October 1998

IDAHO WATER RENTAL PILOT PROJECT PROBABILITY COORDINATION STUDY RESIDENT FISH AND WILDLIFE IMPACTS PHASE III

Annual Report 1998

DOE/BP-02390-3

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views of this report are the author's and do r necessarily represent the views of BPA.

This document should be cited as follows:

Eric,Leitzinger Fisheries Staff Biologist; Idaho Department of Fish and Game, U. S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife, Project Number 1991-067, Contract Number 1993-BI-02390, 45 electronic pages (BPA Report DOE/BP-02390-3)

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IDAHO WATER RENTAL PILOT PROJECT PROBABILITY/COORDINATION STUDY RESIDENT FISH AND WILDLIFE IMPACTS PHASE III

ANNUAL REPORT

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Project Number 91-067
Contract Number 93-BI-02390

October 1998

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EXECUTIVE SUMMARY

Phase III began in 1995 with the overall goal of quantifying changes in resident fish habitat in the Snake River Basin upstream of Brownlee Reservoir resulting from the release of salmon flow augmentation water. Existing data, in the form of weighted usable area versus flow relationships, were used to estimate habitat changes for white sturgeon (*Acipenser transmontanus*) and rainbow trout (*Oncorhynchus mykiss*) in the Snake River between C.J. Strike Dam and Brownlee Pool. The increased flows resulted in increased habitat for adult and juvenile white sturgeon and adult rainbow trout. But, the flows have rarely met mean monthly flow recommendations for the past four years despite the addition of the flow augmentation releases. It is unlikely that the flow augmentation releases have had any significant long-term benefit for sturgeon and rainbow trout in the Snake River. Flow augmentation releases from the Boise and Payette rivers have in some years helped to meet or exceed minimum flow recommendations in these tributaries. In some cases the minimum flows would not have been reached without the flow augmentation releases. The timing of some of the releases need to be adjusted in order to maximize benefits to resident fishes in the upper Snake River Basin.

INTRODUCTION

The use of stored Snake River water to aid anadromous fish migration in the Snake River downstream of Lewiston, Idaho, and in the Columbia River began in 1982 with the adoption of the first Columbia Basin Fish and Wildlife Program (Program) by the Northwest Power Planning Council (NPPC). The Program called for a total of 1.19 million acre-feet (af) of water from the Snake River Basin to be delivered to Lower Granite Dam between April 15 and June 15 each year to aid spring outmigrating anadromous fish (NPPC 1982). This was called the water budget. This water would come primarily from Dworshak and Brownlee reservoirs.

The water budget evolved and became more specific in the NPPC's Strategy for Salmon (NPPC 1992) in the use of Snake River water for flow augmentation. It called for a total of 427,000 af of water to come from the Snake River upstream of Brownlee Reservoir, up to 900,000 af from Dworshak Reservoir to aid spring migrants, and up to 200,000 af from Dworshak Reservoir to aid fall migrants. Then with the listing of Snake River salmon stocks on the endangered species list, the National Marine Fisheries Service (NMFS) in its Biological Opinion (NMFS 1995) on endangered Snake River salmon, replaced the water budget with flow targets for the Snake and Columbia rivers while maintaining the requirement to use at least 427,000 af of upper Snake River Basin water for flow augmentation. In 1996, the Idaho Legislature approved the use of 427,000 af on an experimental basis through the year 2000.

The Idaho Water Rental Pilot Project began in 1991 as part of the 1990 Non-Treaty Storage Fish and Wildlife Agreement (NTSFWA) between Bonneville Power Administration (BPA) and the Columbia Basin Fish and Wildlife Authority (CBFWA). This agreement resulted from concerns over potential impacts to fish and wildlife resulting from the Non-Treaty Storage Agreements (NTSA) signed between BPA and the mid-Columbia utilities, and between BPA and British Columbia Hydro and Power Authority. The NTSFWA contained several provisions designed to ensure the NTSA did not adversely impact fish and wildlife. One of the provisions called for identifying conditions needed for resident fish and wildlife and to protect those needs.

The Idaho Water Rental Pilot Project was designed to "identify resident fish and wildlife issues, concerns, and resources in the Snake River system, estimate impacts, and provide management recommendations to protect and enhance those resources" as impacted by the release of water in the upper Snake River Basin (upstream of Brownlee Reservoir) for enhancing juvenile salmon

outmigration (Riggin and Hansen 1992). After the initial three years of the project, it was integrated into the NPPC's Fish and Wildlife Program. The project was divided into these three phases:

1. Phase I focused on summarizing and identifying existing resident fish and wildlife resources, issues, and concerns as well as making flow recommendations (Riggin and Hansen 1992).

2. Phase II focused on conducting an Instream Flow Incremental Methodology (IFIM) study on the Snake River upstream of American Falls Dam and summarizing Snake River Basin water issues and flow augmentation releases since the completion of Phase I (Stovall 1994).

3. Phase III is focusing on quantifying changes in resident fish habitat in the upper Snake River resulting from salmon flow augmentation releases and has these specific objectives:

    - Determine impacts to resident fish habitat (in weighted usable area (WUA)) in the upper Snake River Basin, for selected native fish species, resulting from salmon flow augmentation releases and make recommendations that will maximize benefits to resident native fish.

    - Develop a model that estimates changes in fish habitat (WUA) in the upper Snake River resulting from salmon flow augmentation releases.

    - Coordinate with state, federal, and tribal agencies to ensure that duplication of effort does not occur in efforts to explore water management opportunities in the upper Snake River Basin for salmon flow augmentation.

STUDY AREA

The study area encompasses the Snake River upstream of Brownlee Pool to the Idaho border, the Henrys Fork, Boise River, and Payette River drainages. The flow augmentation water is physically moved from these Bureau of Reclamation (BOR) facilities within the study area: American Falls, Lucky Peak,

Cascade, and Deadwood reservoirs (Figure 1).

METHODS

The analysis can be divided into two sections. The first is changes in fish habitat resulting from the flow augmentation releases. The second is a qualitative comparison of flows to minimum flow recommendations found in the literature.

Habitat

The same methods were used to estimate changes in fish habitat in the Snake River between C.J. Strike Dam and Brownlee Pool as was done previously (Leitzinger 1996, 1997). Data from the Swan Falls Instream Flow Study (SFIFS) (Anglin et al. 1992) was used to estimate changes in white sturgeon and rainbow trout habitat (weighted usable area) resulting from the release of salmon flow augmentation water from the Snake River Basin upstream of Brownlee Pool. The SFIFS divided the Snake River from C.J. Strike Dam to Brownlee Pool into five study reaches:

1. From C.J. Strike Dam downstream to Swan Falls Pool;

2. Swan Fall Dam downstream to Walters Ferry;

3. Walters Ferry downstream to the mouth of the Boise River;

4. The Boise River mouth downstream to the mouth of the Payette River; and

5. The Payette River mouth downstream to Brownlee Pool.

The SFIFS developed habitat versus flow relationships for six species in each study reach: white sturgeon (*Acipenser transmontanus*), rainbow trout (*Oncorhynchus mykiss*), mountain whitefish (*Prosopium williamsoni*), smallmouth bass (*Micropterus dolomieui*), flathead catfish (*Pylodictis olivaris*), and channel catfish (*Ictalurus punctatus*). The analysis used in this report covered the same five study reaches. White sturgeon and rainbow trout were used in this analysis because they are the primary native game species left in that reach of the basin. Total WUA was expressed in millions of square feet in each reach.

The Idaho Department of Fish and Game (IDFG), in cooperation with the Idaho Department of Water Resources (IDWR) and BOR conducted

minimum flow studies on much of the Snake River in the 1970s and 1980s using the wetted perimeter method (White and Cochnauer 1975; Cochnauer 1976, 1977; Cochnauer and Buettner 1978; Cochnauer and Hoyt 1979; Horton and Cochnauer 1980; Cochnauer and Mabbott 1981). These data were not used because the method is a standard setting method used to define minimum flows. It is based on the assumption that if minimum flows over narrow riffles are adequate for food production, passage, and spawning, then all other habitats will be adequately protected as well (Stalnaker et al. 1994). The wetted perimeter is an indirect measure of habitat and thus could not be used to quantify habitat changes resulting from increased flow.

Data tracking the movement of the flow augmentation water from the upper Snake River Basin were collected and summarized from the BOR and IDWR. One problem with these data is that the agencies' tracking of the data is incomplete from a biological perspective. IDWR has detailed information on the water including days, volumes, flow rates, etc., but it is only monitored at three locations in the upper Snake River Basin. These locations are Milner Dam on the main Snake River, Letha Bridge on the lower Payette River, and the Middleton Gage on the lower Boise River. The Murphy Gage, downstream from Swan Falls Dam, would be an excellent location to account for and demonstrate impacts of the flow augmentation water in the lower Snake River. Unfortunately, it is not being used for this purpose at this time (B. Ondrechen, IDWR personal communication). The BOR data, on the other hand, give the total volumes released from each reservoir but do not give when it was released nor the resulting flows. The major problem with tracking the flow augmentation water has been the difference between the accounting of the water and the actual physical movement of water through the system. On paper, the data from the BOR and IDWR show the water is being moved out of various reservoirs at various times of the year. The reality, however, is that the water is physically moved only out of American Falls Reservoir in the upper Snake River Basin, Lucky Peak Reservoir in the Boise River Basin, and Cascade and Deadwood reservoirs in the Payette River Basin (R. Larson and R. Rigby BOR personal communication) while other reservoir storage accounts are charged with the flow augmentation releases. For example, individuals that own storage rights in any of the reservoirs upstream of Milner Dam (water district 01) may put some of their stored water into the district's rental pool. If the BOR purchases water from the rental pool, it will physically be moved out of American Falls Reservoir even though the storage right may have been from someplace else. The accounting of the water will be charged to the reservoirs where the storage right exists. Also, small amounts have been charged to uncontracted space. The storage

reservoirs within a water district are operated as a single system, not independent reservoirs. They are operated in a way that tries to maximize the operational flexibility of the system. To do this, the reservoirs are prioritized as to which get drawn down first and which maintain as much water as possible for as long as possible. Generally, the BOR strives to keep water as high in the system as possible. Water can always be moved down the system, but not back up. In order to maintain flexibility, it is quite common for storage space to be transferred among reservoirs. So, it is possible to have Anderson Ranch Reservoir storage space in Lucky Peak Reservoir and vice versa. The main concern BOR has is meeting the total demand for water at the control points (i.e. Milner Dam on the Snake, Letha gage on the Payette, and the Middleton gage on the Boise River). If conditions are such that American Falls Reservoir will refill without having to physically move this water, then it will not be moved. American Falls Reservoir usually refills even in low water years due to the large inflow of springs in the area. The only time the water will be physically moved from a reservoir other than American Falls Reservoir in the upper Snake River Basin is during a very low water year when there is not enough water in American Falls Reservoir (R. Larson BOR personal communication). The same holds true for the Boise system. If natural flows are sufficient to refill Lucky Peak Reservoir storage space used for flow augmentation, then the uncontracted storage in Anderson Ranch Reservoir will not be physically moved out of the reservoir even though on paper it appears as though it has.

A Lotus spreadsheet was developed that calculates the change in WUA expressed in millions of square feet in each reach the same ages classes of sturgeon and rainbow trout used in the SFIFS. The sturgeon life stages were: adult, larvae, spawning, and incubation. The age classes for rainbow trout were adult, juvenile, spawning, and fry. The spreadsheet took United States Geological Survey (USGS) daily stream gage data and subtracted the flow augmentation releases from IDWR. The resulting values represented what the flow in the river would have been without the flow augmentation releases. The stream gage data represents the flow in the river with the flow augmentation water. Then using the SFIFS data, WUA was calculated for each flow. These values were subtracted to get the change in WUA resulting from the flow augmentation releases. The SFIFS habitat versus flow curves were developed using flows from 5,000 to 17,000 cubic feet per second (cfs) in 1,000 cfs increments (5,000, 6,000, 7,000, etc.). Actual flows were somewhere between these points, so WUA for the actual flows were estimated by linear interpolation between the two closest increments. If the actual flow was 6,500 cfs, the WUA was calculated to be halfway between the WUA at

6,000 and 7,000 cfs. If the actual flow was 8,900 cfs, the WUA was estimated to be 90% of the difference between the WUA at 8,000 and 9,000 cfs. This analysis was done for the 1997 flow augmentation releases by month. Habitat changes were summarized for each month the flow augmentation water was released.

The data from IDWR give the dates the flow augmentation water passes the three control points (Milner Dam on the Snake River, Letha Bridge on the Payette River, and the USGS gage on the Boise River near Middleton) and the dates the water reaches Brownlee Pool. From this it was possible to determine the number of days it took the water to travel from the control points to Brownlee Pool. It was assumed that the water traveled an equal distance each day in order to estimate when the water reached each of the five study reaches between C.J. Strike Dam and Brownlee Pool.

Flows

Flows in the Boise River, Payette River, and Snake River, with and without the flow augmentation water were compared to flow recommendations from the literature to see if flows were being met and if the augmentation water helped achieve those flows.

RESULTS AND DISCUSSION

Habitat

Flow augmentation releases for 1997 are summarized in Tables 1 and 2. Releases were similar to previous years with respect to the volume, duration, timing, and reservoirs used. Total volume released from the Payette Basin increased by 3,700 af, the Boise Basin release increased by 2,000 af, while the upper Snake Basin release decreased by 2,844 af compared to 1996. The Payette release was split 70/30 between summer and winter releases. This was done in an attempt to balance the fish and water quality needs in Cascade Reservoir and those in the river downstream. Winter has been identified as a critical period for salmonids in the Payette River system. It is thought to be the time when additional flows would benefit the fishery the most (Riggin and Hansen 1992).

Table 3 lists flow releases since 1987. The release of approximately 427,000 af from the Snake River Basin upstream of Brownlee Pool for salmon flow augmentation has occurred since 1993.

Tables 4-13 summarize the changes in fish habitat for white

sturgeon and rainbow trout in the five study reaches in the Snake River from C.J. Strike Dam to Brownlee Pool for 1997. Anglin et al. (1992) summarized the spawning, incubation, larval, and adult/juvenile time periods for each species in each of the five sections. Those for white sturgeon and rainbow trout are listed in Table 14. Habitat changes were estimated only for adult and juvenile white sturgeon and adult, juvenile, and fry rainbow trout. These were the only life stages present during the flow augmentation releases.

In all except one case, the increased flows resulted in increased habitat (in terms of square feet gained) for adult and juvenile white sturgeon (Tables 4-8). The Swan Falls Dam to Walters Ferry reach during September lost 40,000 sf of adult/juvenile white sturgeon habitat. This was a minor decrease, representing less than one percent of the total habitat available. The increases in adult/juvenile white sturgeon habitat ranged from a low of 130,000 sf (3.18%) in the Swan Falls Dam to Walters Ferry reach during August to 5,850,000 sf (15.89%) in the Walters Ferry to Boise River mouth reach during July.

The 1997 flows were higher than in previous years. July 1997 was most similar to previous years but was still higher. Flows in August and September were substantially higher than previous years (Table 15). Higher base flows resulted in smaller increases in habitat both on a percentage basis as well as square feet gained. This is because the flow augmentation water comprises a relatively smaller proportion of the total flow, and the higher flows are at the upper end of the habitat versus flow curves in the SFIFS. At the upper end of these curves, the available habitat starts to level off or increase at a slower rate as flow increases. In some cases, available habitat will decrease as flow increases beyond a certain point. This was the case for adult/juvenile sturgeon in the Swan Falls Dam to Walters Ferry reach.

Lepla and Chandler (1995) identified sturgeon in the middle Snake River as habitat generalists, using a wide variety of habitats. This is true for adults and juveniles. But, sturgeon have very specific requirements for spawning and early life history development. For example, water temperatures should be 13 - 16°C for spawning and 14 - 16°C for egg and larval development. Temperatures of 20°C and greater are lethal to developing eggs and larvae. Physical habitat variables used in IFIM studies (depth, velocity, and substrate) accounted for only 28% of the variability in sturgeon location. Lepla and Chandler (1995) suggested other factors such as prey abundance and availability may be more important than physical habitat in determining the

distribution of white sturgeon in the middle Snake River. This concurs with other work in the Columbia River (Parsley and Beckman 1992). So, increases in sturgeon habitat may not result in any benefit to the sturgeon population especially if the changes are short term and do not benefit a critical or limited life stage (i.e. spawning and larvae) or a limiting time period. The spring sturgeon spawning and larval development period has been identified as a critical time period for sturgeon (D. Parrish, IDFG personal communication) in the reach from upper Salmon Falls Dam to C.J. Strike Reservoir. Often, there are insufficient flows and water temperatures are too warm for successful sturgeon spawning and larval development. But, summer flows have also been identified as a critical period for sturgeon in the stretch of the river from C.J. Strike Dam to Brownlee Pool. Flows in this stretch of the river during the summer are often almost stagnant and suffer from extreme nutrient loading (S. Grunder IDFG personal communication). This results in very low dissolved oxygen levels and even fish kills. Riggin and Hansen (1992) recommended releasing the flow augmentation water from July 1 to September 30 to benefit water quality in this reach of the Snake River. But, water quality benefits are thought to be minimal at best due to this release strategy because the flow augmentation water is warm water released from American Falls Reservoir and is split at Milner Dam (D. Parrish, IDFG personal communication). At present only 200 cfs flows in the river channel and the remaining (approximately 1,300 cfs) water is diverted though an irrigation canal for a little over a mile so it can run through a turbine before it is returned to the river. Thus, the water is subject to increased warming and nutrient loading compared to keeping all the water in the river channel. Obviously, the flow augmentation water can not solve all these problems; but it can help. One option might be to release the water in the spring (April through June) for sturgeon spawning and larval development in dry years and release it starting in June in normal and wet years to protect larval sturgeon and for improved water quality. The spring releases would also aid spring migrating juvenile anadromous fish below Hells Canyon Dam during low water years when they need it the most. Releasing the water in the spring has been shown to increase sturgeon spawning and larval habitat (Leitzinger 1996).

Interpretation of the rainbow trout results is not as straight forward as the sturgeon. The results are summarized in Tables 9-13. Habitat increased for adult rainbow trout in all sections during the month of July. Available habitat decreased for adult rainbow trout in all reaches in September. The recorded flows in the Payette River to Brownlee Pool reach were higher than the range of flows in the SFIFS. Therefore, no estimate of available habitat could be made. During August, available habitat

increased in the three reaches between C.J. Strike Dam and the mouth of the Boise River and decreased in the two reaches from the Boise River to Brownlee Pool. The increases in habitat ranged from 110,000 sf (0.25%) in the C.J. Strike Dam to Swan Falls Pool reach during August to 19,990,000 sf (9.28%) in the Walters Ferry to Boise River mouth reach during July. The decreases ranged from 160,000 sf (1.71%) in the Swan Falls Dam to Walters Ferry reach during September to 9,140,000 sf (3.95%) in the Boise River mouth to Payette River mouth reach during August.

In all cases, the flow augmentation releases result in the loss of juvenile and fry rainbow trout habitat. Juvenile habitat losses ranged from 140,000 sf (2.17%) in the Swan Falls Dam to Walters Ferry reach during July to 14,330,000 sf (16.07%) in the Walters Ferry to Boise River mouth reach during July. Fry habitat losses ranged from 40,000 sf (5.63%) in the Swan Falls Dam to Walters Ferry reach during September to 13,710,000 sf (31.68%) in the Walters Ferry to Boise River mouth reach during July.

These habitat losses are not significant for two reasons. First, it is very unlikely that rainbow trout fry and juveniles used the mainstem Snake River extensively. As with most large rivers, the native rainbows probably had a fluvial life history, meaning the majority of spawning and early rearing occurred in the tributaries, while the adults and larger juveniles reared in the mainstem Snake River. Unfortunately, there is very little documented life history information on native rainbow trout in this reach of the Snake River. The only evidence found came from Irving and Cuplin (1956). They sampled this reach of the Snake River in 1953 and 1954 and the smallest wild rainbow trout caught were eight inches long.

Second, it is extremely difficult to sample large rivers for juvenile and fry life stages, especially at high flow. Because of this, the suitability index (SI) curves used for rainbow trout were not site specific. They were taken from the literature (Raleigh et al. 1984). These curves were developed on small, clear trout streams in Colorado. This calls into question the appropriateness of using these SI curves. Because they were developed for small streams, the preference or use of the habitat (as expressed by depth, velocity, cover, and temperature) will undoubtedly be narrow, especially when compared to the broader range of habitat that would be expected in a larger river. These fish may use a greater range of habitat in a larger river simply because it is available. Thus, using SI curves developed for small streams may result in an artificially reduced or restricted estimate of available habitat when applied to large rivers.

This analysis also raises several questions. Does a short-term (three to five month) increase in flows provide any long-term benefits to resident fish habitat and thus resident fish? When are the flow (or habitat) bottlenecks for sturgeon and rainbow trout (or other resident fish species) in this section of the Snake River? If they are not during the summer, then does this water have any long-term benefit to resident fish? If there is a summer flow bottleneck once these flows are reduced to base flow in the fall, are the benefits then lost because the flow bottleneck has just been delayed to later in the year? These questions are beyond the scope of this project but need to be addressed if this water is to benefit resident fish.

Flows

The flow recommendations in the SFIFS (Anglin et al. 1992) are summarized in Table 15. The recommendations are for flows past the Murphy Gage on the Snake River (downstream of Swan Falls Dam). It is interesting to note that actual mean monthly flows from 1994 through 1997 during the flow augmentation releases met or exceeded the integrated fish flow recommendations (the target flow as defined in the SFIFS) only one month out of the 15 months of flow augmentation releases. They met or exceeded the recommended flows for wet years in only two (August and September 1997) of the 15 months, despite three of the four years being wet years. Only four of the 15 months met the average water year flow recommendation, and 11 of the 15 met the dry year recommendation. Overall, these enhanced flows rarely met the integrated fish flows or the wet year recommendations over the past four years. The 1997 release as measured at the Murphy Gage (Table 16), did not meet the integrated fish flow recommendations in July or August on a mean monthly basis. Flows did, however, exceed the integrated fish flow recommendation for the month of September. Clearly, although the additional flow provided by the flow augmentation water provides benefits to resident fish habitat (primarily adult and juvenile sturgeon and adult rainbow trout), it is not enough to avoid further degradation of sturgeon and rainbow trout habitat because Anglin et al. (1992) defined these minimum flows as that which would prevent “further degradation of resident fish habitat.” At best these additional flows would only slow down the rate of decline of these fish populations.

The comparisons of the actual enhanced flows (i.e. with the salmon flow augmentation water) to the minimum stream flow recommendations for the tributaries and the Snake River are summarized in Table 16. The enhanced flows in the Boise River met or exceeded the minimum flow recommendation all the time on a mean monthly basis. The recommended monthly flows would have

been met only 63% of the time without the flow augmentation water (five of the eight months over the last four years). It needs to be pointed out that this water is released during the summer when flows are not limiting. It also needs to be pointed out that these are **minimum flows**, not preferred or ideal flows. Traditionally, minimum flows have been considered short- term, essential flows that prevent collapse of the fishery. Unfortunately, they have become targets to reach some of the time, and not flows to drop to only in emergencies.

The nonirrigation season (roughly from mid-October to mid-April) has been identified as the period when additional water would most benefit the salmonid fishery in the Boise River downstream of Lucky Peak Dam (Riggin and Hansen 1992; D. Allen, IDFG, personal communication). Analysis of the USGS gaging station records (Brennan et al. 1996) support this. Mean monthly predevelopment winter flows (October - February, 1895 -1916) in the Boise River below Moores Creek ranged from 969 to 1,299 cfs and minimum monthly flows for the same time period ranged from 509 - 925 cfs. Post development (1955 - 1997) mean monthly flows ranged from 206 - 1,572 cfs while mean minimum flows ranged from 0 - 63 cfs at the USGS gage on the Boise River called “Near Boise.” It is clear that the greatest change in the flow regime in the Boise River has been the reduction of nonirrigation season flows. Shifting the flow augmentation release from the summer to the winter in addition to the stream channel maintenance flows presently being released would go a long way toward returning to historic winter flows and a normative hydrograph. The resultant flows would be in the neighborhood of 500 - 600 cfs. While these flows are well below historic mean monthly flows, they are similar to the historic minimum flows and are a vast improvement on the 150 - 240 cfs currently being released for stream channel maintenance in the nonirrigation season.

The summer releases in the Payette River drainage (1994, 1996, 1997) met the mean monthly minimum flow recommendations only 50% of the time (three out of six months) at the Letha gage. Minimum flows would not have been met during those three months if the flow augmentation water was not released. Minimum flow recommendations were met 67% of the time (four of six months) at the Cascade gage. It is impossible to determine how much of an impact the flow augmentation releases had because it is impossible to separate out the Cascade and Deadwood releases. The total flow augmentation release is measured only at the Letha gage, well downstream of each dam.

The winter releases in the Payette River drainage all came out of Cascade Reservoir. Mean monthly minimum flows were met both months during the winter of 1995/96 below Cascade Reservoir and

at the Letha gage. However, the flow recommendations would not have been met below Cascade without the flow augmentation releases. They would have been met at the Letha Gage without the additional water. Mean monthly flows below Cascade Reservoir and at Letha during the winter of 1996/97 met minimums all the time. But, these flows would have been met even without the flow augmentation releases due to unusually high water during that time period. The 1997/98 winter releases met the minimums at both gages. These minimums would not have been met without the flow augmentation water.

CONCLUSIONS AND RECOMMENDATIONS

The additional water provided by the salmon flow augmentation releases appears to have, at best, limited benefits to resident fish and fish habitat. Although usable habitat increased in the Snake River for adult and juvenile sturgeon and adult rainbow trout, the flows were still well below what is needed to sustain viable healthy fish populations. Flow augmentation in the tributaries sometimes helped meet minimum flows; sometimes the flows would have been met even without the additional water; and other times the flows were not met even with the extra water. Obviously, other factors are influencing flows more than the salmon flow releases (e.g. weather and precipitation). Further monitoring and evaluation is needed in order to gain a better understanding of the impacts these flow releases in the tributaries (primarily the Payette system) are having on resident fish.

It is clear that changes are needed if water management in the Snake River Basin is to take into account the needs of the fishery resources. If water quality is to be improved and sturgeon populations are to be recovered to a healthy, viable, harvestable level, then more water is needed at the proper times (namely spring for spawning sturgeon and larval sturgeon development and the summer to improve water quality and prevent fish kills). Salmon flow releases are not sufficient to do it alone. Modification of existing flow augmentation releases in the tributaries could go a long way to improving conditions for fish. The following recommendations are presented in an effort to refine the salmon flow augmentation releases to maximize benefits to resident fish.

1) Release the salmon flow augmentation water out of Lucky Peak Reservoir on the Boise River during the nonirrigation season (mid-October - mid-April) in addition to the stream channel

maintenance flows presently being released. These flows will significantly help keep fry and juvenile trout habitat under water and available during the nonirrigation season. The resulting flows would approach the historic minimum monthly flows observed prior to any dam construction.

2) Continue the 50/50 summer/winter release in the Payette River Basin. This strategy may have benefits to resident fish, but no clear trend is evident. Hopefully, future monitoring will show clear benefits. This strategy is consistent with previous recommendations.

3) The BOR and IDWR should monitor flow augmentation releases from Cascade and Deadwood reservoirs separately. This would allow a much more detailed evaluation of the impact of these flows in the Deadwood, South Fork and North Fork Payette rivers.

4) Discontinue the splitting of the salmon flow releases in the upper Snake River at Milner Dam. Keep the entire 1,500 cfs in the river channel. Current operation is to only send 200 cfs down the river, while the remaining water (approximately 1,300 cfs) gets sent down an irrigation canal for a little over a mile so that it can be sent through turbines before returning to the river. This splitting of the water may negate any water quality benefits this extra water could provide. The 200 cfs left in the river is subject to intense solar radiation and thus excessive warming. The remaining water is also subject to warming as well as additional nutrient loading from agricultural fields the canals irrigate.

5) Conduct IFIM studies below BOR facilities so that changes in fish habitat resulting from the release of the salmon flow augmentation water can be quantified.

6) In dry years, release the water from American Falls Reservoir in the spring (April - June) to aid sturgeon spawning and larval development. In normal to wet years, begin releasing the water in June to keep the water temperatures cooler to protect sturgeon larvae and to improve water quality.

There are not enough IFIM data in the Snake River Basin to estimate resident fish habitat changes resulting from this flow augmentation water in most of the basin. Even where the data exist, quantification of habitat changes are further complicated by the water accounting system established by the BOR and IDWR. The present system is inadequate for describing when the water is

released, the source reservoir for the water, and at what daily rate (in cfs) the water is released, especially in the Snake River upstream of Milner Dam. Until a more detailed method for tracking and recording flow augmentation water is developed, quantifying impacts to resident fish habitat will be very limited.

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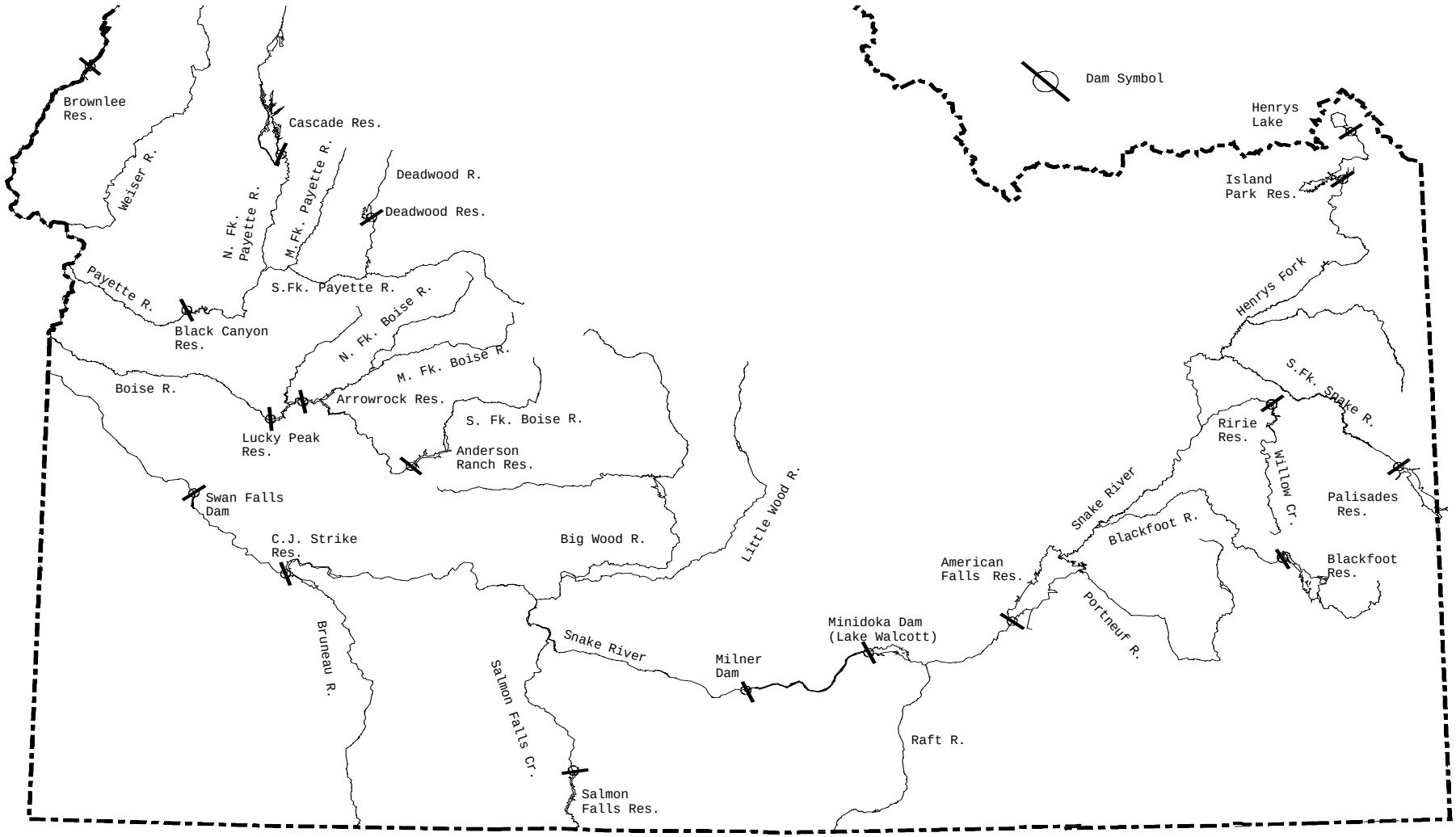

Figure 1. The Idaho water rental project study area.

Table 1. Stored water provided for salmon flow augmentation from Bureau of Reclamation reservoirs in acre-feet, 1997 (data from Bureau of Reclamation and IDWR).

SYSTEM/ RESERVOIR	Reclamation Space		Rental Pool	Total
	Power Head	Uncontracted		
Upper Snake*				
American Falls		8,951		
Jackson		3,923		
Palisades		10,022		
Subtotal		22,896	191,323	214,219
Payette**				
Cascade		69,600		
Deadwood		25,400		
Subtotal		95,000	60,000	155,000
Boise***				
Anderson Ranch (uncontracted)		3,000		
Lucky Peak		35,000		
Subtotal		38,000	2,000	40,000
Oregon				
Skyline Farms		17,649		
Oregon Water Trust			132	
Subtotal		17,649	132	17,781
GRAND TOTAL		173,545	253,455	427,000

* All water was physically moved out of American Falls Reservoir, but storage accounts in the other reservoirs were charged.

** The Payette release was split roughly 70/30 between summer and winter releases. The summer releases were both Cascade and Deadwood storage. The winter release was exclusively Cascade release. A total of 108,880 acre-feet was released in the summer, 46,120 acre-feet was released in the winter. The rental pool water was released from Cascade Reservoir.

*** All water was physically moved out of Lucky Peak Reservoir but 3,000 acre-feet were charged to the Anderson Ranch account.

Table 2. Timing of the 1997 flow augmentation releases from the upper Snake Basin (IDWR data).

System	Source/Space	Start Date	End Date	Location of measured flow
Upper Snake*	Rental Pool	7/9/97	9/10/97	Milner Dam
	Uncontracted	9/10/97	9/18/97	
Boise**	Lucky Peak			
	BOR Space	7/14/97	8/26/97	Middleton Gage
	Uncontracted	8/26/97	8/29/97	
	Rental Pool	8/29/97	8/31/97	
Payette***	Summer Release			
	Uncontracted	7/14/97	8/25/97	Letha Gage
	Rental Pool	8/25/97	9/3/97	
	Winter Release	11/27/97	12/29/97	Cascade Gage
Skyline Farms	Irrigation Purchase	7/2/97	9/19/97	

* This water was actually released from American Falls Reservoir but the start and end dates reflect the dates the water flowed past Milner Dam (source: IDWR).

** The Boise River release came from a purchase of 35,000 acre-feet of storage in Lucky Peak Reservoir, uncontracted storage charged to the Anderson Ranch Reservoir account, and the rental pool.

*** The Payette River release was split roughly 70/30 between summer and winter release. The winter release came exclusively from Cascade Reservoir.

Table 3. Water provided for flow augmentation from the Snake River Basin upstream of Hells Canyon Dam, 1987-1997. Values are in acre-feet.

System	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Upper Snake											
USBR Space	0	0	0	0	0	0	206,617	285,954	22,396	22,396	22,896
Rentals	150,000	50,000	100,000	63,000	0	0	65,000	44,325	232,839	194,667	191,323
BPA Purchase	0	0	0	0	50,000	49,000	0	0	0	0	0
Subtotal	150,000	50,000	100,000	63,000	50,000	49,000	271,617	330,279	255,235	217,063	214,219
Payette											
USBR Space	0	0	0	0	0	90,000	95,000	61,883	94,242	95,000	95,000
Rentals	0	0	0	0	0	0	34,971	0	50,758	56,300	60,000
BPA Purchase	0	0	0	0	51,000	51,000	0	0	0	0	0
Subtotal	0	0	0	0	51,000	141,000	129,971	61,883	145,000	151,300	155,000
Boise											
USBR Space	0	0	0	0	0	0	23,000	35,950	25,000	38,000	38,000
Rentals	0	0	0	0	0	0	0	0	2,000	0	2,000
Subtotal	0	0	0	0	0	0	23,000	35,950	27,000	38,000	40,000
Natural Flows											
Skyline Farms	0	0	0	0	0	0	0	0	0	15,714	17,649
OR Water Trust	0	0	0	0	0	0	0	0	0	64	132
Subtotal	0	0	0	0	0	0	0	0	0	15,778	17,781
Upper Snake Contribution	150,000	50,000	100,000	63,000	101,000	190,000	424,588	428,112	427,235	422,141	427,000
Brownlee	0	0	50,000	87,000	174,000	110,000	102,000	326,270	235,000	298,810	332,191
Grand Total	150,000	50,000	150,000	150,000	275,000	300,000	526,588	754,382	662,235	720,951	759,191

Table 4. Changes in white sturgeon habitat in the Snake River from C.J. Strike Dam to Swan Falls Pool resulting from salmon flow augmentation releases during the summer of 1997. Juv. = juvenile; Spawn = spawning; Incub. = incubation; N/A = not applicable, life stage not present during that month.

Habitat Estimates - Weighted Usable Area in millions of square feet

				Total Flow				Net Flow				Change			
Month	Mean Daily Flow (cfs)	Mean Augment Flow (cfs)	Mean Daily Net Flow (cfs)	Adult/ Juv.	Larvae	Spawn	Incub.	Adult/ Juv.	Larvae	Spawn	Incub.	Adult/ Juv. (%)	Larvae (%)	Spawn (%)	Incub. (%)
July 7/12-7/31	8,005	1,523	6,482	23.69	16.93	5.90	15.45	21.33	16.49	3.91	13.22	+2.36 (11.06)	N/A	N/A	N/A
Aug. 8/1-8/31	10,450	1,506	8,944	26.53	15.66	9.17	18.47	24.91	16.60	7.15	16.68	+1.62 (6.50)	N/A	N/A	N/A
Sept. 9/1-9/21	14,738	1,469	13,269	29.21	11.65	14.71	22.38	28.65	13.00	12.87	21.19	+0.56 (1.95)	N/A	N/A	N/A

Table 5. Changes in white sturgeon habitat in the Snake River from Swan Falls Dam to Walters Ferry resulting from salmon flow augmentation releases during the summer of 1997. Juv. = juvenile; Spawn = spawning; Incub. = incubation; N/A = not applicable, life stage not present during that month.

Habitat Estimates - Weighted Usable Area in millions of square feet

				Total Flow				Net Flow				Change			
Month	Mean Daily Flow (cfs)	Mean Augment Flow (cfs)	Mean Daily Net Flow (cfs)	Adult/ Juv.	Larvae	Spawn	Incub.	Adult/ Juv.	Larvae	Spawn	Incub.	Adult/ Juv. (%)	Larvae (%)	Spawn (%)	Incub. (%)
July 7/13-7/31	8,133	1,523	6,610	3.99	2.41	2.06	3.17	3.77	2.63	1.62	2.92	+0.22 (5.84)	N/A	N/A	N/A
Aug. 8/1-8/31	10,480	1,506	8,974	4.22	2.10	2.61	3.43	4.09	2.28	2.27	3.28	+0.13 (3.18)	N/A	N/A	N/A
Sept. 9/1-9/22	14,809	1,471	13,338	4.29	1.99	3.29	3.61	4.32	1.97	3.11	3.59	-0.04 (0.93)	N/A	N/A	N/A

Table 6. Changes in white sturgeon habitat in the Snake River from Walters Ferry to the Boise River resulting from salmon flow augmentation releases during the summer of 1997. Juv. = juvenile; Spawn = spawning; Incub. = incubation; N/A = not applicable, life stage not present during that month.

Habitat Estimates - Weighted Usable Area in millions of square feet

				Total Flow				Net Flow				Change			
Month	Mean Daily Flow (cfs)	Mean Augment Flow (cfs)	Mean Daily Net Flow (cfs)	Adult/ Juv.	Larvae	Spawn	Incub.	Adult/ Juv.	Larvae	Spawn	Incub.	Adult/ Juv. (%)	Larvae (%)	Spawn (%)	Incub. (%)
July 7/13-7/31	8,133	1,523	6,610	42.66	36.46	4.10	11.65	36.82	33.13	2.59	9.02	+5.85 (15.89)	N/A	N/A	N/A
Aug. 8/1-8/31	10,480	1,506	8,974	51.16	38.24	7.13	16.11	45.84	37.63	5.13	13.18	+5.31 (11.58)	N/A	N/A	N/A
Sept. 9/1-9/22	14,809	1,471	13,338	64.33	34.11	13.97	24.38	60.34	36.15	11.53	21.63	+4.00 (6.63)	N/A	N/A	N/A

Table 7. Changes in white sturgeon habitat in the Snake River from the Boise River to the Payette River resulting from salmon flow augmentation releases during the summer of 1997. Juv. = juvenile; Spawn = spawning; Incub. = incubation; N/A = not applicable, life stage not present during that month.

Habitat Estimates - Weighted Usable Area in millions of square feet

				Total Flow				Net Flow				Change			
Month	Mean Daily Flow (cfs)	Mean Augment Flow (cfs)	Mean Daily Net Flow (cfs)	Adult/ Juv.	Larvae	Spawn	Incub.	Adult/ Juv.	Larvae	Spawn	Incub.	Adult/ Juv. (%)	Larvae (%)	Spawn (%)	Incub. (%)
July 7/14-7/31	10,285	1,872	8,413	48.92	36.03	4.02	13.55	43.42	34.44	2.33	11.14	+5.49 (12.64)	N/A	N/A	N/A
Aug. 8/1-8/31	12,620	1,927	10,693	54.86	35.86	6.59	16.38	50.01	36.19	4.43	14.05	+4.85 (9.70)	N/A	N/A	N/A
Sept. 9/1-9/23	17,148	1,512	15,636	63.65	30.86	12.59	21.55	61.28	32.92	10.44	19.82	+2.37 (3.87)	N/A	N/A	N/A

Table 8. Changes in white sturgeon habitat in the Snake River from the Payette River to Brownlee Pool resulting from salmon flow augmentation releases during the summer of 1997. Juv. = juvenile; Spawn = spawning; Incub. = incubation; N/A = not applicable, life stage not present during that month.

Habitat Estimates - Weighted Usable Area in millions of square feet

				Total Flow				Net Flow				Change			
Month	Mean Daily Flow (cfs)	Mean Augment Flow (cfs)	Mean Daily Net Flow (cfs)	Adult/ Juv.	Larvae	Spawn	Incub.	Adult/ Juv.	Larvae	Spawn	Incub.	Adult/ Juv. (%)	Larvae (%)	Spawn (%)	Incub. (%)
July 7/2-7/13	22,008	110	21,898	--	--	--	--	--	--	--	--	--	N/A	N/A	N/A
July 7/14-7/31	13,772	2,958	10,814	47.08	29.89	11.53	21.56	43.65	30.28	7.91	17.95	+3.43 (7.86)	N/A	N/A	N/A
Aug. 8/1-8/31	15,410	3,116	12,294	47.83	28.87	13.54	23.00	45.66	30.37	9.67	19.91	+2.17 (4.75)	N/A	N/A	N/A
Sept. 9/1-9/24	19,133	1,719	17,414	--	--	--	--	--	--	--	--	--	N/A	N/A	N/A

Table 9. Changes in rainbow trout habitat in the Snake River from C.J. Strike Dam to Swan Falls Pool resulting from salmon flow augmentation releases during the summer of 1997. Juv. = juvenile; Spawn = spawning; N/A = not applicable, life stage not present during that month.

Habitat Estimates - Weighted Usable Area in millions of square feet

				Total Flow				Net Flow				Change			
Month	Mean Daily Flow (cfs)	Mean Augment Flow (cfs)	Mean Daily Net Flow (cfs)	Adult	Juv.	Spawn	Fry	Adult	Juv.	Spawn	Fry	Adult (%)	Juv. (%)	Spawn (%)	Fry (%)
July 7/12-7/31	8,005	1,523	6,482	44.24	15.42	3.13	6.99	42.73	17.10	2.53	7.29	+1.51 (3.53)	-1.68 (9.82)	N/A	-0.29 (3.98)
Aug. 8/1-8/31	10,450	1,506	8,944	44.96	13.27	4.34	4.46	44.85	14.80	3.53	6.02	+0.11 (0.25)	-1.53 (10.34)	N/A	-1.56 (25.91)
Sept. 9/1-9/21	14,738	1,469	13,269	40.93	9.40	4.43	2.35	42.62	10.49	4.76	2.60	-1.69 (3.97)	-1.09 (10.39)	N/A	-0.25 (9.62)

Table 10. Changes in rainbow trout habitat in the Snake River from Swan Falls Dam to Walters Ferry resulting from salmon flow augmentation releases during the summer of 1997. Juv. = juvenile; Spawn = spawning; N/A = not applicable, life stage not present during that month.

Habitat Estimates - Weighted Usable Area in millions of square feet

				Total Flow				Net Flow				Change			
Month	Mean Daily Flow (cfs)	Mean Augment Flow (cfs)	Mean Daily Net Flow (cfs)	Adult	Juv.	Spawn	Fry	Adult	Juv.	Spawn	Fry	Adult (%)	Juv. (%)	Spawn (%)	Fry (%)
July 7/13-7/31	8,133	1,523	6,610	8.70	6.30	0.38	2.24	7.48	6.44	0.39	3.05	+1.22 (16.31)	-0.14 (2.17)	N/A	-0.81 (26.56)
Aug. 8/1-8/31	10,480	1,506	8,974	9.39	5.40	0.27	1.16	9.12	6.02	0.38	1.75	+0.28 (3.07)	-0.62 (10.30)	N/A	-0.58 (33.14)
Sept. 9/1-9/22	14,809	1,471	13,338	9.21	4.02	0.18	0.66	9.37	4.40	0.18	0.71	-0.16 (1.71)	-0.38 (8.64)	N/A	-0.04 (5.63)

Table 11. Changes in rainbow trout habitat in the Snake River from Walters Ferry to the Boise River resulting from salmon flow augmentation releases during the summer of 1997. Juv. = juvenile; Spawn = spawning; N/A = not applicable, life stage not present during that month.

Habitat Estimates - Weighted Usable Area in millions of square feet

				Total Flow				Net Flow				Change			
Month	Mean Daily Flow (cfs)	Mean Augment Flow (cfs)	Mean Daily Net Flow (cfs)	Adult	Juv.	Spawn	Fry	Adult	Juv.	Spawn	Fry	Adult (%)	Juv. (%)	Spawn (%)	Fry (%)
July 7/13-7/31	8,133	1,523	6,610	235.40	74.87	104.28	29.57	215.40	89.20	84.63	43.27	+19.99 (9.28)	-14.33 (16.07)	N/A	-13.71 (31.68)
Aug. 8/1-8/31	10,480	1,506	8,974	244.48	57.50	107.94	18.58	241.38	67.35	113.09	24.23	+3.11 (1.29)	-9.85 (14.63)	N/A	-5.65 (23.32)
Sept. 9/1-9/22	14,809	1,471	13,338	226.00	42.93	87.76	9.62	234.03	47.20	95.04	12.24	-8.02 (3.43)	-4.28 (9.07)	N/A	-2.62 (21.41)

Table 12. Changes in rainbow trout habitat in the Snake River from the Boise River to the Payette River resulting from salmon flow augmentation releases during the summer of 1997. Juv. = juvenile; Spawn = spawning; N/A = not applicable, life stage not present during that month.

Habitat Estimates - Weighted Usable Area in millions of square feet

				Total Flow				Net Flow				Change			
Month	Mean Daily Flow (cfs)	Mean Augment Flow (cfs)	Mean Daily Net Flow (cfs)	Adult	Juv.	Spawn	Fry	Adult	Juv.	Spawn	Fry	Adult (%)	Juv. (%)	Spawn (%)	Fry (%)
July 7/14-7/31	10,285	1,872	8,413	232.35	60.54	76.68	24.69	226.82	69.36	79.35	32.16	+5.53 (2.44)	-8.82 (12.72)	N/A	-7.47 (23.23)
Aug. 8/1-8/31	12,620	1,927	10,693	222.13	54.83	62.90	21.26	231.27	59.38	75.18	23.76	-9.14 (3.95)	-4.55 (7.66)	N/A	-2.51 (10.56)
Sept. 9/1-9/23	17,148	1,512	15,636	198.16	49.07	46.18	20.06	206.02	50.28	51.98	20.24	-7.86 (3.82)	-1.21 (2.41)	N/A	-0.17 (0.84)

Table 13. Changes in rainbow trout habitat in the Snake River from the Payette River to Brownlee Pool resulting from salmon flow augmentation releases during the summer of 1997. Juv. = juvenile; Spawn = spawning; N/A = not applicable, life stage not present during that month.

Habitat Estimates - Weighted Usable Area in millions of square feet

				Total Flow				Net Flow				Change			
Month	Mean Daily Flow (cfs)	Mean Augment Flow (cfs)	Mean Daily Net Flow (cfs)	Adult	Juv.	Spawn	Fry	Adult	Juv.	Spawn	Fry	Adult (%)	Juv. (%)	Spawn (%)	Fry (%)
July 7/2-7/13	22,008	110	21,898	--	--	--	--	--	--	--	--	--	--	N/A	--
July 7/14-7/31	13,772	2,958	10,814	130.82	40.88	41.71	11.84	129.73	53.23	33.10	18.13	+1.08 (0.83)	-12.35 (23.20)	N/A	-6.29 (34.69)
Aug. 8/1-8/31	15,410	3,116	12,294	128.25	36.52	42.70	9.85	131.55	46.37	38.50	14.20	-3.30 (2.51)	-9.86 (21.26)	N/A	-4.36 (30.70)
Sept. 9/1-9/24	19,133	1,719	17,414	--	--	--	--	--	--	--	--	--	--	N/A	--

Table 14. White sturgeon and rainbow trout life stages and time of occurrence in the Snake River (from Anglin et al. 1992 and Lepla and Chandler 1995). Incub.= incubation; Juv.= juvenile.

Species/ Life Stage	C.J. Strike to Swan Falls	Swan Falls to Walters Ferry	Walters Ferry to Boise River	Boise River to Payette River	Payette River to Brownlee Pool
Sturgeon Spawning	April-May (2 months)	April-May (2 months)	April-May (2 months)	April-May (2 months)	April-May (2 months)
Sturgeon Larvae	April-June (3 months)	April-June (3 months)	April-June (3 months)	April-June (3 months)	April-June (3 months)
Sturgeon Incub.	April-May (2 months)	April-May (2 months)	April-May (2 months)	April-May (2 months)	April-May (2 months)
Sturgeon Adult/Juv.	all year	all year	all year	all year	all year
Rainbow Trout Spawning	March-April (2 months)	March-April (2 months)	March-April (2 months)	March-April (2 months)	March-April (2 months)
Rainbow Trout Fry	April-Sept. (6 months)	April-Sept. (6 months)	April-Sept. (6 months)	April-Sept. (6 months)	April-Sept. (6 months)
Rainbow Trout Juv.	all year	all year	all year	all year	all year
Rainbow Trout Adult	all year	all year	all year	all year	all year

Table 15. Integrated (target) fish flows and recommended minimum stream flows by month for average, wet and dry years, and actual flows recorded at the Murphy Gage on the Snake River downstream of Swan Falls Dam during the flow augmentation period in 1994 - 1997. The integrated and recommended minimum flows are also for the Murphy Gage. Data is from Anglin et al. (1992). Flows are in cubic feet per second.

Flow	April	May	June	July	August	September	October
Integrated Fish Flow	15,000	12,500	9,000	12,500	12,500	12,500	12,500
Recommended Minimum Flow							
Average Year	13,600	12,500	9,000	8,100	7,500	8,500	10,700
Wet Year (20% exceedence)	15,000	12,500	9,000	8,800	8,100	9,300	12,300
Dry Year (80% exceedence)	8,400	7,400	7,300	6,500	6,700	7,900	8,700
Actual Flows							
1994	7,947	8,341	7,004	6,565	6,225	--	--
1995	--	--	--	7,941	7,400	8,413	7,930
1996	--	--	--	7,466	7,765	7,927	--
1997	--	--	--	8,133	10,480	14,809	--

Table 16. Flow summary for years 1994 - 1997 showing the salmon flow augmentation release dates, total mean monthly flows, flow augmentation component of total flow, minimum flow recommendations, frequency that flows met or exceeded minimums, and recommended release time.

RIVER	YEAR	LOCATION (USGS GAGE)	FLOW AUGMENT. PERIOD	TOTAL FLOW MEAN MONTHLY (CFS)	MEAN AUGMENT. FLOW (CFS)	MAXIMUM FLOW (CFS)	MINIMUM FLOW (CFS)	FLOW RECOMMEND. (CFS)	DAYS MET	RECOMMENDED RELEASE TIME
Boise	1994	Middleton	7/5-7/31 8/1-8/19	557 481	410 371	601 525	293 343	240 240	All All	non-irrigation season (mid October - mid April)
	1995	Middleton	7/17-7/31 8/1-8/20	775 622	400 381	1,060 772	699 403	240 240	All All	non-irrigation season (mid October - mid April)
	1996	Middleton	7/11-7/31 8/1-8/29	610 632	386 390	705 702	572 564	240 240	All All	non-irrigation season (mid October - mid April)
	1997	Middleton	7/14-7/31 8/1-8/31	775 864	393 423	883 948	650 800	240 240	All All	non-irrigation season (mid October - mid April)
Payette	1994	Cascade*	7/1-7/31 8/1-8/15	1,778 1,576	? ?	1,940 1,920	1,140 1,350	1,400 1,400	27/31 13/15 (22/31 August)	50/50 split between summer and non-irrigation season (mid October - mid April)
	1994	Letha	7/2-7/31 8/1-8/16	911 560	825 430	1,350 986	340 310	1,165 1,165	3/31 0/16	50/50 split between summer and non-irrigation season

										(mid October - mid April)

Table 16. Cont'd.

RIVER	YEAR	LOCATION (USGS GAGE)	FLOW AUGMENT. PERIOD	TOTAL FLOW MEAN MONTHLY (CFS)	MEAN AUGMENT. FLOW (CFS)	MAXIMUM FLOW (CFS)	MINIMUM FLOW (CFS)	FLOW RECOMMEND. (CFS)	DAYS MET	RECOMMEDED RELEASE TIME
Payette	1995/ 1996	Cascade	11/30-12/31 1/1-1/15	1,748 2,078	1,548 1,878	2,230 2,200	475 1,720	400 400	All All	50/50 split between summer and non-irrigation season (mid October - mid April)
	1995/ 1996	Letha	12/2-12/31 1/1-1/17	4,243 3,735	1,518 1,892	8,000 4,370	2,590 3,140	1,165 1,165	All All	50/50 split between summer and non-irrigation season (mid October - mid April)
	1996	Cascade*	7/11-7/31 8/1-9/1	1,248 1,343	? ?	1,460 1,410	1,060 1,300	1,400 1,400	1/21 3/32	50/50 split between summer and non-irrigation season (mid October - mid April)
	1996	Letha	7/12-7/31 8/1-9/2	1,525 816	778 677	2,320 1,260	1,170 230	1,165 1,165	All 2/33	50/50 split between summer and non-irrigation season (mid October - mid April)

Table 16. Cont'd.

RIVER	YEAR	LOCATION (USGS GAGE)	FLOW AUGMENT. PERIOD	TOTAL FLOW MEAN MONTHLY (CFS)	MEAN AUGMENT. FLOW (CFS)	MAXIMUM FLOW (CFS)	MINIMUM FLOW (CFS)	FLOW RECOMMEND. (CFS)	DAYS MET	RECOMMEDED RELEASE TIME
Payette	1996/ 1997	Cascade	12/11-12/31 1/1-1/31 2/1-2/8	1,610 2,679 2,114	501 1,750 1,577	1,900 3,780 3,680	1,500 212 198	400 400 400	All 26/31 6/8	50/50 split between summer and non-irrigation season (mid October - mid April)
	1996/ 1997	Letha	12/13-12/31 1/1-1/31 2/1-2/10	4,650 8,417 6,526	554 1,680 1,479	11,600 27,000 8,040	2,560 5,230 4,420	1,165 1,165 1,165	All All All	50/50 split between summer and non-irrigation season (mid October - mid April)
	1997	Cascade*	7/12-7/31 8/1-9/1	1,532 1,462	? ?	1,540 1,550	1,520 1,360	1,400 1,400	All 19/32	50/50 split between summer and non-irrigation season (mid October - mid April)
	1997	Letha	7/14-7/31 8/1-9/3	1,854 1,180	1,083 1,041	2,320 1,740	1,540 536	1,165 1,165	All 17/32	50/50 split between summer and non-irrigation season (mid October - mid April)

Table 16. Cont'd.

RIVER	YEAR	LOCATION (USGS GAGE)	FLOW AUGMENT. PERIOD	TOTAL FLOW MEAN MONTHLY (CFS)	MEAN AUGMENT. FLOW (CFS)	MAXIMUM FLOW (CFS)	MINIMUM FLOW (CFS)	FLOW RECOMMEND. (CFS)	DAYS MET	RECOMMEDED RELEASE TIME
Payette	1997/ 1998	Cascade**	11/27-12/29	920	720	1,008	455	400	All	50/50 split between summer and non-irrigation season (mid October - mid April)
	1997/ 1998	Letha**	11/29-12/31	1,739	720	2,303	839	1,165	31/33	50/50 split between summer and non-irrigation season (mid October - mid April)
Snake	1994	Murphy	4/17-4/30 5/1-5/31 6/1-6/30 7/1-7/31 8/1-8/20	7,947 8,341 7,004 6,565 6,225	1,360 1,309 1,465 1,515 954	9,720 9,490 9,020 8,180 6,950	7,150 6,890 5,750 5,490 5,370	15,000 12,500 9,000 12,500 12,500	0 0 1/30 0 0	spring - sturgeon spawning, incubation, and early rearing; summer - water quality
	1995	Murphy	7/6-7/31 8/1-8/31 9/1-9/30 10/1-10/3	7,941 7,400 8,413 7,930	1,491 1,553 1,361 316	9,440 8,080 9,160 8,140	6,240 6,860 7,370 7,770	12,500 12,500 12,500 12,500	0 0 0 0	spring - sturgeon spawning, incubation, and early rearing; summer - water quality

Table 16. Cont'd.

RIVER	YEAR	LOCATION (USGS GAGE)	FLOW AUGMENT. PERIOD	TOTAL FLOW MEAN MONTHLY (CFS)	MEAN AUGMENT. FLOW (CFS)	MAXIMUM FLOW (CFS)	MINIMUM FLOW (CFS)	FLOW RECOMMEND. (CFS)	DAYS MET	RECOMMEDED RELEASE TIME
Snake	1996	Murphy	7/8-7/31 8/1-8/31 9/1-9/18	7,466 7,765 7,927	1,847 1,543 974	8,420 8,490 9,030	6,500 6,980 7,130	12,500 12,500 12,500	0 0 0	spring - sturgeon spawning, incubation, and early rearing; summer - water quality
	1997	Murphy	7/13-7/31 8/1-8/31 9/1-9/22	8,133 10,480 14,809	1,523 1,506 1,471	9,280 12,800 16,100	6,970 7,990 13,400	12,500 12,500 12,500	0 5/31 All	spring - sturgeon spawning, incubation, and early rearing; summer - water quality

* = Flow augmentation component could not be determined. Augmentation releases from Cascade and Deadwood reservoirs were not recorded separately.
** = Provisional data, not finalized, subject to change.