Calculations:

Upper river escapement = 6,016 + 3,624 = 9640

Adults at base of SRD = Upper river escapement/(0.85) = 9,640/(0.85) = 11,341

SRD adult upstream mortality = 0.15(11,341) = 1,701

Adult increase due to eliminating SRD adult passage loss = 1,701

Downstream juvenile passage at dam

Assumptions:

Most of river harvest is on half-pounders, produced above but harvested below SRD. — Source: ODFW, 1994, p.189

(Does not include adult returns from half-pounders to avoid double counting).

SRD juvenile mortality = 15%(juveniles migrating to SRD) — Source: Young, 1994 (estimated average 10-15%, range 5-30%)

Hatchery juvenile-to-half-pounder survival rate = 12% — Source: ODFW,1994, p.1, range = 3 - 28%, 1976-91 returns

Hatchery juveniles released = 144,523 — Source: ODFW,1994,p.134, 1974-91 average

(Current releases = 220,000) — Source: ODFW, hatchery release data, 1991-94

Juveniles migrating to SRD = 80%(Juveniles released each year) — Source: Evenson, personal communication, estimate

Half-pounder equivalent increase = (SRD juvenile mortality)(Juvenile-to-half-pounder survival)

Hatchery adults = 31% of total population passing Gold Ray Dam — Source: ODFW,1994, p.51, 1970-91 brood years

Hatchery adults = 0.31(6,016) = 1,865

Hatchery adults = (1,865)/(9,640) = 19.3% of total adults passing Savage Rapids Dam

Calculations:

Hatchery juveniles migrating to SRD = 0.80(144,523) = 115,618

SRD hatchery fish juvenile mortality = 0.15(115,168) = 17,343

Half-pounder equivalent increase of hatchery fish = (17,343)(0.12) = 2,081

Half-pounder equiv. increase wild + hatchery fish = half-pounder equiv. increase hatch. fish/percentage of hatchery adults of total passing SRD

Half-pounder equiv. increase wild + hatchery fish = (2081)/(0.193) = 10,782

Half-pounder equiv. increase wild fish = 10,782 - 2,081 = 8,701

Half-pounder equivalent increase due to eliminating SRD downstream loss = 8,701

Total Summer Steelhead Increase		Upstream Passage		Half-pounder Equiv. Downstream Passage
10,402	=	1,701	+	8,701

Table 4. Estimated Winter Steelhead Increases Resulting from Savage Rapids Dam Removal - Mid Range

<u>Upstream adult passage at dam</u>

Assumptions:

SRD adult upstream mortality = 15%(Adults at base of SRD) — Source: Young, 1994 (estimated range 10-30% adult passage loss)

Gold Ray Dam counts = 9,317 — Source: Gold Ray Dam counts, 1942 - 93, average

Returns between Gold Ray and Savage Rapids dams = 4056 — Source: Satterthwaite, 1992

Upper river escapement = Gold Ray Dam counts + Returns between Gold Ray and Savage Rapids

Upper river escapement = 9,317 + 4,056 = 13,373

Upper river escapement = 0.85(Adults at base of SRD)

Calculations:

Adults at base of SRD = Upper river escapement/(0.85) = 13,373/(0.85) = 15,733

SRD adult upstream mortality = 0.15(15,733) = 2,360

Adult increase due to eliminating SRD adult passage loss = 2,360

<u>Downstream juvenile passage at dam</u>

Assumptions:

Most of river harvest is on half-pounders, produced above but harvested below SRD. — Source: ODFW, 1994, p.189

(Does not include adult returns from half-pounders to avoid double counting).

SRD juvenile mortality = 15%(juveniles migrating to SRD) — Source: Young, 1994 (estimated average 10-15%, range 5-30%)

Hatchery juvenile-to-half-pounder survival rate = 12% — Source: ODFW, 1994

Hatchery juvenile-to-adult survival rate = 1.2% — Source: ODFW, hatchery data, (average, 1974-86 brood years)

Hatchery juveniles released = 121,000 — Source: ODFW,1990,p.68, 1976-86 average, Rogue stock only

(Current release target = 150,000) — Source: ODFW, hatchery release data, 1989-94

Juveniles migrating to SRD = 80%(Juveniles released each year) — Source: Evenson, personal communication, estimate

Adult equivalent increase = (SRD juvenile mortality)(Juvenile-to-adult survival)

Hatchery adults = 23% of total population passing Gold Ray Dam — Source: ODFW,1990, p.32, 1979-87 average

Hatchery adults = 0.23(9,317) = 2,143

Hatchery adults = (2,143)/(13,373) = 16% of total adults passing Savage Rapids Dam

Wild adults passing Savage Rapids Dam = Total upper river escapement - Hatchery adults = 13,373 - 2,143 = 11,230

Half-pounder return to river = 70% of total adult + half-pounder return — Source: ODFW, 1990,p.44, Angler catch, middle river, 1978/79 and 1979/80

Calculations:

Hatchery juveniles migrating to SRD = 0.80(121,000) = 96,800

SRD hatchery fish juvenile mortality = 0.15(96,800) = 14,520

Half-pounder equivalent increase of hatchery fish = 0.70 (14,520)(0.12) = 1,219

Half-pounder equiv. increase wild + hatchery fish = half-pounder equiv. increase hatch. fish/percentage of hatchery adults of total passing SRD

Half-pounder equiv. increase wild + hatchery fish = (1,219)/(0.16) = 7,619

Half-pounder equiv. increase wild fish = 7,619 - 1,219 = 6,400

Table 4, continued. Estimated Winter Steelhead Increases Resulting from Savage Rapids Dam Removal - Mid Range

Adult equivalent increase of hatchery fish = 0.30(14,520)(0.012) = 52
Adult equiv. increase of wild + hatchery fish = (52)/(0.16) = 325
Adult equiv. increase wild fish = 325 - 52 = 273
Total adult and half-pound equiv. increase of wild and hatchery fish = 7,619 + 325 = 7,944

Adult and half-pounder equivalent increase due to eliminating downstream loss = 7,944

Total Winter Steelhead Increase		Upstream Passage		Adult and Half-pounder Equiv. Downstream Passage
10,304	=	2,360	+	7,944

Table 5. Estimated Coho Salmon Increases Resulting from Savage Rapids Dam Removal - Mid Range

Upstream adult passage at dam

Assumptions:

SRD adult upstream mortality = 15%(Adults at base of SRD) — Source: Young, 1994 (estimated range 10-30% adult passage loss)
Gold Ray Dam counts = 1,981 — Source: Gold Ray Dam counts, 1942 - 93, average
Assume no wild fish spawning between Gold Ray and Savage Rapids dams
Upper river escapement = Gold Ray Dam counts = 0.85(Adults at base of SRD)

Calculations:

Adults at base of SRD = Upper river escapement/(0.85) = 1,981/(0.85) = 2,331
SRD adult upstream mortality = 0.15(2,331) = 350

Adult increase due to eliminating SRD adult passage loss = 350

Downstream juvenile passage at dam

Assumptions:

SRD juvenile mortality = 15%(juveniles migrating to SRD) — Source: Young, 1994 (estimated average 10-15%, range 5-30%)
Hatchery juvenile-to-adult survival rate = 2% — Source: Lewis, 1993 Average 1977-89 brood years,range 0.3-12%
Hatchery juveniles released = 200,000 — Source: ODFW, hatchery release data, 1985-94
(Juveniles produced each year)(Juvenile-to-adult survival) = Hatchery Adults produced (includes ocean harvest)
Juveniles migrating to SRD = 80%(Juveniles produced each year) — Source: Evenson, personal communication, estimate
Adult equivalent increase = (SRD juvenile mortality)(Juvenile-to-adult survival)

Calculations:

Juveniles migrating to SRD = 0.90(200,000) = 180,000
SRD juvenile mortality = 0.15(180,000) = 27,000
Adult equivalent increase = (27,000)(0.02) = 540

Adult equivalent increase due to eliminating SRD downstream loss = 350

Total Hatchery Coho Increase		Upstream Passage		Adult Equiv. Downstream Passage
890	=	350	+	540

Table 6. Estimated Salmon and Steelhead Increases Resulting from Savage Rapids Dam Removal - Mid Range

(Adults or adult equivalents contributing to ocean harvest, river harvest, and spawning)

Species	Upstream Passage	Downstream Passage	Spawning Habitat Increase	Total
Spring Chinook	5,493	8,604		14,097
Fall Chinook	2,205	2,659	3,063	7,927
Summer Steelhead	1,701	8,701		10,402
Winter Steelhead	2,360	7,944		10,304
Coho (hatchery fish only)	350	540		890
			Grand Total =	43,620

Table 7. Estimated Spring Chinook Salmon Increases Resulting from Savage Rapids Dam Removal - Low Range

Upstream adult passage at dam

GRD Counts	Loss SRD	Adults below SRD	SRD Upst. Increase
31,126	0.1	34,584	3,458

Downstream juvenile passage at dam

	# juvs	Loss SRD	Juv. loss	Surv to adult	Adult equiv increase
Hatchery	1,458,000	0.05	72,900	0.02	1,458
Wild	1,410,000	0.05	70,500	0.02	1,410
			Adult Equivalent Downstream Increase		2,868

Total Spring Chinook			Upstream Passage		Adult Equiv. Downstream Passage
Increase	6,326	=	3,458	+	2,868

Table 8. Estimated Fall Chinook Salmon Increases Resulting from Savage Rapids Dam Removal - Low Range

Above SRD Adult Production

GRD Count	SRD-GRD	Spawn Escapement	River harvest	Presp. mort	Ocean harv
3,148	9,350	12,498	0.095	0.2	2

Upper river run at mouth =	17,728		
River harvest =	1,684		
Prespawning mortality =	3,546		
Ocean harvest =	35,455	Above Savage Rapids Adult Production =	53,183

Adult spawning habitat increases

SRD run at mouth =	1,021	
River harvest =	97	
Ocean harvest =	2,042	
	3,063	= Total adult increases if spawning habitat were restored

Upstream adult passage at dam

Spawn Escapement	Loss SRD	Adults below SRD	SRD Upst. Increase
12,498	0.1	13,886	1,389

Downstream juvenile passage at dam

Surv.to adult	#juvs	Loss SRD	Juv loss	Adult equiv increase
0.02	886,383	0.05	44,319	886

Total Fall Chinook		Upstream Passage		Adult Equiv. Downstream Passage		Spawning Population Increase
Increase	5,338	1,389	+	886	+	3,063

Table 9. Estimated Summer Steelhead Increases Resulting from Savage Rapids Dam Removal - Low Range

Upstream adult passage at dam

GRD Count	SRD-GRD	Upper River Esc	Loss SRD	Ad.belowSRD	SRD Upst. Increase
6,016	3,624	9,640	0.1	10,711	1,071

Downstream juvenile passage at dam

Juv released	Surv to dam	Hatchery Juvs at SRD	Loss SRD	Hat. Juv. Increase
144,523	0.8	115,618	0.05	5,781

Half-pounder equiv. increase hatchery fish = 694

Half-pounder equiv. increase wild + hatchery fish = 3,594 = SRD Half-pounder Equiv Downstream Increase

Half-pounder equiv. increase wild fish = 2,901

Total Summer Steelhead Increase		Upstream Passage		Half-pounder Equiv. Downstream Passage
4,665	=	1,071	+	3,594

Table 10. Estimated Winter Steelhead Increases Resulting from Savage Rapids Dam Removal - Low Range

Upstream adult passage at dam

GRD Count	SRD-GRD	Upper River Esc	Loss SRD	Ad.belowSRD	SRD Upst. Increase
9,317	4,056	13,373	0.1	14,858	1,486

Downstream juvenile passage at dam

Juv releasd	Surv to dam	Hatchery Juvs at SRD	Loss SRD	Hat. Juv. Increase
121,000	0.8	96,800	0.05	4,840

Half-pounder equiv. increase hatchery fish = 407

Half-pounder equiv. increase wild + hatchery fish = 2,541 = SRD Half-pounder Equiv Downstream Increase

Half-pounder equiv. increase wild fish = 2,134

Adult equivalent increase of hatchery fish = 17

Adult equiv. increase of wild + hatchery fish = 109

Adult equiv. increase wild fish = 91

Total adult and half-pound equiv. increase of wild and hatchery fish = 2,650

Total Winter Steelhead Increase		Upstream Passage		Adult and Half-pounder Equiv. Downstream Passage
4,136	=	1,486	+	2,650

Table 11. Estimated Coho Salmon Increases Resulting from Savage Rapids Dam Removal - Low Range

Upstream adult passage at dam

	GRD Count	Loss SRD	Adults below SRD	SRD Upst. Increase
	1981	0.1	2,201	220

Downstream juvenile passage at dam

	# juvs	#juv at SRD	Loss SRD	Juv. loss	Surv to adult	Adult equiv increase
Hatchery	200,000	180,000	0.05	9,000	0.02	180

Total Hatchery Coho Increase		Upstream Passage		Adult Equiv. Downstream Passage
400	=	220	+	180

Table 12. Estimated Salmon and Steelhead Increases Resulting from Savage Rapids Dam Removal - Low Range

(Adults or adult equivalents contributing to ocean harvest, river harvest, and spawning)

Species	Upstream Passage	Downstream Passage	Spawning Habitat Increase	Total
Spring Chinook	3,458	2,868		6,326
Fall Chinook	1,389	886	3,063	5,338
Summer Steelhead	1,071	3,594		4,665
Winter Steelhead	1,486	2,650		4,136
Coho (hatchery fish only)	220	180		400
			Grand Total =	20,866

Table 13. Estimated Spring Chinook Salmon Increases Resulting from Savage Rapids Dam Removal - High Range

Upstream adult passage at dam

GRD Counts	Loss SRD	Adults below SRD	SRD Upst. Increase
31,126	0.3	44,465	13,340

Downstream juvenile passage at dam

	# juvs	Loss SRD	Juv. loss	Surv to adult	Adult equiv increase
Hatchery	1,458,000	0.3	437,400	0.02	8,748
Wild	1,410,000	0.3	423,000	0.02	8,460
			Adult Equivalent Downstream Increase		17,208

Total Spring Chinook			Upstream Passage		Adult Equiv. Downstream Passage
Increase	30,548	=	13,340	+	17,208

Table 14. Estimated Fall Chinook Salmon Increases Resulting from Savage Rapids Dam Removal - High Range

Above SRD Adult Production

GRD Count	SRD-GRD	Spawn Escapement	River harvest	Presp. mort	Ocean harvest
3,148	9,350	12,498	0.095	0.2	2

Upper river run at mouth =	17,728		
River harvest =	1,684		
Prespawning mortality =	3,546		
Ocean harvest =	35,455	Above Savage Rapids Adult Production =	53,183

Adult spawning habitat increases

SRD run at mouth =	1,021	
River harvest =	97	
Ocean harvest =	2,042	
	3,063	= Total adult increases if spawning habitat were restored

Upstream adult passage at dam

Spawn Escapement	Loss SRD	Adults below SRD	SRD Upst. Increase
12,498	0.3	17,854	5,356

Downstream juvenile passage at dam

Surv.to adult	#juvs	Loss SRD	Juv loss	Adult equiv increase
0.02	886,383	0.3	265,915	5,318

Total Fall Chinook		Upstream Passage		Adult Equiv. Downstream Passage		Spawning Population Increase
Increase	13,737	5,356	+	5,318	+	3,063

Table 15. Estimated Summer Steelhead Increases Resulting from Savage Rapids Dam Removal - High Range

Upstream adult passage at dam

GRD Count	SRD-GRD	Upper River Esc	Loss SRD	Ad.belowSRD	SRD Upst. Increase
6,016	3,624	9,640	0.3	13,771	4,131

Downstream juvenile passage at dam

Juv released	Surv to dam	Hatchery Juvs at SRD	Loss SRD	Hat. Juv. Loss
144,523	0.8	115,618	0.3	34,686

Half-pounder equiv.increase hatchery fish = 4,162

Half-pounder equiv. increase wild + hatchery fish = 21,566 =SRD Half-pounder Equiv Downstream Increase

Half-pounder equiv. increase wild fish = 17,404

Total Summer Steelhead			Upstream Passage		Half-pounder Equiv. Downstream Passage
Increase	25,697	=	4,131	+	21,566

Table 16. Estimated Winter Steelhead Increases Resulting from Savage Rapids Dam Removal - High Range

Upstream adult passage at dam

GRD Count	SRD-GRD	Upper River Esc	Loss SRD	Ad.belowSRD	SRD Upst. Increase
9,317	4,056	13,373	0.3	19,104	5,731

Downstream juvenile passage at dam

Juv released	Surv to dam	Hatchery Juvs at SRD	Loss SRD	Hat. Juv. Loss
121,000	0.8	96,800	0.3	29,040

Half-pounder equiv. increase hatchery fish = 2,439

Half-pounder equiv. increase wild + hatchery fish = 15,246 =SRD Half-pounder Equiv Downstream Increase

Half-pounder equiv. increase wild fish = 12,807

Adult equivalent increase of hatchery fish = 105

Adult equiv. increase of wild + hatchery fish = 653

Adult equiv. increase wild fish = 549

Total adult and half-pound equiv. increase of wild and hatchery fish = 15,899

Total Winter Steelhead			Upstream Passage		Adult and Half-pounder Equiv. Downstream Passage
Increase	21,631	=	5,731	+	15,899

Table 17. Estimated Coho Salmon Increases Resulting from Savage Rapids Dam Removal - High Range

Upstream adult passage at dam

GRD Count	Loss SRD	Adults below SRD	SRD Upst. Increase
1981	0.3	2,830	849

Downstream juvenile passage at dam

	# juvs	#juv at SRD	Loss SRD	Juv. loss	Surv to adult	Adult equiv increase
Hatchery	200,000	180,000	0.3	54,000	0.02	1,080

Total Hatchery Coho			Upstream Passage		Adult Equiv. Downstream Passage
Increase	1,929	=	849	+	1,080

Table 18. Estimated Salmon and Steelhead Increases Resulting from Savage Rapids Dam Removal - High Range

(Adults or adult equivalents contributing to ocean harvest, river harvest, and spawning)

Species	Upstream Passage	Downstream Passage	Spawning Habitat Increase	Total
Spring Chinook	13,340	17,208		30,548
Fall Chinook	5,356	5,318	3,063	13,737
Summer Steelhead	4,131	21,566		25,697
Winter Steelhead	5,731	15,899		21,631
Coho (hatchery fish only)	849	1,080		1,929
			Grand Total =	93,542

Table 19. Summary of Estimated Salmon and Steelhead Increases Resulting from Savage Rapids Dam Removal for Low, Mid, and High Range Values

(Adults or adult equivalents contributing to ocean harvest, river harvest, and spawning)

Species	Low Range	Mid Range	High Range
Spring Chinook	6,326	14,097	30,548
Fall Chinook	5,338	7,927	13,737
Summer Steelhead	4,665	10,402	25,697
Winter Steelhead	4,136	10,304	21,631
Coho (hatchery fish only)	400	890	1,929
Totals:	20,865	43,620	93,542

Figure 1. Potential Increased Salmon and Steelhead Returns for Harvest and Spawning resulting from Savage Rapids Dam Removal

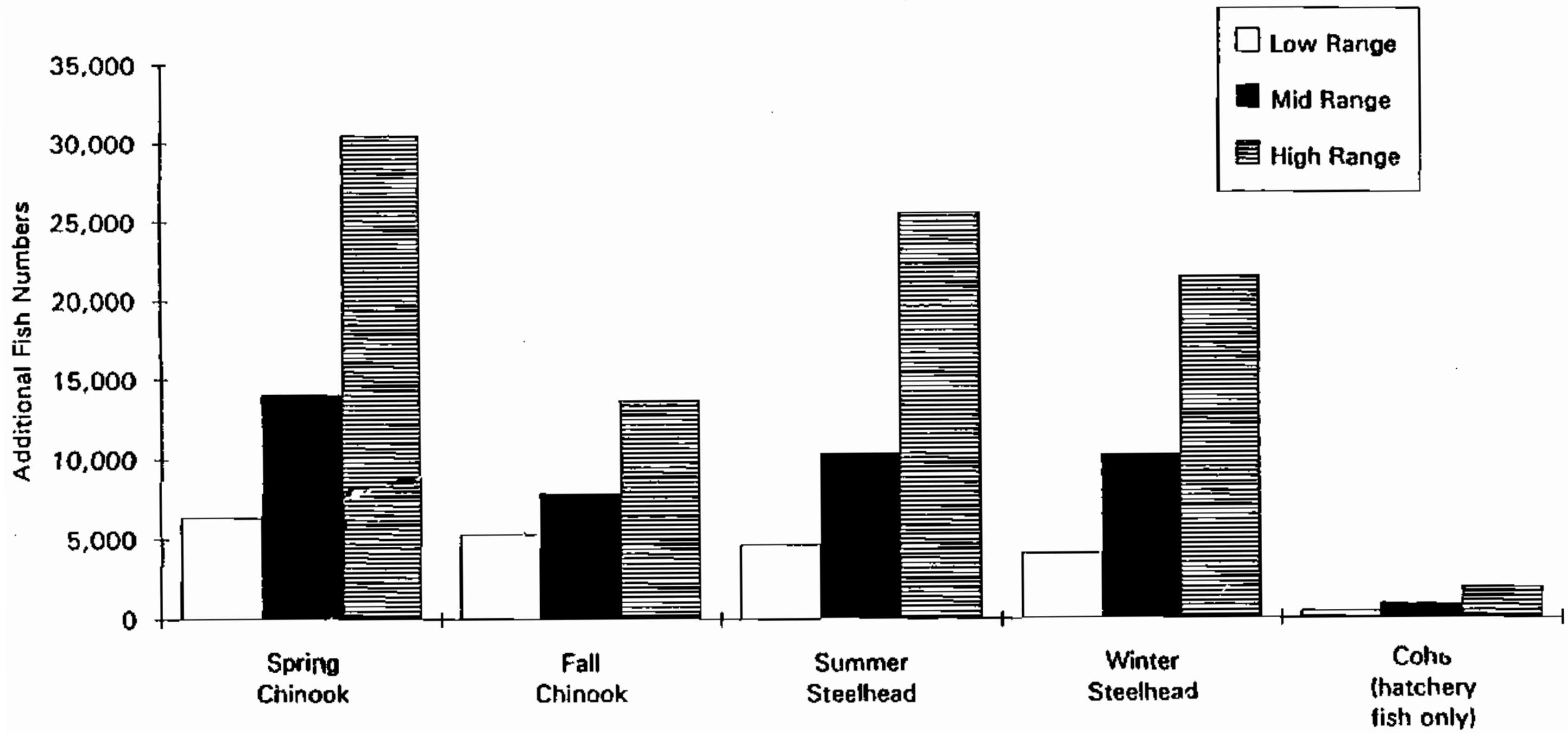
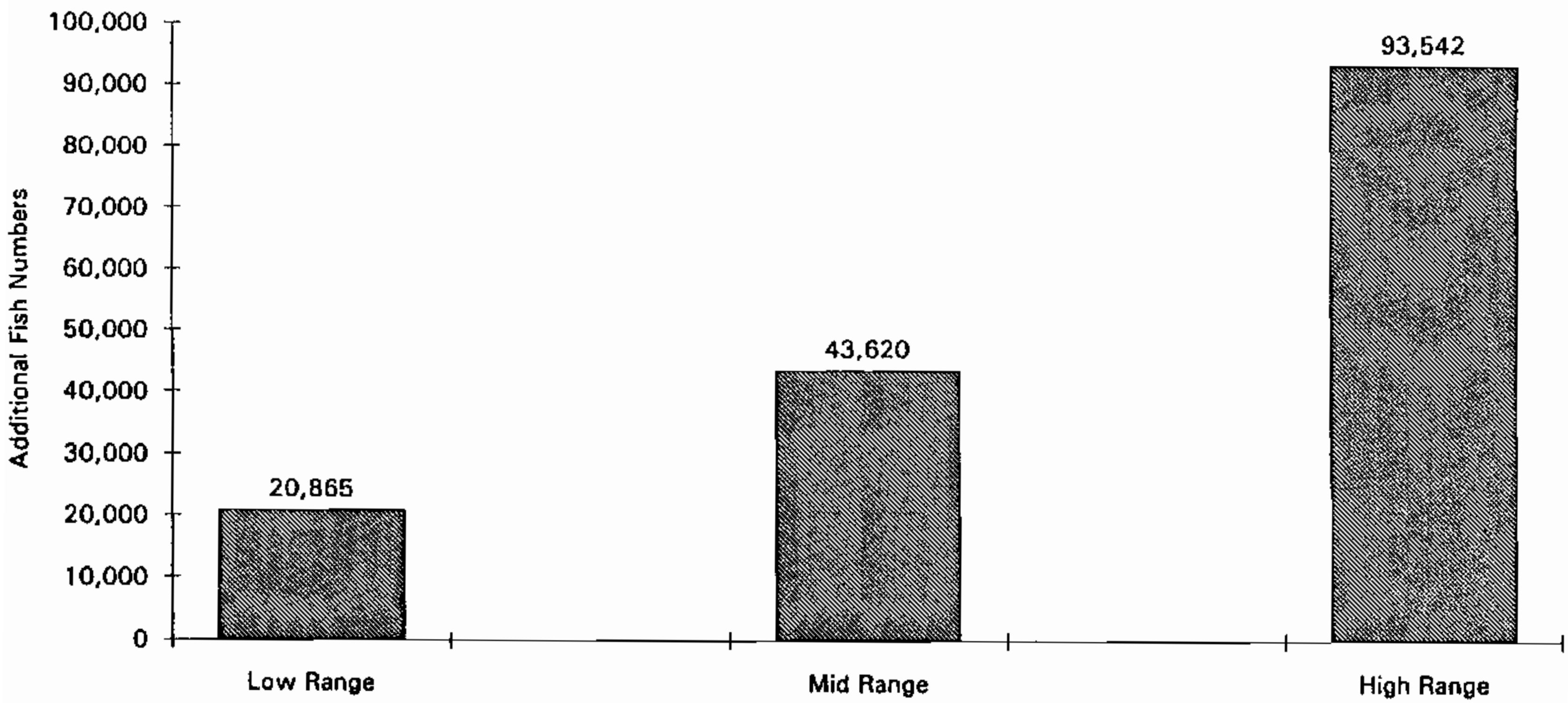


Figure 2. Total Potential Increased Salmon and Steelhead Returns for Harvest and Spawning resulting from Savage Rapids Dam Removal



Oregon

MEMORANDUM

DEPARTMENT OF FISH AND WILDLIFE

Date: July 15, 1994

To: Stephanie Burchfield

From: Frank Young

Subj: Site Visit to Savage Rapids Dam

I visited Savage Rapids Dam July 6-7, 1994 to become familiar with the project and its fish passage facilities. On the morning of July 7 Gerald Budziak, a Department employee with many years of experience working with the project fish passage facilities, provided a tour of the project and described how the various elements of the juvenile and adult fish passage facilities functioned.

In the past I have been involved in seeking solutions to fish passage problems at mainstem dams in the Snake and Columbia rivers for 27 of the 30 years that I was employed by ODFW. While most of my work focused on the mainstem dams, I also participated in design review and inspection of smaller juvenile and adult passage facilities throughout the basin including those in the Umatilla, Yakima, Wenatchee, Deschutes, Grande Ronde and Willamette basins.

Adult Passage

I found the adult fish ladders to be quite primitive compared to fish ladders in the Columbia Basin. The south shore ladder appeared to have three major problems. First, there is no automatic control section for adjusting the height of the weirs at the ladder exit to compensate for fluctuations in forebay level and there doesn't seem to be anyone assigned by the irrigation district to make timely adjustments when the forebay elevation changes. There was a drop of nearly

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2 feet from the exit weir (where there should have been only 1 foot) creating very turbulent conditions in the pool below. Secondly, the large pool in the middle of the ladder had water spilling into it from where a stoplog in the dam had been lifted about one foot to provide make-up water necessary to keep the lower half of the ladder fully watered. The plunge of about six feet created turbulence and a false attraction which could stimulate fish to jump and injure themselves on the rocks at the end of this pool. Thirdly, the ladder exit plunged nearly three feet to the tailrace (where a plunge of only one foot is desirable) causing considerable turbulence and filling the approach to the ladder entrance with bubbles. These bubbles reduce water density and make it more difficult for fish to jump the distance from the tailrace to the first pool. The most likely area for a fish to land when jumping to enter the ladder was on a rock apron off to one side of the ladder.

The north shore ladder suffered from the same lack of ability to be adjusted to compensate for the fluctuations in forebay elevation as the south ladder. In addition, attraction water for the ladder exit was augmented by piped water from the forebay plunging about six feet into the approach to the ladder entrance which produced great turbulence and bubbles at the ladder entrance.

It is my opinion that the cumulative effects of all of the adult passage problems mentioned above are likely resulting in a significant delay to adult fish in passing this area of the river. In both the Columbia and Willamette rivers we have found that any significant delay in upstream passage reduces the probability that delayed fish will spawn successfully.

<u>Juvenile Passage</u>

I believe that there are two potentially significant sources of mortality to juvenile salmonids associated with the project. First, the screen in the south bank canal does not meet criteria for approach velocity, increasing the likelihood of impingement of small fish when there is any debris buildup. Second, water velocity in the reservoir is greatly reduced from that of a river thereby increasing the amount of time juveniles are exposed to predation. The reservoir also increases average water depth, silhouetting juveniles, which travel primarily in the top 15 feet, and thereby making them more vulnerable to predators feeding from below. In addition, since juvenile fish are passed primarily through spill over the dam into extremely turbulent conditions, there is the potential for substantial losses of disoriented juveniles through predation by northern squawfish and predaceous birds.

Conclusions

Under the much better passage facilities of the Columbia River, losses of adult salmonids average about 5-10% per dam. Losses of adult salmonids under the conditions at Savage Rapids Dam could be considerably higher depending upon the flow and ladder entrance and exit conditions at the time of peak passage. I believe that a range of 10-30% adult passage loss is possible based on my observation and experience.

Losses of juvenile fish from predation average about 10% per project for Columbia River dams. I would expect losses of a similar magnitude from predation at Savage Rapids Dam, depending on flow and temperature, with higher losses for juveniles which pass during lower flows and higher temperatures. Additional losses from impingement on the diversion screens could be substantial. At screen facilities where approach velocities meet ODFW standards of 0.8 ft/sec for yearling-sized fish and 0.4 ft/sec for subyearling fish, mortality ranges from 0-5%. When these approach velocities are not met, mortality rates are higher, primarily caused by impingement on the screens when fish can no longer maintain sustained swimming speeds and give up in exhaustion. Given that the approach velocity for the irrigation diversion screens at Savage Rapids Dam are 1.5 ft/sec on the north shore and 1.0 ft/sec on south shore, I believe that mortality rates ranging from 5-30% on diverted fish could be expected.

I believe that losses to juvenile fish from all causes at Savage Rapids Dam may average 10-15%, although actual losses could be much higher.

c.

Nigro

Oregon

DEPARTMENT OF
FISH AND
WILDLIFE

OFFICE OF THE
DIRECTOR

March 13, 1995

Dear Interested Public:

Enclosed is the second report of a two-phased analysis of the impacts of Savage Rapids Dam on salmon and steelhead in the Rogue River. The U.S. Bureau of Reclamation recently released for public review its "Planning Report/Draft Environmental Statement of Fish Passage Improvement -- Savage Rapids Dam" (December, 1994). The report examines in detail two alternatives for improving fish passage conditions at the dam: 1) dam removal with installation of electric pumps to supply water to the irrigation district; and 2) dam retention with replacement of fishways and screens with state-of-the-art facilities. The fish benefits calculated in that report are based on analyses conducted by the National Marine Fisheries Service and the U.S. Fish and Wildlife Service in the 1970's and 1980's.

In response to questions regarding the current applicability of these earlier fish benefit analyses, Oregon Department of Fish and Wildlife (ODFW) staff biologists were asked to review current information and make independent estimates of potential increases in salmon and steelhead populations under both the "dam removal" and "dam retention and improvement" alternatives. The first analysis, presented in an October 1994 report by ODFW, considered the potential increases in adult fish harvest and spawning expected from the "dam removal" alternative. This second analysis utilizes the same methodology for estimating fish increases associated with the "dam retention and improvement" alternative. Increased salmon and steelhead populations would be expected if either of the two alternatives were implemented, although fewer additional fish would be expected with "dam retention and improvement" than with the "dam removal" alternative.

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If you have not yet received the first report, "Estimation of Rogue River Salmon and Steelhead Population Increases for the Savage Rapids 'Dam Removal' Option", and would like a copy, please contact Stephanie Burchfield, ODFW, 2501 SW First Avenue, Portland, Oregon 97207, or by telephone at (503) 229-6967, extension 441.

Sincerely,

RUDOLPH A. ROSEN
Director

Attachment

ESTIMATION OF ROGUE RIVER SALMON AND STEELHEAD POPULATION INCREASES FOR THE SAVAGE RAPIDS "DAM RETENTION AND IMPROVEMENT" OPTION

Oregon Department of Fish and Wildlife*
2501 SW First Avenue
Portland, OR 97207

March 1995

Background

This report presents the second part of an assessment by Oregon Department of Fish and Wildlife (ODFW) of the impacts of Savage Rapids Dam on Rogue River salmon and steelhead populations. The first report, "Estimation of Rogue River salmon and steelhead population increases for the the Savage Rapids 'Dam Removal' option" (October, 1994), presented results of a model analysis of population increases that would be expected if Savage Rapids Dam were removed. This assessment utilizes the same model to estimate expected population increases under a second alternative, dam retention and fish passage improvement.

The dam retention and improvement alternative is described in the U.S. Bureau of Reclamation's report, "Planning Report/Draft Environmental Statement of Fish Passage Improvement -- Savage Rapids Dam" (December, 1994). In addition to numerous modifications to improve dam safety and irrigation diversion structures, significant changes would be made to improve fish passage at the dam. All new facilities would be designed using state-of-the-art features to meet current design criteria. These include the following:

- Replacement of existing screens at the north bank pumping plant intake with vertical traveling screens
- Replacement of existing screens at the south bank gravity canal with rotating drum screens
- Replacement of north and south bank fish ladders with two vertical slot ladders
- Replacement of existing radial spill gates with new spillways and improved gate control system
- Construction of a plunge pool below the spillway to improve conditions for fish passing over the spillway
- Restructuring of the river channel below the dam to improve attraction flows to the fish ladders

As in the first report on the dam removal option, the following analysis makes use of modeling techniques for mathematically predicting population increases given improvements in fish

* Prepared by Stephanie Burchfield, Michael D. Evenson, Mark W. Chilcote, Franklin R. Young, Michael D. Jennings, and Barry P. McPherson

survival associated with changes at the dam site. These techniques allow rapid and credible estimates, but without the great expense of extended and time-consuming data collection and analysis. By this technique ODFW biologists are able to estimate the lowest probable level of fish increases expected from dam retention and improvement, as well as the highest probable level. These low and high estimates are based on field studies at other dams where similar fish screens and ladders have been installed and evaluated. The low and high estimates are used to set the reasonable boundaries, within which the actual population number will lie. Because a number of factors influence this number from year to year, the actual population number will vary yearly, but this variation is expected to fall within the low and high boundaries discussed above.

Approach

High and low values for upstream and downstream fish loss rates are assumed for the improved fish passage facilities that would be installed under the dam retention alternative. These ranges are based on field studies at other dams where similar, state-of-the-art fish passage facilities have been installed. The attached memorandum from Frank Young, ODFW, February 9, 1995, summarizes existing research and recommends appropriate ranges for this analysis. Young's memorandum assumes no juvenile or adult fish mortality associated with passage over the improved spillway. Acute losses caused by emergency shutdown or facility failure are not included in Young's estimates of expected fish losses. It also assumes that losses of juvenile fish to predation are the same for the alternatives of dam retention and dam removal. We make this assumption because we cannot predict whether Umpqua squawfish will colonize the area around Savage Rapids Dam.

Umpqua squawfish are not native to the Rogue River and have spread upstream since they entered the Rogue River at Grave Creek in 1979. Recent sampling has shown that squawfish prey on juvenile salmon and steelhead in areas downstream of Grants Pass, especially in late spring (ODFW unpublished data). Work on the Columbia River indicates that losses of juvenile salmon to predation by squawfish is greatest in areas near dams (Tabor et al. 1993; Petersen 1994) and that predation losses may be as high as 11 percent (Rieman et al. 1991). Thus, retention of Savage Rapids Dam may result in greater predation losses of juvenile salmon and steelhead than would be expected from the dam removal alternative.

Other than the parameters described above that characterize expected losses at improved fish passage facilities, this model utilizes the same calculations and parameter values as were used in the first report. This includes estimates of adult fish passing Gold Ray Dam, ocean and river harvests, hatchery releases, and smolt-to-adult survival rates. The dam removal alternative calculated fall chinook salmon production associated with increased spawning habitat in the area presently inundated by the reservoir. These calculations are omitted from the dam retention alternative, because with dam retention the reservoir will continue to inundate this habitat, making it unavailable for spawning.

The model estimates annual increases in harvest and spawning populations of salmon and steelhead based on the difference between estimated losses under present dam conditions and losses expected with the dam retention and improvement alternative. Improved fish passage facilities at the dam will result in net increases in salmon and steelhead production in the Rogue River as compared to current conditions.

Details and calculations associated with ODFW's estimate are contained in the attached tables 1 through 13.

Results

Tables 1 through 5 show the assumptions and calculations that were made to estimate "low range" annual increases in harvest and spawning populations of spring chinook, fall chinook, summer steelhead, winter steelhead, and coho salmon. The low range increases are based on the highest expected mortality rates for the proposed fish passage facilities and the lowest mortality rates assumed for the existing facilities. For the proposed facilities at Savage Rapids Dam, an upstream adult fish mortality rate of 3 percent and a downstream juvenile fish mortality rate of 5 percent are assumed (Young 1995). The tables cite sources of data and assumptions used in the mathematical computations. The "Literature Cited" section provides full reference information for these sources.

Table 6 is a summary table that lists "low range" estimates for each species. Based on the assumptions in this model, we estimate that an additional 5,515 salmon and steelhead would be available for harvest and spawning annually if the Savage Rapids Dam retention and improvement alternative were implemented.

Tables 7 through 11 represent "high range" estimates of annual salmon and steelhead increases based on the lowest expected mortality rates for the proposed facilities and the highest mortality rates assumed for the existing facilities. For the proposed facilities, upstream and downstream fish mortality rates of 0 percent are assumed (Young 1995). Table 12 summarizes the "high range" estimates for each species, and shows a combined "high range" estimate for all species of 90,358.

Table 13 summarizes previous tables and shows the range of additional fish available for harvest and spawning for each species. Figure 1 shows this information for each species in graphic form. For all species combined, our estimates range from a low of 5,515 to a high of 90,358.

Conclusions

The range of numbers obtained, 5,515 to 90,358 fish annually, represents a reasonable range of estimates for expected salmon and steelhead population increases attributable to the Savage Rapids Dam retention and improvement alternative. As stated above, actual increases will vary yearly, and are highly dependent on run sizes, harvest rates and proper operation and maintenance of fish passage facilities.

In our first report, ODFW estimated 20,865 to 93,542 additional fish would be expected under the dam removal alternative. Figure 2 shows the ranges of additional fish estimated for both the dam removal and the dam retention alternatives. The large difference in low range estimates reflects both the relatively high rates of fish loss possible at state-of-the-art fish passage facilities and the assumption that existing fish passage losses at the dam are low. For the high range estimates, this difference results primarily from the fact that fall chinook spawning habitat in the reservoir area will be made available with the dam removal option but not with the dam retention alternative. The high range estimates for both alternatives are very close because juvenile and adult fish mortality associated with dam passage is assumed to be zero under the dam retention alternative. This assumption is extremely optimistic, because it requires new facilities to be continuously operated in "like new" condition. Young (1995) states that the range of fish mortality rates he suggests for the dam retention alternative are what one would expect if the facilities are operated and maintained in prime condition. Moreover, this analysis does not account for fish losses that would likely be incurred under the dam retention alternative from acute incidents such as screen failure and ongoing losses caused by spillway passage and increased predation.

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Table 1. Estimated Spring Chinook Salmon Increases Resulting from Savage Rapids Dam Retention and Improvement Alternative - Low Range

Adult Production = Upper river (UR) returns + River harvest + Ocean harvest

Assumptions:

UR returns =	31,126	Source: Gold Ray Dam counts, 1942 - 93 average
Lower river harvest rate =	28%	Source: Cramer et al, 1985, p. 255 (1964-81); does not include jacks
Ocean harvest =	43,397	Source: Satterthwaite, 1987, p.27, Table 9; catch:escapement = 1:1

Calculations:

River harvest = 0.28(Total fish at mouth) = 0.28(UR return + River harvest) = 0.28 (UR return)/(1-0.28)

River harvest = 0.28(31,126)/0.72 = 12, 105

Upper R. Returns	+ River Harvest	+ Ocean Harvest =	Adult Production
31,126	12,105	43,397	86,628

Upstream adult passage at dam

Assumptions:

SRD adult loss existing conditions (low range) =3,458 — Source: Burchfield et al, 1994, Table 7

SRD adult loss with dam ret. alt.=3%(Adults at base of SRD) — Source: Young, 1995 (estimated range 0-3% adult passage loss)

Assume no loss between Savage Rapids (SRD) and Gold Ray (GRD) dams

Calculations:

Adults at base of SRD = GRD counts + SRD Upstream Loss = GRD counts + 0.03(Adults at base of SRD)

0.97(Adults at base of SRD) = GRD counts

Adults at base of SRD = GRD counts/0.97 = 31,126/0.97 = 32,089

Adults at base of SRD x SRD adult loss rate = Adult loss with dam retention alternative

32,089 3% 963

Adult increase = Adult loss under existing conditions - adult loss expected with dam retention alternative

= 3,458 - 963 = 2,495 =Adult increase (upstream passage) with dam retention alternative

Downstream juvenile passage at dam

Assumptions:

SRD adult equivalent loss existing conditions (low range) =2,868	Source: Burchfield et al, 1994, Table 7
SRD juvenile mortality = 5%(smolts migrating to SRD)	Source: Young, 1995 (estimated range 0-5%)
Hatchery smolts produced = 1,458,000	Source: ODFW, hatchery release data, 1986-94
Wild smolts produced = 1,410,000	Source: ODFW unpublished data, mean for 1976-90
Hatchery smolt-to-adult survival rate = 2%	Source: ODFW, hatchery data, includes harvest
Wild smolt-to-adult survival rate = 2%	Source: Satterthwaite, 1994, personal communication.

Table 1, continued. Estimated Spring Chinook Salmon Increases Resulting from Savage Rapids Dam Retention and Improvement Alternative - Low Range

Downstream juvenile passage at dam, continued

Calculations:

SRD juvenile loss (hatchery) = 5%(1,458,000) = 72,900
SRD juvenile loss (wild) = 5%(1,410,000) = 70,500

Adult equivalent loss with dam ret. alt = (SRD hatchery juvenile loss x hatchery smolt-to-adult survival rate) +
(SRD wild juvenile loss x wild smolt-to-adult survival rate) = (72,900 x 0.02) + (70,500 x 0.02) = 2,868
Adult equivalent increase = Adult equiv. loss existing conditions - adult equiv. loss with dam ret. alt.
= 2,868 - 2,868 = 0 = Adult equiv. increase (downstream passage) with dam retention alternative

Total Spring Chinook Increase		Upstream Passage		Adult Equiv. Downstream Passage
2,495	=	2,495	+	0

Table 2. Estimated Fall Chinook Salmon Increases Resulting from Savage Rapids Dam Retention and Improvement Alternative - Low Range

Above Savage Rapids Adult Production = Upper river run at mouth + Ocean harvest of fish originating above SRD

Assumptions:

Upper river run at mouth = Spawning escapement + River harvest + lower river prespawning mortality
Spawning escapement = Gold Ray Dam counts + Spawning between SRD and GRD
Gold Ray Dam counts = 3,148 Source: Gold Ray Dam counts, 1942 - 93 average
Spawning between SRD and GRD = 9,350 Source: Satterthwaite, 1992 (500 fish/km)
River harvest = 9.5% (upper river run at mouth) Source: ODFW, 1992, p.78, 1974-86 average
Prespawning mortality = 20%(upper river run at mouth) Source: Satterthwaite, personal communication
Ocean harvest = 2(upper river run at mouth) Source: Satterthwaite, personal communication, assume C:E = 2:1 for upper river fall chinook

Calculations:

Spawning escapement = 3,148 + 9,350 = 12,498
Upper river run at mouth = 12,498 + 0.095(upper run) + 0.20(upper run)
Upper run(1-0.095-0.20) = 12,498
Upper run = 12,498/0.70 = 17,728
River harvest = (0.095)(17,728) = 1,684
Prespawning mortality = (0.20)(17,728) = 3,546
Ocean harvest = 2(17,728) = 35,456
Above Savage Rapids Adult Production = 17,728 + 35,456 = 53,184

Table 2, continued. Estimated Fall Chinook Salmon Increases Resulting from Savage Rapids Dam Retention and Improvement Alternative - Low Range

Upstream adult passage at dam

Assumptions:

SRD adult passage loss existing conditions (low range) =1,389 — Source: Burchfield et al, 1994, Table 8

SRD adult loss with dam ret. alt.=3%(Adults at base of SRD) — Source: Young, 1995 (estimated range 0-3% adult passage loss)

Spawning escapement = Gold Ray Dam counts + Spawning between SRD and GRD = 12,498

Spawning escapement = 0.97(Adults at base of SRD)

Calculations:

Adults at base of SRD = Spawning escapement/(0.97) = 12,498/(0.97) = 12,884

SRD adult passage loss with dam ret. alt. = 0.03(12,884) = 387

Adult increase = Adult loss under existing conditions - adult loss expected with dam retention alternative

= 1,389 - 387 = 1,002 =Adult increase (upstream passage) with dam retention alternative

Downstream juvenile passage at dam

Assumptions:

SRD adult equivalent loss existing conditions (low range) = 886 — Source: Burchfield et al, 1994, Table 8

SRD juvenile mortality = 5%(juveniles migrating to SRD) — Source: Young, 1995 (estimated range 0-5%)

Wild juvenile-to-adult survival rate = 2% — Source: ODFW unpublished data, 1976-90 average

(Juveniles produced each year)(Juvenile-to-adult survival rate) = Upper river adult run at mouth

Adult equivalent loss with dam ret. alt. = (SRD juvenile mortality)(Juvenile-to-adult survival rate)

Calculations:

Juveniles produced = Upper river adult run at mouth/juvenile-to-adult survival rate = 17,728/0.02

Juveniles produced = 886,400

SRD juvenile mortality = 0.05(886,400) = 44,320

Adult equivalent loss with dam ret. alt. = (44,320)(0.02) = 886

Adult equivalent increase = Adult equiv. loss existing conditions - adult equiv. loss with dam ret. alt.

= 886 - 886 = 0 =Adult equiv. increase (downstream passage) with dam retention alternative

Total Fall Chinook Increase		Upstream Passage		Adult Equiv. Downstream Passage
1,002	=	1,002	+	0

Table 3. Estimated Summer Steelhead Increases Resulting from Savage Rapids Dam Retention and Improvement Alternative - Low Range

Upstream adult passage at dam

Assumptions:

SRD adult loss existing conditions (low range) =1,071 — Source: Burchfield et al, 1994, Table 9
SRD adult loss with dam ret. alt.=3%(Adults at base of SRD) — Source: Young, 1995 (estimated range 0-3% adult passage loss)
Gold Ray Dam counts = 6,016 — Source: Gold Ray Dam counts, 1942 - 93, average
Returns between Gold Ray and Savage Rapids dams = 3624 — Source: Satterthwaite, 1992
Upper river escapement = Gold Ray Dam Counts + Returns between Gold Ray and Savage Rapids
Upper river escapement = 0.97(Adults at base of SRD)

Calculations:

Upper river escapement = 6,016 +3,624 = 9640
Adults at base of SRD = Upper river escapement/(0.97) = 9,640/(0.97) = 9,938
SRD adult passage loss with dam ret. alt. = 0.03(9,938) = 298
Adult increase = Adult loss under existing conditions - adult loss expected with dam retention alternative
= 1,071 - 298 = 773 =Adult increase (upstream passage) with dam retention alternative

Downstream juvenile passage at dam

Assumptions:

Most of river harvest is on half-pounders, produced above but harvested below SRD. — Source: ODFW, 1994, p.189
(Does not include adult returns from half-pounders to avoid double counting).
SRD half-pounder equivalent loss existing conditions (low range) =3,594 — Source: Burchfield et al, 1994, Table 9
SRD juvenile mortality = 5%(juveniles migrating to SRD) — Source: Young, 1995 (estimated range 0-5%)
Hatchery juvenile-to-half-pounder survival rate = 12% — Source: ODFW,1994, p.1, range = 3 - 28%, 1976-91 returns
Hatchery juveniles released = 144,523 — Source: ODFW,1994,p.134, 1974-91 average
(Current releases = 220,000) — Source: ODFW, hatchery release data, 1991-94
Juveniles migrating to SRD = 80%(Juveniles released each year) — Source: Evenson, personal communication, estimate
Half-pounder equivalent loss with dam ret. alt = (SRD juvenile mortality)(Juvenile-to-half-pounder survival rate)
Hatchery adults = 31% of total population passing Gold Ray Dam — Source: ODFW,1994,p.51, 1970-91 brood years
Hatchery adults = 0.31(6,016) = 1,865
Hatchery adults = (1,865)/(9,640) = 19.3% of total adults passing Savage Rapids Dam

Table 3, continued. Estimated Summer Steelhead Increases Resulting from Savage Rapids Dam Retention and Improvement Alternative - Low Range

Calculations:

Hatchery juveniles migrating to SRD = 0.80(144,523) = 115,618
SRD hatchery fish juvenile mortality = 0.05(115,168) = 5,758
Half-pounder equivalent loss hatchery fish with dam ret. alt. = (5,758)(0.12) = 691
Half-pounder equiv. loss wild + hatchery fish = half-pounder equiv. loss hatch. fish/percentage of hatchery adults of total passing SRD
Half-pounder equiv. loss wild + hatchery fish = (691)/(0.193) = 3,580
Half-pounder equiv. loss wild fish = 3,580 - 691 = 2,889
Half-pounder equivalent increase = Half-pounder equiv. loss existing conditions - half-pounder equiv. loss with dam ret. alt.
= 3,594 - 3,580 = 14 =Half-pounder equiv. increase (downstream passage) with dam retention alternative

Total Summer Steelhead Increase		Upstream Passage		Half-pounder Equiv. Downstream Passage
787	=	773	+	14

Table 4. Estimated Winter Steelhead Increases Resulting from Savage Rapids Dam Retention and Improvement Alternative - Low Range

Upstream adult passage at dam

Assumptions:

SRD adult loss existing conditions (low range) = 1,486 — Source: Burchfield et al, 1994, Table 10
SRD adult loss with dam ret. alt.=3%(Adults at base of SRD) — Source: Young, 1995 (estimated range 0-3% adult passage loss)
Gold Ray Dam counts = 9,317 — Source: Gold Ray Dam counts, 1942 - 93, average
Returns between Gold Ray and Savage Rapids dams = 4056 — Source: Satterthwaite, 1992
Upper river escapement = Gold Ray Dam counts + Returns between Gold Ray and Savage Rapids
Upper river escapement = 9,317 + 4,056 = 13,373
Upper river escapement = 0.97(Adults at base of SRD)

Calculations:

Adults at base of SRD = Upper river escapement/(0.97) = 13,373/(0.97) = 13,787
SRD adult passage loss with dam ret. alt. = 0.03(13,787) = 414
Adult increase = Adult loss under existing conditions - adult loss expected with dam retention alternative
= 1,486 - 414 = 1,072 =Adult increase (upstream passage) with dam retention alternative

Table 4, continued Estimated Winter Steelhead Increases Resulting from Savage Rapids Dam Retention and Improvement Alternative - Low Range

Downstream juvenile passage at dam

Assumptions:

Most of river harvest is on half-pounders, produced above but harvested below SRD. Source: ODFW, 1994, p.189
(Does not include adult returns from half-pounders to avoid double counting).

SRD adult and half-pounder equivalent loss existing conditions (low range) =2,650 Source: Burchfield et al, 1994, Table 10

SRD juvenile mortality = 5%(juveniles migrating to SRD) Source: Young, 1995 (estimated range 0-5%)

Hatchery juvenile-to-half-pounder survival rate = 12% Source: ODFW, 1994

Hatchery juvenile-to-adult survival rate = 1.2% Source: ODFW, hatchery data, (average, 1974-86 brood years)

Hatchery juveniles released = 121,000 Source: ODFW,1990,p.68, 1976-86 average, Rogue stock only
(Current release target = 150,000) Source: ODFW, hatchery release data, 1989-94

Juveniles migrating to SRD = 80%(Juveniles released each year) Source: Evenson, personal communication, estimate

Hatchery adults = 23% of total population passing Gold Ray Dam Source: ODFW,1990, p.32, 1979-87 average

Hatchery adults = 0.23(9,317) = 2,143

Hatchery adults = (2,143)/(13,373) = 16% of total adults passing Savage Rapids Dam

Wild adults passing Savage Rapids Dam = Total upper river escapement - Hatchery adults = 13,373 - 2,143 = 11,230

Half-pounder return to river = 70% of total adult + half-pounder return Source: ODFW, 1990,p.44, Angler catch, middle river, 1978/79 and 1979/80
(Adult return = 30% of total returns)

Half-pounder equivalent loss with dam ret. alt. = 70%(SRD juvenile mortality)(Juvenile-to-half-pounder survival rate)

Adult equivalent loss with dam ret. alt. = 30%(SRD juvenile mortality)(Juvenile-to-adult survival rate)

Calculations:

Hatchery juveniles migrating to SRD = 0.80(121,000) = 96,800

SRD hatchery fish juvenile mortality = 0.05(96,800) = 4,840

Half-pounder equivalent loss hatchery fish with dam ret. alt. = 0.70 (4,840)(0.12) = 407

Half-pounder equiv. loss wild + hatchery fish = half-pounder equiv. loss hatch. fish/percentage of hatchery adults of total passing SRD

Half-pounder equiv. loss wild + hatchery fish = (407)/(0.16) = 2,544

Half-pounder equiv. loss wild fish = 2,544 - 407 = 2,137

Adult equivalent loss of hatchery fish = 0.30(4,840)(0.012) = 17

Adult equiv. loss of wild + hatchery fish = (17)/(0.16) = 106

Adult equiv. loss wild fish = 106 - 17 = 89

Total adult and half-pounder equiv. loss of wild and hatchery fish = 2,544 + 106 = 2,650

Adult and half-pounder equivalent increase = Adult and half-pounder equiv. loss existing conditions
- adult and half-pounder equiv. loss with dam ret. alt.

2,650 - 2,650 = 0 =Adult and half-pounder equiv. increase (downstream passage) with dam ret. alternative

Total Winter Steelhead Increase		Upstream Passage		Adult and Half-pounder Equiv. Downstream Passage
1,072	=	1,072	+	0

Table 5. Estimated Coho Salmon Increases Resulting from Savage Rapids Range Dam Retention and Improvement Alternative - Low Range

Upstream adult passage at dam

Assumptions:

SRD adult loss existing conditions (low range) = 220	Source: Burchfield et al, 1994, Table 11
SRD adult loss with dam ret. alt. = 3%(Adults at base of SRD)	Source: Young, 1995 (estimated range 0-3% adult passage loss)
Gold Ray Dam counts = 1,981	Source: Gold Ray Dam counts, 1942 - 93, average

Assume no wild fish spawning between Gold Ray and Savage Rapids dams

Upper river escapement = Gold Ray Dam counts = 0.97(Adults at base of SRD)

Calculations:

Adults at base of SRD = Upper river escapement/(0.97) = 1,981/(0.97) = 2,042

SRD adult passage loss with dam ret. alt. = 0.03(2,042) = 61

Adult increase = Adult loss under existing conditions - adult loss expected with dam retention alternative

= 220 - 61 = 159 =Adult increase (upstream passage) with dam retention alternative

Downstream juvenile passage at dam

Assumptions:

SRD adult equivalent loss existing conditions (low range) = 160	Source: Burchfield et al, 1994, Table 11
SRD juvenile mortality = 5%(juveniles migrating to SRD)	Source: Young, 1995 (estimated range 0-5%)
Hatchery juvenile-to-adult survival rate = 2%	Source: Lewis, 1993 Average 1977-89 brood years,range 0.3-12%
Hatchery juveniles released = 200,000	Source: ODFW, hatchery release data, 1985-94

(Juveniles produced each year)(Juvenile-to-adult survival) = Hatchery Adults produced (includes ocean harvest)

Juveniles migrating to SRD = 80%(Juveniles produced each year)	Source: Evenson, personal communication, estimate

Adult equivalent loss with dam ret. alt. = (SRD juvenile mortality)(Juvenile-to-adult survival rate)

Calculations:

Juveniles migrating to SRD = 0.80(200,000) = 160,000

SRD juvenile mortality = 0.05(160,000) = 8,000

Adult equivalent loss with dam ret. alt. = (8,000)(0.02) = 160

Adult equivalent increase = Adult equiv. loss existing conditions - adult equiv. loss with dam ret. alt.

= 160 - 160 = 0 =Adult equiv. increase (downstream passage) with dam retention alternative

Total Hatchery Coho Increase		Upstream Passage		Adult Equiv. Downstream Passage
159	=	159	+	0

Table 6. Estimated Salmon and Steelhead Increases Resulting from Savage Rapids Dam Retention and Improvement Alternative - Low Range

(Adults or adult equivalents contributing to ocean harvest, river harvest, and spawning)

Species	Upstream Passage	Downstream Passage	Spawning Habitat Increase	Total
Spring Chinook	2,495	0	0	2,495
Fall Chinook	1,002	0	0	1,002
Summer Steelhead	773	14	0	787
Winter Steelhead	1,072	0	0	1,072
Coho (hatchery fish only)	159	0	0	159
			Grand Total =	**5,515**

Table 7. Estimated Spring Chinook Salmon Increases Resulting from Savage Rapids Dam Retention and Improvement Alternative - High Range

Adult Production = Upper river (UR) returns + River harvest + Ocean harvest

Assumptions:

UR returns =	31,126	Source: Gold Ray Dam counts, 1942 - 93 average
Lower river harvest rate =	28%	Source: Cramer et al, 1985, p. 255 (1964-81); does not include jacks
Ocean harvest =	43,397	Source: Satterthwaite, 1987, p.27, Table 9; catch:escapement = 1:1

Calculations:

River harvest = 0.28(Total fish at mouth) = 0.28(UR return + River harvest) = 0.28 (UR return)/(1-0.28)

River harvest = 0.28(31,126)/0.72 = 12, 105

Upper R. Returns	+ River Harvest	+ Ocean Harvest =	Adult Production
31,126	12,105	43,397	86,628

Upstream adult passage at dam

Assumptions:

SRD adult loss existing conditions (high range) =13,340 — Source: Burchfield et al, 1994, Table 13

SRD adult loss with dam ret. alt. =0%(Adults at base of SRD) — Source: Young, 1995 (estimated range 0-3% adult passage loss)

Assume no loss between Savage Rapids (SRD) and Gold Ray (GRD) dams

Calculations:

Adults at base of SRD = GRD counts + SRD Upstream Loss = GRD counts + 0.00(Adults at base of SRD)

(Adults at base of SRD) = GRD counts

Adults at base of SRD = GRD counts = 31,126

Adults at base of SRD	x SRD adult loss rate =	Adult loss with dam retention alternative
31,126	0%	0

Adult increase = Adult loss under existing conditions - adult loss expected with dam retention alternative

= 13,340 - 0 = 13,340 =Adult increase (upstream passage) with dam retention alternative

Downstream juvenile passage at dam

Assumptions:

SRD adult equivalent loss existing conditions (high range) =17,208	Source: Burchfield et al, 1994, Table 13
SRD juvenile mortality = 0%(smolts migrating to SRD)	Source: Young, 1995 (estimated range 0-5%)
Hatchery smolts produced = 1,458,000	Source: ODFW, hatchery release data, 1986-94
Wild smolts produced = 1,410,000	Source: ODFW unpublished data, mean for 1976-90
Hatchery smolt-to-adult survival rate = 2%	Source: ODFW, hatchery data, includes harvest
Wild smolt-to-adult survival rate = 2%	Source: Satterthwaite, 1994, personal communication.

Table 7, continued. Estimated Spring Chinook Salmon Increases Resulting from Savage Rapids Dam Retention and Improvement Alternative - High Range

Downstream juvenile passage at dam, continued

Calculations:

SRD juvenile loss (hatchery) = 0%(1,458,000) = 0

SRD juvenile loss (wild) = 0%(1,410,000) = 0

Adult equivalent loss with dam ret. alt = (SRD hatchery juvenile loss x hatchery smolt-to-adult survival rate) + (SRD wild juvenile loss x wild smolt-to-adult survival rate) = (0 x 0.02) + (0 x 0.02) = 0

Adult equivalent increase = Adult equiv. loss existing conditions - adult equiv. loss with dam ret. alt.
= 17,208 - 0 = 17,208 = Adult equiv. increase (downstream passage) with dam retention alternative

Total Spring Chinook Increase		Upstream Passage		Adult Equiv. Downstream Passage
30,548	=	13,340	+	17,208

Table 8. Estimated Fall Chinook Salmon Increases Resulting from Savage Rapids Dam Retention and Improvement Alternative - High Range

Above Savage Rapids Adult Production = Upper river run at mouth + Ocean harvest of fish originating above SRD

Assumptions:

Upper river run at mouth = Spawning escapement + River harvest + lower river prespawning mortality

Spawning escapement = Gold Ray Dam counts + Spawning between SRD and GRD

Gold Ray Dam counts = 3,148 Source: Gold Ray Dam counts, 1942 - 93 average

Spawning between SRD and GRD = 9,350 Source: Satterthwaite, 1992 (500 fish/km)

River harvest = 9.5% (upper river run at mouth) Source: ODFW, 1992, p.78, 1974-86 average

Prespawning mortality = 20%(upper river run at mouth) Source: Satterthwaite, personal communication

Ocean harvest = 2(upper river run at mouth) Source: Satterthwaite, personal communication, assume C:E = 2:1 for upper river fall chinook

Calculations:

Spawning escapement = 3,148 + 9,350 = 12,498

Upper river run at mouth = 12,498 + 0.095(upper run) + 0.20(upper run)

Upper run(1-0.095-0.20) = 12,498

Upper run = 12,498/0.70 = 17,728

River harvest = (0.095)(17,728) = 1,684

Prespawning mortality = (0.20)(17,728) = 3,546

Ocean harvest = 2(17,728) = 35,456

Above Savage Rapids Adult Production = 17,728 + 35,456 = 53,184

Table 8, continued. Estimated Fall Chinook Salmon Increases Resulting from Savage Rapids Dam Retention and Improvement Alternative - High Range

Upstream adult passage at dam

Assumptions:

SRD adult passage loss existing conditions (high range) =5,356 — Source: Burchfield et al, 1994, Table 14

SRD adult loss with dam ret. alt.=0%(Adults at base of SRD) — Source: Young, 1995 (estimated range 0-3% adult passage loss)

Spawning escapement = Gold Ray Dam counts + Spawning between SRD and GRD = 12,498

Spawning escapement = Adults at base of SRD

Calculations:

Adults at base of SRD = Spawning escapement = 12,498

SRD adult passage loss with dam ret. alt. = 0.0(12,498) = 0

Adult increase = Adult loss under existing conditions - adult loss expected with dam retention alternative

= 5,356 - 0 = 5,356 =Adult increase (upstream passage) with dam retention alternative

Downstream juvenile passage at dam

Assumptions:

SRD adult equivalent loss existing conditions (high range) = 5,318 — Source: Burchfield et al, 1994, Table 14

SRD juvenile mortality = 0%(juveniles migrating to SRD) — Source: Young, 1995 (estimated range 0-5%)

Wild juvenile-to-adult survival rate = 2% — Source: ODFW unpublished data, 1976-90 average

(Juveniles produced each year)(Juvenile-to-adult survival rate) = Upper river adult run at mouth

Adult equivalent loss with dam ret. alt. = (SRD juvenile mortality)(Juvenile-to-adult survival rate)

Calculations:

Juveniles produced = Upper river adult run at mouth/juvenile-to-adult survival rate = 17,728/0.02

Juveniles produced = 886,400

SRD juvenile mortality = 0.0(886,400) = 0

Adult equivalent loss with dam ret. alt. = (0)(0.02) = 0

Adult equivalent increase = Adult equiv. loss existing conditions - adult equiv. loss with dam ret. alt.

= 5,318 - 0 = 5,318 =Adult equiv. increase (downstream passage) with dam ret. alternative

Total Fall Chinook Increase		Upstream Passage		Adult Equiv. Downstream Passage
10,674	=	5,356	+	5,318

Table 9. Estimated Summer Steelhead Increases Resulting from Savage Rapids Dam Retention and Improvement Alternative - High Range

Upstream adult passage at dam

Assumptions:

SRD adult loss existing conditions (high range) = 4,131 — Source: Burchfield et al, 1994, Table 15
SRD adult loss with dam ret. alt. ≈ 0%(Adults at base of SRD) — Source: Young, 1995 (estimated range 0-3% adult passage loss)
Gold Ray Dam counts = 6,016 — Source: Gold Ray Dam counts, 1942 - 93, average
Returns between Gold Ray and Savage Rapids dams = 3624 — Source: Satterthwaite, 1992
Upper river escapement = Gold Ray Dam Counts + Returns between Gold Ray and Savage Rapids
Upper river escapement = Adults at base of SRD

Calculations:

Upper river escapement = 6,016 + 3,624 = 9640
Adults at base of SRD = Upper river escapement = 9,640
SRD adult passage loss with dam ret. alt. = 0.0(9,640) = 0
Adult increase = Adult loss under existing conditions - adult loss expected with dam retention alternative
= 4,131 - 0 = 4,131 = Adult increase (upstream passage) with dam retention alternative

Downstream juvenile passage at dam

Assumptions:

Most of river harvest is on half-pounders, produced above but harvested below SRD. — Source: ODFW, 1994, p.189
(Does not include adult returns from half-pounders to avoid double counting).
SRD half-pounder equivalent loss existing conditions (high range) = 21,566 — Source: Burchfield et al, 1994, Table 15
SRD juvenile mortality = 0%(juveniles migrating to SRD) — Source: Young, 1995 (estimated range 0-5%)
Hatchery juvenile-to-half-pounder survival rate = 12% — Source: ODFW,1994, p.1, range = 3 - 28%, 1976-91 returns
Hatchery juveniles released = 144,523 — Source: ODFW,1994,p.134, 1974-91 average
(Current releases = 220,000) — Source: ODFW, hatchery release data, 1991-94
Juveniles migrating to SRD = 80%(Juveniles released each year) — Source: Evenson, personal communication, estimate
Half-pounder equivalent loss with dam ret. alt = (SRD juvenile mortality)(Juvenile-to-half-pounder survival rate)
Hatchery adults = 31% of total population passing Gold Ray Dam — Source: ODFW,1994,p.51, 1970-91 brood years
Hatchery adults = 0.31(6,016) = 1,865
Hatchery adults = (1,865)/(9,640) = 19.3% of total adults passing Savage Rapids Dam

Table 9, continued. Estimated Summer Steelhead Increases Resulting from Savage Rapids Dam Retention and Improvement Alternative - High Range

Calculations:

Hatchery juveniles migrating to SRD = 0.80(144,523) = 115,618
SRD hatchery fish juvenile mortality = 0.0(115,168) = 0
Half-pounder equivalent loss hatchery fish with dam ret. alt. = (0)(0.12) = 0
Half-pounder equiv. loss wild + hatchery fish = half-pounder equiv. loss hatch. fish/percentage of hatchery adults of total passing SRD
Half-pounder equiv. loss wild + hatchery fish = (0)/(0.193) = 0
Half-pounder equiv. loss wild fish = 0 - 0 = 0
Half-pounder equivalent increase = Half-pounder equiv. loss existing conditions - half-pounder equiv. loss with dam ret. alt.
= 21,566 - 0 = 21,566 =Half-pounder equiv. increase (downstream passage) with dam retention alternative

Total Summer Steelhead Increase		Upstream Passage		Half-pounder Equiv. Downstream Passage
25,697	=	4,131	+	21,566

Table 10. Estimated Winter Steelhead Increases Resulting from Savage Rapids Dam Retention and Improvement Alternative - High Range

<u>Upstream adult passage at dam</u>

Assumptions:

SRD adult loss existing conditions (high range) =5,731 — Source: Burchfield et al, 1994, Table 16
SRD adult loss with dam ret. alt.= 0%(Adults at base of SRD) — Source: Young, 1995 (estimated range 0-3% adult passage loss)
Gold Ray Dam counts = 9,317 — Source: Gold Ray Dam counts, 1942 - 93, average
Returns between Gold Ray and Savage Rapids dams = 4056 — Source: Satterthwaite, 1992
Upper river escapement = Gold Ray Dam counts + Returns between Gold Ray and Savage Rapids
Upper river escapement = 9,317 + 4,056 = 13,373
Upper river escapement = Adults at base of SRD

Calculations:

Adults at base of SRD = Upper river escapement = 13,373
SRD adult passage loss with dam ret. alt. = 0.0(13,373) = 0
Adult increase = Adult loss under existing conditions - adult loss expected with dam retention alternative
= 5,731 - 0 = 5,731 =Adult increase (upstream passage) with dam retention alternative

Table 10, continued. Estimated Winter Steelhead Increases Resulting from Savage Rapids Dam Retention and Improvement Alternative - High Range

Downstream juvenile passage at dam

Assumptions:

Most of river harvest is on half-pounders, produced above but harvested below SRD. Source: ODFW, 1994, p.189
(Does not include adult returns from half-pounders to avoid double counting).
SRD adult and half-pounder equivalent loss existing conditions (high range) =15,899 Source: Burchfield et al, 1994, Table 16
SRD juvenile mortality = 0%(juveniles migrating to SRD) Source: Young, 1995 (estimated range 0-5%)
Hatchery juvenile-to-half-pounder survival rate = 12% Source: ODFW, 1994
Hatchery juvenile-to-adult survival rate = 1.2% Source: ODFW, hatchery data, (average, 1974-86 brood years)
Hatchery juveniles released = 121,000 Source: ODFW,1990,p.68, 1976-86 average, Rogue stock only
(Current release target = 150,000) Source: ODFW, hatchery release data, 1989-94
Juveniles migrating to SRD = 80%(Juveniles released each year) Source: Evenson, personal communication, estimate
Hatchery adults = 23% of total population passing Gold Ray Dam Source: ODFW,1990, p.32, 1979-87 average
Hatchery adults = 0.23(9,317) = 2,143
Hatchery adults = (2,143)/(13,373) = 16% of total adults passing Savage Rapids Dam
Wild adults passing Savage Rapids Dam = Total upper river escapement - Hatchery adults = 13,373 - 2,143 = 11,230
Half-pounder return to river = 70% of total adult + half-pounder return Source: ODFW, 1990,p.44, Angler catch, middle river, 1978/79 and 1979/80
(Adult return = 30% of total returns)
Half-pounder equivalent loss with dam ret. alt. = 70%(SRD juvenile mortality)(Juvenile-to-half-pounder survival rate)
Adult equivalent loss with dam ret. alt. = 30%(SRD juvenile mortality)(Juvenile-to-adult survival rate)

Calculations:

Hatchery juveniles migrating to SRD = 0.80(121,000) = 96,800
SRD hatchery fish juvenile mortality = 0.0(96,800) = 0
Half-pounder equivalent loss hatchery fish with dam ret. alt. = 0.70 (0)(0.12) = 0
Half-pounder equiv. loss wild + hatchery fish = half-pounder equiv. loss hatch. fish/percentage of hatchery adults of total passing SRD
Half-pounder equiv. loss wild + hatchery fish = (0)/(0.16) = 0
Half-pounder equiv. loss wild fish = 0 - 0 = 0

Adult equivalent loss of hatchery fish = 0.30(0)(0.012) = 0
Adult equiv. loss of wild + hatchery fish = (0)/(0.16) = 0
Adult equiv. loss wild fish = 0 - 0 = 0
Total adult and half-pounder equiv. loss of wild and hatchery fish = 0 + 0 = 0
Adult and half-pounder equivalent increase = Adult and half-pounder equiv. loss existing conditions
- adult and half-pounder equiv. loss with dam ret. alt.
15,899 - 0 = 15,899 =Adult and half-pounder equiv. increase (downstream passage) with dam ret. alternative

Total Winter Steelhead Increase		Upstream Passage		Adult and Half-pounder Equiv. Downstream Passage
21,630	=	5,731	+	15,899

Table 11. Estimated Coho Salmon Increases Resulting from Savage Rapids Range Dam Retention and Improvement Alternative - High Range

Upstream adult passage at dam

Assumptions:

SRD adult loss existing conditions (high range) = 849 — Source: Burchfield et al, 1994, Table 17

SRD adult loss with dam ret. alt. = 0%(Adults at base of SRD) — Source: Young, 1995 (estimated range 0-3% adult passage loss)

Gold Ray Dam counts = 1,981 — Source: Gold Ray Dam counts, 1942 - 93, average

Assume no wild fish spawning between Gold Ray and Savage Rapids dams

Upper river escapement = Gold Ray Dam counts = Adults at base of SRD

Calculations:

Adults at base of SRD = Upper river escapement = 1,981

SRD adult passage loss with dam ret. alt. = 0.0(1,981) = 0

Adult increase = Adult loss under existing conditions - adult loss expected with dam retention alternative

= 849 - 0 = 849 =Adult increase (upstream passage) with dam retention alternative

Downstream juvenile passage at dam

Assumptions:

SRD adult equivalent loss existing conditions (high range) = 960 — Source: Burchfield et al, 1994, Table 17

SRD juvenile mortality = 0%(juveniles migrating to SRD) — Source: Young, 1995 (estimated range 0-5%)

Hatchery juvenile-to-adult survival rate = 2% — Source: Lewis, 1993 Average 1977-89 brood years,range 0.3-12%

Hatchery juveniles released = 200,000 — Source: ODFW, hatchery release data, 1985-94

(Juveniles produced each year)(Juvenile-to-adult survival) = Hatchery Adults produced (includes ocean harvest)

Juveniles migrating to SRD = 80%(Juveniles produced each year) — Source: Evenson, personal communication, estimate

Adult equivalent loss with dam ret. alt. = (SRD juvenile mortality)(Juvenile-to-adult survival rate)

Calculations:

Juveniles migrating to SRD = 0.80(200,000) = 160,000

SRD juvenile mortality = 0.0(160,000) = 0

Adult equivalent loss with dam ret. alt. = (0)(0.02) = 0

Adult equivalent increase = Adult equiv. loss existing conditions - adult equiv. loss with dam ret. alt.

= 960 - 0 = 960 =Adult equiv. increase (downstream passage) with dam retention alternative

Total Hatchery Coho Increase		Upstream Passage		Adult Equiv. Downstream Passage
1,809	=	849	+	960

Table 12. Estimated Salmon and Steelhead Increases Resulting from Savage Rapids Dam Retention and Improvement Alternative - High Range

(Adults or adult equivalents contributing to ocean harvest, river harvest, and spawning)

Species	Upstream Passage	Downstream Passage	Spawning Habitat Increase	Total
Spring Chinook	13,340	17,208	0	30,548
Fall Chinook	5,356	5,318	0	10,674
Summer Steelhead	4,131	21,566	0	25,697
Winter Steelhead	5,731	15,899	0	21,630
Coho (hatchery fish only)	849	960	0	1,809
			Grand Total =	**90,358**

Table 13. Summary of Estimated Salmon and Steelhead Increases Resulting from Savage Rapids Dam Retention and Improvement Alternative

(Adults or adult equivalents contributing to ocean harvest, river harvest, and spawning)

Species	Low Range	High Range
Spring Chinook	2,495	30,548
Fall Chinook	1,002	10,674
Summer Steelhead	787	25,697
Winter Steelhead	1,072	21,630
Coho (hatchery fish only)	159	1,809
Totals:	5,515	90,358

Figure 1. Potential Increased Salmon and Steelhead Returns for Harvest and Spawning resulting from Savage Rapids Dam Retention and Improvement Alternative

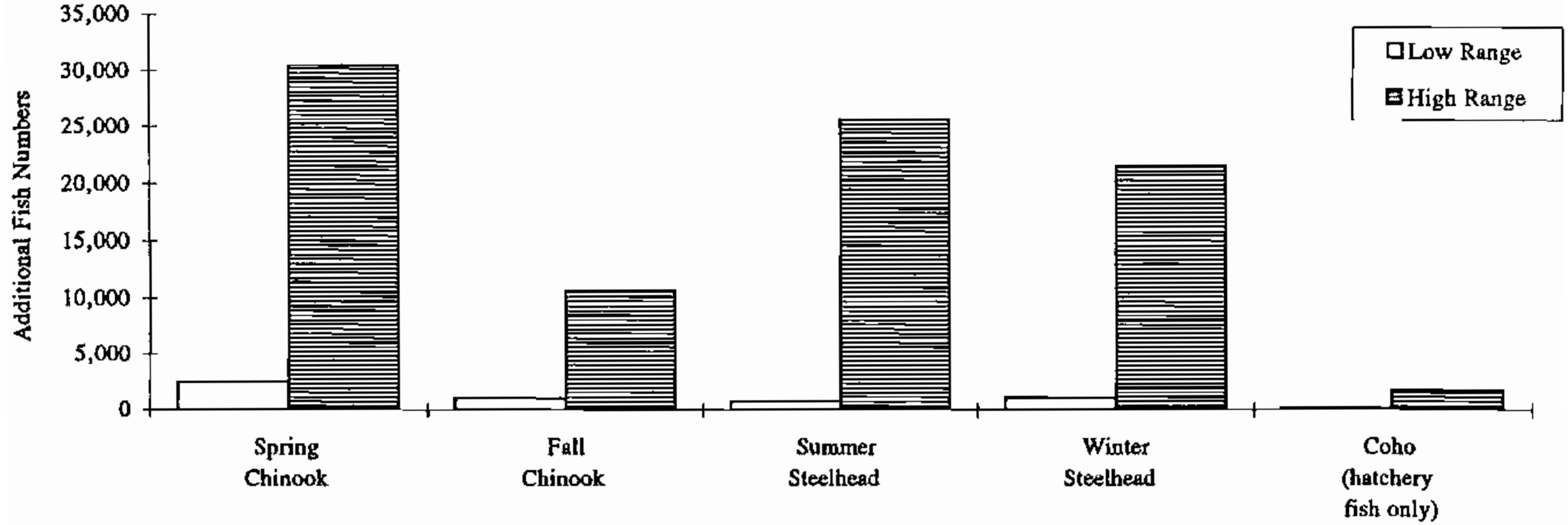
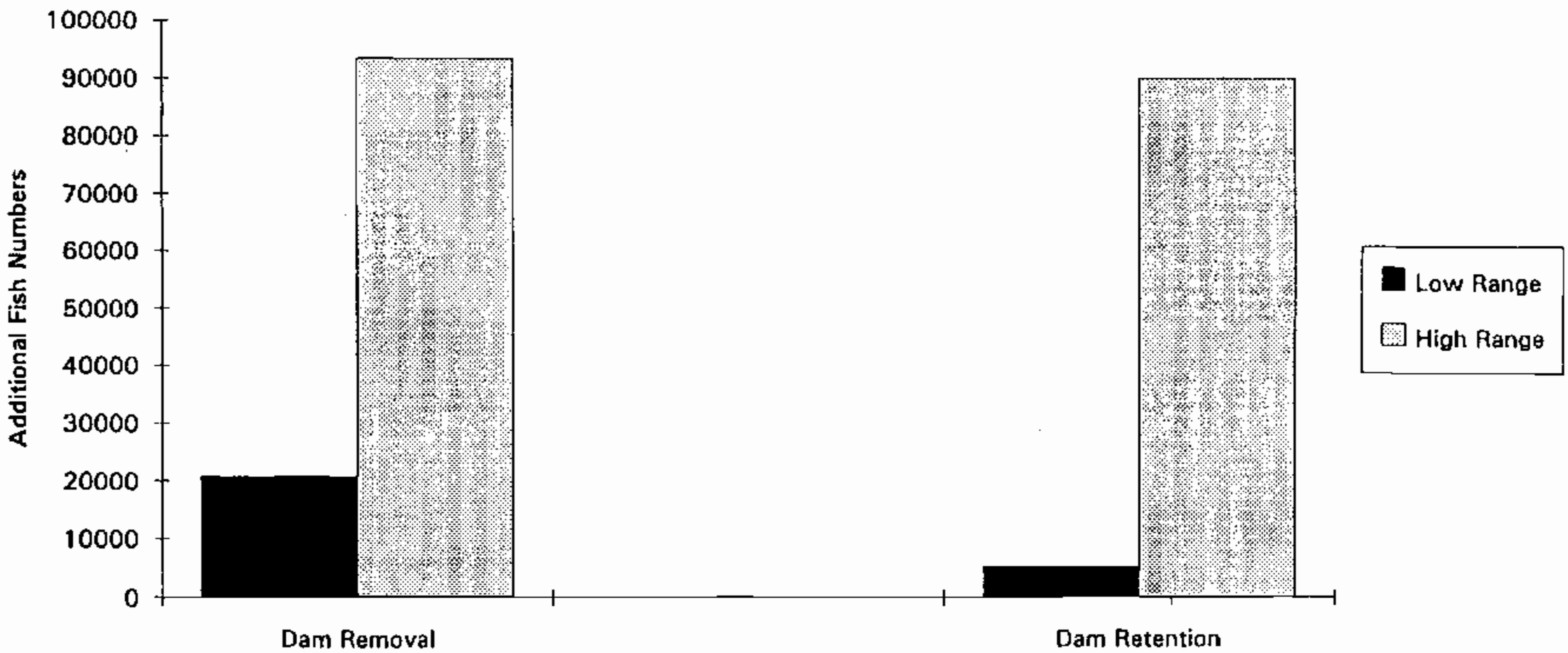


Figure 2. Total Potential Increased Salmon and Steelhead Returns for Harvest and Spawning Expected from Two Alternatives for Savage Rapids Dam: Dam Removal and Dam Alternative



Oregon

DEPARTMENT OF FISH AND WILDLIFE

MEMORANDUM

DATE: February 9, 1995

TO: Stephanie Burchfield, HCD

FROM: Frank Young, Fish Division FY

SUBJECT: Summary of Recent Research on Passage of Juvenile and Adult Salmonids at State-of-the-Art Fish Screen and Ladder Facilities, and Implications for Savage Rapids "Dam Retention" Alternative

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This memo is in response to your request that I examine results of existing research on state-of-the-art fish passage facilities and relate this information to expected survival rates of salmonids at Savage Rapids Dam under the "Dam Retention" alternative. My understanding is that with this alternative, state-of-the-art facilities would replace existing facilities and that monitoring, operations and maintenance would be continued following construction.

Juvenile Fish Passage at State-of-the-Art Rotating Drum Screen Facilities

Fisheries biologists and engineers in the Pacific Northwest generally agree that the safest and most reliable screen design for bypassing juvenile salmonids around a diversion intake is the rotating drum screen set at an angle to incoming flow. In the early 1980's, National Marine Fisheries Service (NMFS), Washington Department of Fisheries (WDF) and Oregon Department of Fish and Wildlife (ODFW) developed design criteria based on studies of fish swimming capabilities and evaluations of existing screens. For fry-sized fish (often called "zero-age"), these criteria included an approach velocity of no greater than 0.5 feet per second and a screen mesh size no greater than 0.125 inches in any direction. In the late 1980's, the agencies lowered the design approach velocity criterion to 0.4 fps for fry-sized fish based on evidence of impingement at the higher velocity. In the last year, the agencies have considered decreasing the criterion for mesh size to 3/32 or 0.0938 inches based on evaluations of screens built during the 1980's that showed fry-sized fish were able to pass through screens with mesh size equal to or greater than 0.125 inches. NMFS is expected to adopt revised criteria that include this decreased mesh size in early 1995. The study results summarized in this section were conducted at facilites designed to meet either the 0.5 or 0.4 feet per second approach velocity and 0.125 inches mesh size criteria.

Neitzel et al (1985) evaluated chinook salmon and steelhead smolts released above rotating drum screens at the Sunnyside Canal on the Yakima River in Washington. They concluded that these smolts were safely diverted to the Yakima River. Less than 2 percent of the chinook salmon smolts were descaled or dead following passage by the screens, and none of the steelhead smolts were descaled or dead.

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In 1986, Neitzel et al (1987) conducted similar evaluations at the Richland and Toppenish/Satus canal fish screening facilities, located on the Yakima River and Toppenish Creek, respectively. Spring chinook and steelhead smolts and fall chinook fry were tested in this study. No significant difference in injury was detected between test and control groups for all species. The authors concluded that both screens safely divert fish from the canals back to the river. Although the authors observed no increase in predation because of the screening facilities, they noted that predatory fish populations could increase in subsequent years and should be reevaluated after several years of continuous operation of the screening facilities.

The Richland and Wapato Canal rotating drum screens on the Yakima River were evaluated by Neitzel et al (1988) in spring, 1987. Descaling and injury rates for test groups of both steelhead and spring chinook smolts were not signficantly different from control groups. At the Richland screens, no loss of fall chinook fry was found resulting from either impingement or passage through the screens. At the Wapato screens, Neitzel estimated 3 to 4 percent of the fall chinook fry were lost from either impingement or passage through the screens or screen seals.

In spring, 1988, Neitzel et al (1990a) conducted evaluations of the rotating drum screens at Wapato, Sunnyside, and Toppenish Creek canals. The authors concluded that fish are neither descaled or killed during passage at the rotating drum screens. They also concluded that although screening facilities could exacerbate predation on juvenile salmonids because of stress, injury or delayed migration, they did not observe loss to predation at these three facilities.

Neitzel et al (1990b) conducted evaluations of the Westside Ditch and Wapato Canal rotating drum screening facilities in 1989. No significant difference in descaling and injury was detected between test and control groups of steelhead and chinook salmon smolts. At the Westside Ditch screens, however, 25 percent of the chinook fry, zero-age fish, passed through the screens. Design criteria for these screens followed the 0.5 feet per second approach velocity and 0.125 inches mesh size criteria recommended by the fisheries agencies in the early 1980's.

The Westside Ditch and Town Canal rotating drum screens on the Yakima River were evaluated by Neitzel et al (1990c) in spring 1990. The authors found no significant difference in descaling between test and control groups of steelhead smolts at the Town Canal. They concluded that 8.5 percent of the native zero-age chinook salmon fry at the Town Canal and 16.8 percent of the same species at the Westside Ditch were lost as a result of passage through the screens. These fish (presumably spring chinook salmon) were mostly less than 36 mm in length. Screen mesh size at both facilities was 0.125 inches.

In 1987 through 1989, Hosey and Associates (1990) evaluated angled rotating drum screens at the Columbia, Chandler, Roza and Easton facilities on the Yakima River in Washington. The authors estimated less than 1 percent of the smolt- and fry-sized spring chinook, fall chinook and steelhead were either descaled or killed as a result of bypass by the screens. Although there was no evidence of fish passing through the screens at Columbia, Chandler or Roza, some spring chinook fry and smolt-sized fish were lost at Easton. The authors attributed this loss to inadequate screen seals. Predation was not considered a major problem during the study period. Avian predation (gulls) was observed at the Columbia facility. Squawfish predation at the Chandler facility was identified as a potential problem during periods of warm water temperatures. The screens at these four facilities were designed to meet design criteria of 0.5 feet per second approach velocity and 0.125 inches mesh size.

In the Umatilla River in Oregon, Hayes et al (1992) evaluated juvenile fish passage at a rotating drum screening facility in the West Extension Irrigation District Canal at Three Mile Falls Dam. The authors detected no significant difference in injury rates between test and control groups of spring chinook, fall chinook and summer steelhead smolts. Screen efficiency was estimated at 99.8 percent, which means that approximately 0.2 percent of the test fish passed through or over the screens into the canal. Screen mesh size was 0.125 inches and design approach velocity was 0.5 feet per second at this facility.

Similar studies were conducted at Furnish Canal on the Umatilla River in 1994. Highest screen efficiency rates were measured when gaps were sealed with foot and top wedges on drum screens and an improved bottom seal mount design was utilized (Cameron et al, 1995).

The need to keep rotating drum screening facilities in proper operating condition was stressed in several studies, including 1993 and 1994 evaluations of new facilities in the Umatilla River (Cameron et al, 1994 and 1995). Proper maintenance is also needed to keep facilities within design criteria.

Juvenile Fish Passage at Vertical Traveling Screen Facilities

Hydraulic design standards for vertical traveling screens are the same as for rotating drum screens. If vertical traveling screens are designed to these standards, including such important factors as uniform distribution of flow approaching the screens, adequate sweeping velocity across the screens, adequate bypass entrance velocity and large bypass entrances, there is no reason why fish survival at this type of screen would not be as high as that encountered at rotating drum screens (Rainey, personal communication). Rainey cautioned, however, that because there are more mechanical parts to vertical traveling screens than rotating drum screens, the likelihood of mechanical failure is greater, which would result in more instances of screen shutdown and potential acute fish mortalities.

Few vertical traveling screens have been installed in recent years that meet current design standards. In the Yakima River basin, where many rotating drum screens were installed in the 1980's, vertical traveling screens have also been installed as secondary screens at two facilities. Both the Chandler and Roza facilities have vertical traveling screens located in the juvenile bypass system after fish have passed the rotating drum screens to bleed off excess bypass flow and pump it back into the canals (Rainey, personal communication). These screens were designed for an approach velocity of 0.4 feet per second and screen mesh size of 0.125 inches. Hosey and Associates (1990) evaluated the vertical traveling screens as part of the entire screen facility survival study described above with reference to rotating drum screens. Overall mortality rates of less than 1 percent were calculated for juvenile fish diverted first by the rotating drum screens and then by the vertical traveling screens.

Vertical traveling screens have also been installed as secondary screens at the West Extension Irrigation District diversion at Three Mile Falls Dam on the Umatilla River (Cameron and Knapp, 1993). Fish impingement on these screens was determined to be a problem when velocities through the screen were too high. The authors concluded that placement of a restrictive orifice downstream of the traveling screen created unfavorable hydraulics at the traveling screen.

The Marmot Dam vertical traveling screens on the Sandy River were evaluated over a thirteen-year period from 1980 through 1993 by Portland General Electric (Cramer, 1993). Numerous modifications were made to the screen facility over the years to improve fish passage problems identified in evaluations. Screen mesh size is currently 0.125 inches. Approach velocity averages 1.1 feet per second, yet ranges from 0.5 to 1.9 due to uneven flow distribution across the screen. The screen is set perpendicular to the flow, and thus there is no sweeping velocity to guide fish to the bypass entrances. Instead, a spray wash system was installed to spray impinged fish off the screen and into a conveyance to the bypass pipe. Mortality of salmon and steelhead fry (35 mm to 50 mm in length) has been reduced as a result of the spray wash system, although mortality continues to be strongly affected by changes in spray wash pressure, direction of spray nozzles, and canal water surface elevation. PGE concluded that 95.4 percent of salmon and steelhead fry survive passage around the screens under average conditions. PGE noted that fry survival might be increased to 98 percent with additional modifications. Hatchery spring chinook and steelhead smolts survived at rates of 95 percent and 97.3 percent, respectively. Survival of wild smolts and other juvenile fish over 50 mm was estimated between 95 percent and 100 percent, but test fish numbers were too low for accurate estimation.

Adult Fish Passage at State-of-the-Art Vertical Slot Ladder Facilities

Few controlled survival studies have been conducted at vertical slot fishways. Most studies to evaluate vertical slot and other fishways have compared rates of fish passage under various operating scenarios, evaluated fallback of adult fish that successfully passed over a dam, identified pooling of fish below a dam or jumping of fish at spillways or other water sources, or evaluated fish delay associated with dam passage.

Fish passage rates and success are largely affected by the distribution of discharge from a dam and the effectiveness of the attraction flows at the fishway entrance (Bjornn and Peery, 1992). Bjornn noted that spill at dams should be shaped to avoid false attraction of adult fish to the spillway rather than to fish ladder entrances. Fishway entrances on both banks of the river, with added attraction flows at the entrances, provide good conditions for fish passage. Bjornn also discussed the location of fishway exits in relation to spillways. If exits are located too close to spillways, fish are more likely to fallback over the dam during high spill rates.

In 1991 and 1992, Hockersmith et al (1994) evaluated passage of adult spring chinook salmon in the Yakima River with radio telemetry equipment. They concluded that migration delays for radio-tagged spring chinook salmon at Yakima River basin dams were similar or less than passage times at Columbia and Snake River dams. Median passage times were less than one day at all of the dams equipped with state-of-the-art vertical slot ladders except at the upper elevation dams where fish were probably holding during the prespawning period. Wapatox Dam on the Naches River, a tributary to the Yakima River, had not been retrofitted with vertical slot ladders. Its existing pool and weir fishway did not pass spring chinook salmon as quickly compared to the other dams. Median passage times were 3.5 days in 1991 and 4.2 days in 1992. Only 7 percent of the radio-tagged fish in 1991 died during the approximate 100 to 150 mile migration from Prosser Dam to spawning grounds in the upper basin. In 1992, mortality associated with migration was estimated at 3 percent. Since these fish passed over 4 to 6 dams in their migration to spawning grounds, it appears that fish ladder passage did not contribute significantly to mortality.

The Technical Advisory Committee (TAC) for U.S. v. Oregon management of anadromous fish harvest in the Columbia River has prepared models of fish survival through the Columbia River dams in its biological assessments of fish harvests under the Endangered Species Act. These models are based on current field studies, harvest information, and daily fish counts at the dams. In 1994, the TAC assumed adult fall chinook losses of 5 percent per dam for the dams from Bonneville to McNary on the Columbia River. The TAC's estimate of adult spring chinook losses in 1995 is 8 percent per dam from Bonneville to McNary on the Columbia River and 5 percent per dam through the four dams on the lower Snake River (Technical Advisory Committee, 1994 and 1995). Because these dams are much larger than Savage Rapids Dam, I would assume that adult fish mortality rates at state-of-the-art fish ladders at Savage Rapids would be even lower than those assumed for the Columbia and Snake River dams.

Recommendations for Modeling Anticipated Passage Success at Savage Rapids Dam under the "Dam Retention" Alternatiive

Rotating Drum Screens: The "Dam Retention" alternative at Savage Rapids Dam calls for a state-of-the-art angled, rotating drum screen facility to be constructed at the Gravity Canal diversion on the south bank of the river. At the time the initial conceptual designs for this facility were developed, design criteria of 0.4 feet per second approach velocity and 0.125 inches screen mesh were assumed. I recommend that, if this alternative is chosen, the most recent design criteria be used to ensure best possible fish protection. At this time, an approach velocity of 0.4 feet per second and screen mesh of 3/32 or 0.0938 inches are recommended design criteria by National Marine Fisheries Service where fry-sized salmonids are present. Given the results of recent research studies listed above and assuming that the new facilities will be operated and maintained in prime condition, I believe juvenile fish mortality for all species associated with the rotating drum screen facility should range from 0 to 5 percent.

Vertical Traveling Screens: The "Dam Retention" alternative also calls for installation of vertical traveling screens at the pump-turbine diversion on the north bank of the river. Conceptual design criteria call for 0.4 feet per second approach velocity and 0.125 inch screen mesh. As stated above regarding the rotating drum screens, I recommend that the most recent design criteria, notably screen mesh of 0.0938 inches, be utilized if this alternative is chosen. It is reasonable to assume that juvenile fish survival at the proposed screens would be greater than that measured at existing screens which do not meet "state-of-the-art" design criteria. Given the results of research studies listed above and considering improvements that the proposed screens would exhibit that are lacking in screens at Marmot Dam, I believe juvenile fish mortality for all species associated with the vertical traveling screens should range from 0 to 5 percent. These screens must also be properly operated and maintained to ensure that fish mortality does not increase above the 0 to 5 percent range.

Fish Ladders: Both the north and south bank fishways would be replaced under the "Dam Retention" alternative with vertical slot ladders that meet current design standards. Based on both actual field studies in the Yakima River basin where state-of-the-art vertical slot fishways have been installed and on model calculations of fish survival through the Columbia and Snake river dams, I believe that adult fish losses and delay at Savage Rapids Dam with the new fishways would be greatly reduced from current conditions. It is my understanding that the dam retention alternative would include modifications to the river channel below the dam to eliminate false attraction flows that currently pose serious impediments to adult fish passage. I suggest using a range of 0 to 3 percent mortality for all adult salmon and steelhead species at the project.

Other Potential Sources of Fish Mortality: This memo does not summarize research results on other sources of mortality at dams, such as spillway mortality, predation and acute losses caused by emergency shutdown or screen failure.

- Spillway: Most studies of state-of-the-art spillways that include good plunge pools show insignificant fish mortality. When adequate plunge pools are provided, the only source of mortality has been associated with high levels of dissolved gases. This situation only occurs at high rates of spill over much higher dams than Savage Rapids and is usually limited to rivers with several dams in progression. Since none of these factors are present at Savage Rapids Dam, I would assume that spillway fish mortality would be essentially zero with the new facilities planned under the dam retention alternative.

- Predation: Studies have shown that predation on juvenile fish by other fish and birds is usually higher in the forebay and tailrace of a dam than in a normal riverine environment. However, my experience studying predation in the Columbia River has indicated that these predators are successful because inadequate hydraulic conditions exist at fish bypass entrances and outlets, resulting in juvenile fish that are easy prey for predators. If the fish facilities at Savage Rapids Dam under the dam retention alternative are designed to optimize hydraulic conditions for fish, predation should be minimized. Without site specific information about predation, I am unable to estimate a mortality rate associated with predation for the dam retention alternative.

- Emergency shutdown: Fish losses can be severe when facilities shutdown unexpectedly, especially if no one is stationed on-site on a 24-hour basis. If juvenile or adult fish are trapped in a holding pool and flow is cut off, dissolved oxygen can be quickly depleted and the fish will die. Other problems, such as debris buildup on screens, tears in screens or improperly fitted screen seals, can result in large numbers of fish diverted into irrigation canals before the screen failure is detected. With rotating drum screens, a spare drum can be kept on-site to replace one that needs maintenance. Vertical traveling screens, however, are not so simple to replace, and it may take days or even weeks to repair or replace such screens. The key to reducing the probability of acute losses is to institute a comprehensive operation and maintenance plan, including regular inspections. Because I am unaware of the extent of maintenance planned for the dam retention alternative, I am unable to estimate a mortality rate associated with acute incidents.

Literature Cited

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