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

FINAL COMPLETION REPORT

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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 (WUA) 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 Reservoir in 1999. In 1999, existing data were also used to estimate habitat changes for rainbow trout and bull trout (*Salvelinus confluentus*) in the Deadwood River between Deadwood Dam and the mouth.

Flows with and without the salmon flow augmentation component were compared to minimum streamflow recommendations found in the literature. This provides a qualitative assessment of the impacts of the salmon flow augmentation releases.

A summary of flow augmentation since 1994 is also provided.

1999

The increased flows in the Snake River resulted in an increase in the quantity of useable habitat for adult and juvenile white sturgeon and adult rainbow trout and decreases in the quantity of rainbow trout fry and juvenile habitat. Flows in the Snake River did not attain mean monthly flow recommendations at the Murphy Gage described in the Swan Falls Instream Flow Study (Anglin et al. 1992).

Flow augmentation in the Deadwood River has resulted in a decrease in the quantity of useable habitat for all bull trout and rainbow trout life stages. This is because summer flows are relatively high in the Deadwood River due to irrigation demand. Flows are typically at the upper end of the flow versus habitat curve where additional flow (e.g. from flow augmentation) results in a decrease in useable habitat.

The flows in the Boise River during the 1999 flow augmentation release period would have met the recommended minimum flows without the flow augmentation releases on a mean monthly basis. Summer irrigation demand is typically adequate to achieve the recommended minimum flows in the Boise River.

Flow augmentation releases helped meet or exceed the recommended minimum flows in the Payette Drainage at the Cascade Gage (below Cascade Reservoir) during the summer on a mean monthly basis. In the lower river, flow augmentation helped meet or exceed recommended minimum flows at the Letha Gage (below Black Canyon Reservoir) during July. In August and early September, flows approached the recommended flows the majority of the time but actually met them only 10 of the 34 days. These recommended flows at both gages would not have been met without the flow augmentation releases.

On the other hand, recommended minimum flows would have been met in the Deadwood River even without the flow augmentation releases on a mean monthly basis. As on the Boise River, summer irrigation demand is typically adequate to achieve the recommended minimum flows.

The winter releases out of Cascade Reservoir also helped meet or exceed recommended minimum flows on a mean monthly basis. The recommended minimum flows would not have been met at the Cascade gage or at the Letha gage during the month of November without the flow augmentation releases. But, the recommended flows would have been met at the Letha gage in December even without flow augmentation.

1994 - 1999

Between 1994 and 1999 adult and juvenile white sturgeon WUA increased an average of approximately 9.6% per year between C.J. Strike Dam and Brownlee Pool resulting from the salmon flow augmentation releases. The increases in available habitat were temporary because the flows dropped to base flow after the augmentation period ended.

Adult rainbow trout WUA in the same reaches of the Snake River increased on average approximately 6.5% per year, while juvenile and fry rainbow trout WUA decreased an average of 9.4% and 19.2% respectively per year. As with white sturgeon, the changes in available habitat were temporary because the flows dropped to base flow after the augmentation period ended.

Flows in the Snake River at the Murphy gage have rarely met the minimum flow recommendations for the past six 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.

In the Deadwood River, adult bull trout weighted useable area decreased in seven of the 10 months of flow augmentation since 1994. It decreased for adult rainbow trout in nine out of 10 months, decreased all 10 months for juvenile bull trout and for rainbow trout juveniles and fry.

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 permanently increase the quantity of useable resident fish habitat 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). 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. 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 1999. In 2000, the Idaho Legislature extended the approval for one year.

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:

a. 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 would increase the useable habitat for native fish.

b. Work with the Bureau of Reclamation (BOR) to develop a model that estimates changes in fish habitat (WUA) in the upper Snake River resulting from salmon flow augmentation releases.

c. 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 Reservoir to the Idaho border, the Henrys Fork, Boise River, and Payette River drainages. The flow augmentation water was physically moved from these BOR facilities within the study area every year since 1994: American Falls, Lucky Peak, Cascade, and Deadwood reservoirs (Figure 1).

METHODS

The analysis can be divided into two sections. The first quantifies 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 Reservoir as was done previously (Leitzinger 1996, 1997, 1998). 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 Reservoir. The SFIFS divided the Snake River from C.J. Strike Dam to Brownlee Reservoir into five study reaches:

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

The SFIFS developed habitat versus flow relationships for six species in each study reach: white sturgeon, rainbow trout, 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 BOR and the Idaho Department of Water Resources (IDWR) have been able to estimate the Deadwood Reservoir flow augmentation component separately from the Cascade Reservoir release. They estimated the timing (start and end dates), and the daily flow (in cfs) for each year since 1994. This has allowed the use of U. S. Forest Service instream flow data on the Deadwood River to estimate the changes in bull trout and rainbow trout habitat resulting from flow augmentation. The Deadwood River data is expressed as WUA in square feet per thousand linear feet of stream.

An Excel spreadsheet was developed that calculates the change in WUA expressed in millions of square feet in each reach for the same age 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 1994 - 1999 flow augmentation releases on a mean monthly basis for each of the five reaches identified in the SFIFS. Habitat changes were summarized for each month the flow augmentation water was released.

The same spreadsheet was used for the Deadwood River data. The spreadsheet was modified slightly so the results were consistent with the U. S. Forest Service data (habitat expressed as weighted useable area in square feet per thousand linear feet of stream).

Data tracking the movement of the flow augmentation water from the upper Snake River Basin were collected and summarized from the BOR and IDWR. IDWR collects detailed information on the water including days, volumes, flow rates, etc., but it is only monitored at three gages (referred to as control points) in the upper Snake River Basin. These gage 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 BOR data, on the other hand, give the total volumes released from each reservoir but do not give when it was released or the resulting flows.

The data from IDWR give the dates the flow augmentation water passes the three control points and the dates the water reaches Brownlee Reservoir. From this it was possible to determine the number of days it took the water to travel from the control points to Brownlee Reservoir. 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 Reservoir. Approximate water travel times for the Boise and Payette rivers were obtained from BOR and IDWR personnel. It was then possible to determine when the flow augmentation water was released from the dams, when it passed the control points and when it reached the Snake River.

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. However, after 1994, the water has been 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 another reservoir. The accounting of the water will be charged to the reservoirs where the storage right exists. Also, small amounts of flow augmentation water have been charged to uncontracted space in other storage reservoirs even though the water was not moved from these. 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. In order to maintain flexibility, it is quite common for storage space to be transferred among reservoirs within a basin. So, it is possible to have Anderson Ranch Reservoir storage space in Lucky Peak Reservoir and vice versa.

The main concern BOR and IDWR have is meeting the total water demand 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 water from higher in the system, 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 low water year when there is not enough water available in American Falls Reservoir to meet irrigation and other demands (R. Larson BOR personal communication). This occurred only during the 1994 flow augmentation period. The same holds true for the Boise system. If natural flows are sufficient to refill the Lucky Peak Reservoir storage space used for flow augmentation, then storage in Anderson Ranch Reservoir will not be physically moved out of the reservoir even though on paper that storage space has been assigned to flow augmentation. Thus the storage appears to have been moved from Anderson Ranch Reservoir.

The Idaho Department of Fish and Game (IDFG), in cooperation with the 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 wetted perimeter 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 (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.

Flow Comparisons

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

RESULTS AND DISCUSSION

Flow Augmentation Releases

Flow augmentation releases for 1999 are summarized in Tables 1 - 3. The release of approximately 427,000 af from the Snake River Basin upstream of Brownlee Reservoir for salmon flow augmentation has occurred since 1993. Releases were similar to years 1995 – 1998 with respect to the volume, duration, timing, rate of release, and reservoirs used. The total volume released from the Payette Basin was 160,000 af, the Boise Basin release was 40,932 af, and the upper Snake Basin release was 208,221 af. Also, 17,847 af came from natural flow rights in the Malheur River Basin and mainstem Snake River in Oregon.

Snake River

The Snake River releases usually pass Milner Dam during the first week of July and end in mid September. The water takes approximately six days to reach Brownlee Reservoir. The flow augmentation adds approximately 1,500 cfs to the river between American Falls Dam and the mouth of the Boise River (approximately 319 river miles). Total mean monthly flows at the Murphy gage (downstream of Swan Falls Dam) during the flow augmentation period usually have ranged from about 6,200 cfs to 9,000 cfs. Only in August 1997 (10,480 cfs) and September 1997 (14,809 cfs) were mean monthly flows outside this range.

The flow augmentation release is split at Milner Dam. Only 200 cfs is released at the dam and remains in the river channel. Two hundred cubic feet per second is the capacity of the Idaho Power Company (IPC) turbine at the dam. The remaining 1,300 cfs is diverted down an irrigation canal for just over a mile to be run through another IPC turbine to generate hydroelectric power prior to returning to the river.

Payette River

Like previous years, the 1999 Payette release was split approximately 60%/40% 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. Cascade Reservoir and the lower Payette River downstream of Black Canyon Dam have been designated water quality limited during the summer by the Environmental Protection Agency. Therefore, the water managers try to keep as much water in Cascade Reservoir during the summer to minimize the chance of exceeding water quality standards. This is done by releasing the Deadwood Reservoir component in the summer along with a portion of the Cascade Reservoir component. This allows a portion of the Cascade Reservoir component to be kept in the reservoir and released during the nonirrigation season. These summer flows are also thought to improve the lower Payette River water quality by helping to flush sediments and keep water temperatures lower. The remaining portion of the total Payette contribution (usually 30 – 50%) is then released from Cascade Reservoir during the nonirrigation season. The nonirrigation season 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). Another critical factor in the success of this scenario has been an agreement with IPC whereby IPC releases an additional volume of water during the summer from Brownlee Reservoir. This volume of water is equivalent to the volume of water to be released during the nonirrigation season from Cascade Reservoir. IPC pre-releases this water in the summer when the salmon managers want it for flow augmentation in the lower Snake River and then gets paid back with an equal volume during the nonirrigation season.

The typical summer flow augmentation release out of Deadwood Reservoir is approximately 150 cfs during July, then dropping to 100 cfs during August. Total flow near the mouth of the Deadwood River, including the flow augmentation component, averages around 675 cfs in July and 750 cfs in August. The Cascade Reservoir flow augmentation release averages about 800 cfs in July, dropping to 500 cfs in August. Total flow from Cascade Reservoir for July and August, including the flow augmentation component, stays fairly constant at approximately 1,500 cfs.

Winter flow augmentation releases all come from Cascade Reservoir. These flows have been released primarily in December and January, and have averaged approximately 1,300 cfs. Total releases from the reservoir, including the flow augmentation component, during the winter flow augmentation period have averaged approximately 1,860 cfs.

Boise River

The Boise River releases have been made during the summer. Typically the release begins in early July and ends in late August. The flow augmentation adds approximately 400 cfs to the existing flow. Summer flow (with flow augmentation) through the City of Boise approaches 1,500 cfs depending on irrigation demand and water supply. The 1,500 cfs is considered the upper limit for safe recreational activity (floating in inner tubes and small rafts).

Habitat

Snake River

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 Reservoir for 1999. 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 cases, the increased flows resulted in increased habitat (in terms of square feet gained) for adult and juvenile white sturgeon (Tables 4-8). The increases in adult/juvenile white sturgeon habitat ranged from a low of 10,000 sf (0.02%) in the reach from the Payette River mouth to Brownlee Reservoir in early July to 6,690,000 sf (17.47%) in the reach from the Boise River mouth to Payette River mouth during August. The smallest increase (10,000 sf) was due to the natural flow right from Skyline Farms (110 cfs) starting to pass through this reach prior to the bulk of the salmon flow augmentation water from the upper Snake River. When the upper Snake River contribution, including the Boise and Payette River (approximately 2,600 cfs), began flowing through the reach, useable habitat increased by 4,350,000 sf (10.55%) for the remainder of July.

Although 1999 was another above average water year, the flows were not as high as in 1997. However, flows were very similar to 1995, 1996, and 1998 (Table 18). The release strategies were also similar. Because of this, habitat changes were similar to 1995, 1996, and 1998.

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 Reservoir. 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 relatively 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.

An alternative 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. Releasing the water in the spring has been shown to increase sturgeon spawning and larval habitat (Leitzinger 1996). 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.

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 except for the reach from the Boise River mouth to Payette River mouth in September, and in the reach from the Payette River mouth to Brownlee Reservoir in early July. The increases in habitat ranged from 20,000 sf (0.02%) in the reach from the Payette River mouth to Brownlee Reservoir during September to 26,820,000 sf (13.63%)

in the reach from Walters Ferry to the Boise River mouth during July. The decreases ranged from 270,000 sf (0.21%) in the reach from Payette River mouth to Brownlee Reservoir in early July to 1,040,000 sf (0.45%) in the reach from the Boise River mouth to Payette River mouth during September.

In all but one case, the flow augmentation releases result in the loss of juvenile and fry rainbow trout habitat. Juvenile habitat losses ranged from 50,000 sf (0.78%) in the reach from Swan Falls Dam to Walters Ferry during August to 14,000,000 sf (15.09%) in the reach from the Walters Ferry to Boise River mouth during August. Fry habitat losses ranged from 100,000 sf (1.13%) in the Payette River mouth to Brownlee Reservoir reach in early July to 14,090,000 sf (29.93%) in the reach from Walters Ferry to the Boise River mouth during August. The lone increase was for juvenile rainbow trout habitat in the reach from Swan Falls Dam to Walters Ferry. The increase was small, 23,000 sf (3.70%).

These declines in available habitat for rainbow trout fry and juveniles are not significant for two reasons. First, it is very unlikely that rainbow trout fry and juveniles use the mainstem Snake River extensively. As with most large rivers, the native rainbows probably have a fluvial life history, meaning the majority of spawning and early rearing occurs in the tributaries, while the adults and larger juveniles rear 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. Irving and Cuplin (1956) sampled this reach of the Snake River in 1953 and 1954 and the smallest wild rainbow trout caught were eight inches long. IPC has documented juvenile and adult rainbow trout leaving the Malad River (near Hagerman Idaho), rearing in the mainstem Snake River and returning to the Malad River to spawn (Brink 2000).

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.

Deadwood River

Tables 15 and 16 summarize the changes in the quantity of useable habitat for bull trout and rainbow trout in the Deadwood River from Deadwood Dam downstream to the mouth resulting from the flow augmentation releases in 1999. The Deadwood releases have been made during July and August only. In both months there was a decrease in the quantity of useable adult and juvenile bull trout habitat. The decreases ranged from 160 ft^2 per 1,000 ft of stream (0.56%) for adults in August to 1,004 ft^2 per 1,000 ft of stream (3.35%) for adults in July. If base flows are less than approximately 500 cfs, then the typical flow augmentation release (roughly 150 cfs) results in an increase in the quantity of useable adult bull trout habitat. Base flows greater than roughly 560 cfs result in a decrease in the quantity of useable adult bull trout habitat.

The flow augmentation releases from Deadwood Dam also resulted in a decrease in the quantity of useable habitat for all rainbow trout life stages present during the flow augmentation period (adults, juveniles, and fry). Decreases ranged from 1,187 ft^2 per 1,000 ft of stream (3.70%) for fry in August to 3,705 ft^2 per 1,000 ft of stream (11.89%) for juveniles in July.

This indicates that flow augmentation from Deadwood Reservoir released during the summer does very little to benefit bull trout and rainbow trout habitat. It typically results in a decrease in available habitat. This is because summer flows are relatively high in the deadwood due to irrigation demand. Flows are typically at the upper end of the flow versus habitat curve where additional flow (e.g. from flow augmentation) results in a decrease in useable habitat. Summer does not appear to be the best time to release the Deadwood Reservoir flow augmentation component if benefiting resident fish habitat is a priority. Riggin and Hansen (1992) identified nonirrigation season flows (October – March) as a critical factor for salmonids in the Deadwood River and recommended the flow augmentation releases be made during those months when additional flow is greatly needed.

Summary

Tables 19 - 21 summarize the changes in WUA in the Snake and Deadwood rivers resulting from salmon flow augmentation since 1994. The WUA for adult and juvenile white sturgeon increased in all years and in all five reaches. The increases averaged 9.56% across all reaches and years.

Adult rainbow trout WUA increased in all reaches and all years except during 1997. Adult rainbow trout WUA decreased in three reaches that year. Overall, adult rainbow trout WUA increased an average of 6.59% over the five reaches since 1994, while juvenile and fry rainbow trout WUA decreased an average of 9.43% and 19.24% respectively.

The 1997 water year was one of the highest in the recent past, and the highest during this study. Because of this, the base flows were higher than normal. These flows were near the upper limits of the habitat versus flow relationships described in the SFIFS (Anglin et al. 1992), where useable habitat either increases slowly with increases in flow or may decrease as flows increase. This is why white sturgeon had the lowest increases in WUA in four of the five reaches in 1997. The main reason changes in WUA weren't lower in the fifth reach is that for almost half of the flow augmentation period, the flows through that reach were higher than the flows used to develop the habitat versus flow relationships. These highest flows would have had a smaller increase in WUA, thus lowering the average gain in WUA for that reach.

These high base flows also explain why adult rainbow trout WUA decreased in three of the five reaches in 1997 and why juvenile and fry rainbow trout WUA decreases were the greatest in three of the five reaches.

The 1997 data help show that the highest percent gain (or lowest loss) of useable habitat would be achieved at low to intermediate flows. Additional flows that could be used to benefit resident fish habitat should be targeted for a time period or life stage that would benefit the most.

The only life stage in the Deadwood River that appeared to benefit from flow augmentation was adult bull trout. Three of the five years of flow augmentation resulted in increases in WUA. All the changes were small, ± 2% or less. The overall average was +0.08%. Summer flow augmentation resulted in a decrease of WUA for all other life stages analyzed (juvenile bull trout, adult, juvenile, and fry rainbow trout). Summer releases in addition to irrigation demand do not appear to provide much benefit to resident fish. Changing the timing of the releases to coincide with a critical time (e.g. nonirrigation season) or life stage would provide greater benefits to resident fish.

The temporary (two to five month) increase in flows probably does not provide any long-term benefits to resident fish habitat and thus resident fish, especially if flows are reduced to base flow after flow augmentation ends. WUA would be reduced accordingly. Also, the majority of the water is released

during the summer. If summer is not a limiting period, then the additional habitat provided by the increased flows will not benefit the resident fish populations. It appears that the major limiting period for salmonids in the Payette and Boise rivers is during the nonirrigation season, when river flows have been reduced to refill storage reservoirs. For sturgeon and salmonids in the Snake River, the critical period could be any time of year depending on the water year, and reach of the river. Often, spring time flows are not sufficient for successful sturgeon and salmonid spawning and early life history development. Poor water quality exacerbated by low flows and excessive nutrient loading has caused fish kills in some sections of the river during the summer. Ammonia toxicity has killed aquatic life during low flow periods in the nonirrigation season in other sections. The additional water from the flow augmentation releases may provide some summer water quality benefits. But, the benefits have not been thoroughly studied. For example, in the reach below Milner Dam, flows are typically around 200 cfs during the irrigation season. With flow augmentation, flows have been increased to 1,500 cfs. At 1,500 cfs, there is sediment and macrophyte redistribution in the river channel, and some dilution of pollutants (Idaho Division of Environmental Quality personal communication).

Flow Comparisons

Snake River

The mean monthly flow recommendations in the SFIFS (Anglin et al. 1992) and the actual mean monthly flows at the Murphy Gage on the Snake River (downstream of Swan Falls Dam) are summarized in Table 17. Table 18 also compares the actual flows to the SFIFS recommendations at the Murphy Gage. The actual mean monthly flows from 1994 through 1999 during the flow augmentation period did not meet the integrated fish flow recommendations (the target flow as defined in the SFIFS) 17 out of the 18 months of flow augmentation. The 1999 release as measured at the Murphy Gage, did not meet the integrated fish flow recommendations for July, August, or September on a mean monthly basis. In fact, the SFIFS flow recommendation was not met at all during the 1999 flow augmentation period on a daily basis (zero out of 69 days). Since 1994, the flow recommendation has been met only 28 out of a total of 503 days of flow augmentation (5.6%).

Although the additional flow provided by flow augmentation provides temporary benefits to resident fish habitat (primarily for adult and juvenile sturgeon and adult rainbow trout), it is not enough to avoid further degradation of sturgeon and rainbow trout habitat. 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.

Payette River

The summer releases in the Payette River drainage (1994, 1996, 1997, 1998, and 1999) met the mean monthly minimum flow recommendations only 50% of the time (five out of 10 months) in the Lower Payette River at the Letha gage. Minimum flows would not have been met at all if the flow augmentation water was not released.

Minimum flow recommendations were met 80% of the time (eight of ten months) at the Cascade gage during the summer with the flow augmentation releases. These minimums would not have been met without the flow augmentation releases.

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 1998/1999 below Cascade Reservoir at the

Cascade gage. These flow recommendations would not have been met without the flow augmentation releases. The minimum flows were also met at the Letha gage on a mean monthly basis. These minimums would have been met without the flow augmentation water. The 1999 winter releases met mean monthly minimums both months (November and December) at the Cascade gage. Like the 1998/1999 winter release, the minimums would not have been met without the flow augmentation releases. The minimums were also met at the Letha gage both months in 1999. They would not have been met in November without the flow augmentation releases, but they would have been met in December.

Flows in the Deadwood River exceeded minimum flow recommendations all the time on a mean monthly basis. The flows were met or exceeded 254 days out of the 258 days of flow augmentation from 1994 – 1999. The mean monthly minimum flows would have been met even without the flow augmentation releases. This is further indication that summer flow augmentation in the Deadwood River does little to benefit or increase the quantity of resident fish habitat.

Boise River

The Boise River from Lucky Peak Dam downstream through the city of Boise to the Star Bridge is characterized as a cold water salmonid fishery. Summer flows are not limiting the fish populations in this reach because irrigation demand provides higher than historic summer flows. Flows in this reach approach 1,500 cfs during the summer flow augmentation period. That is about six times greater than the 240 cfs minimum recommendation listed in table 18. Flow augmentation probably does little, if anything, to benefit resident fish or fish habitat in this reach.

The Boise River from the Star Bridge to the mouth is comprised primarily of agricultural return flow, has low summer flows, high summer water temperatures, high sediment and nutrient levels, and is comprised primarily of warm water and non-game fishes. The Middleton gage (the control point where the augmentation is measured) is located downstream of the Star Bridge. The biological needs of the fish are not well documented in this reach. There is no IFIM or other habitat data available and very limited biological data. It is assumed that increased flows in the summer will provide some benefit to the fishery. Flows in this reach, including the augmentation water have ranged from approximately 480 to 860 cfs (measured at the Middleton gage).

Previous IFIM studies in the Boise River downstream of Lucky Peak Dam (Pruitt and Nadeau 1978, Horton and Cochnauer 1980) have defined the study area as including all or most of the river downstream of Lucky Peak Dam. But, all of the data was collected in the upstream reach from Lucky Peak Dam to Star Bridge. It is unlikely that the flow recommendations developed in the upper section of this reach (upstream of Star Bridge) would be applicable to the lower section due to the major change in the character of the river. The flow recommendations ranged from 150 – 400 cfs during the flow augmentation period depending on the IFIM method and fish species investigated.

The 240 cfs flow recommendation is used in this report (Table 18) because it was the minimum flow requested by IDFG to the Idaho Water Resource Board and is within the range of recommended flows from previous studies. However, it is considered too low for the maintenance of aquatic resources, especially during the nonirrigation season. It was based on limited biological data and the professional judgement of the regional fisheries manager in 1975. There was no available IFIM data at the time. It serves to illustrate that the flow augmentation water was still needed to achieve this low flow 25% of the time on a mean monthly basis in the reach from Star bridge to the mouth even though these years were average or above average water years.

With the exception of the Deadwood River, flow augmentation in the tributaries does appear to provide some benefit to resident fish. However, data is lacking that would allow these benefits to be quantified in all the tributaries except the Deadwood River. Sometimes the flow augmentation releases helped meet minimum flows; sometimes the minimum flows would have been met even without the additional water; and other times the minimum flows were not met even with the augmentation water. In the Payette River, the summer releases helped achieve minimum flows at both the Cascade and Letha gages. But the water was insufficient to achieve these minimums all the time. The winter releases out of Cascade Reservoir helped achieve minimum flows but like the summer flows, was insufficient to meet the recommendations all the time. The Deadwood Reservoir releases exceeded the minimum flow recommendation but resulted in a loss of useable habitat. The Boise River releases also helped achieve minimum recommendations some of the time. But, the majority of the time the recommendations would have been met without the flow augmentation releases.

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 by releasing the water during a critical or limiting period.

The scenarios described below represent IDFG's recommendations on how the 427,000 acre-feet of flow augmentation water should be released in order to minimize adverse impacts to and in some instances benefit resident fish resources in the upper Snake River Basin. These recommendations do not consider other uses of the system such as agriculture, hydropower, flood control, or recreation.

Although the water is typically moved out of just the four reservoirs previously mentioned, other reservoirs and drainages are included in the event that they may be included in future flow augmentation releases.

FLOW SCENARIO # 1: PREFERRED OPTION.

Payette River Basin

The volume of water released from the Payette Drainage has ranged from 145 KAF to 160 KAF from 1995 – 1999. The majority of the water has been released from Cascade Reservoir. Typically, only about 25KAF has been released out of Deadwood Reservoir (all during July and August). The remainder comes from Cascade Reservoir. This Cascade release has been split between the summer (July and August) and winter releases (December and January). This was done in an attempt to balance the fisheries and water quality concerns in Cascade Reservoir with the fisheries and water quality concerns in the lower Payette River. The Cascade Reservoir fishery has continued to decline despite several back-to-back good water years. The reasons for this are not clearly understood. The impacts of salmon flow releases on the reservoir fishery are also not clearly understood.

The summer releases are in addition to irrigation demand and typically are not a critical limiting time for fish in the river. However, this increased drafting of the reservoir may result in an additional reduction in useable trout habitat in the reservoir and an increase in trout mortality. It may also result in an increase in entrainment of perch from the reservoir.

Because the fishery and water quality problems may be exacerbated by the salmon flow releases, we recommend shifting the salmon releases from the Payette Basin to the upper Snake Basin. This would protect the resident fisheries and improve water quality in Cascade Reservoir by maintaining a larger pool volume in both summer and winter (thus increasing useable fish habitat) and reducing the number of fish lost through entrainment.

American Falls Reservoir

The volume released from the upper Snake River has ranged from 214 KAF to 255 KAF from 1994 - 1999. Under this scenario upper Snake Basin volume would increase to approximately 385 KAF. The BOR has physically moved the upper Snake River contribution from just American Falls Reservoir most years. Between 1994 and 1999, water was moved from other reservoirs only during the low flow year of 1994. The BOR strives to move the water from the most downstream reservoirs first, to maximize their operating flexibility.

Under this scenario, Reclamation would likely have to release water from other sources (i.e. Jackson, Palisades, Ririe, Island Park). Because in order to protect fisheries resources in the reservoir as well as downstream, a year-round minimum pool of 170,000 AF in American Falls Reservoir and flows of at least 4,100 cfs past American Falls Dam must be maintained.

During drought years, the water should be released in the spring (May and June) to aid sturgeon spawning and larval development upstream of Brownlee pool, as well as spring outmigrating juvenile anadromous fish downstream of Hells Canyon Dam. Releasing salmon flow water in the spring (as in 1994) has been shown to increase sturgeon spawning and larval sturgeon habitat in the Snake River upstream of Brownlee pool (Leitzinger 1996). The additional water provided in this scenario would further increase sturgeon spawning and larval habitat.

During normal and above normal water years, move the salmon water out during the summer (July - September) as is done currently.

Upper Snake River

If the Payette Basin Water releases are shifted to the upper Snake Basin and the flows and pool levels recommended for American Falls Reservoir can not be maintained, it seems likely that water would be have to be released from higher in the system. Because the locations, timing, and volumes have not been identified, IDFG would like to work with the BOR and other water users to identify potential release scenarios. The following recommendations would protect the resident fisheries in the Snake River Basin upstream of American Falls.

<u>Palisades Dam and South Fork Snake River:</u>
Maintain a minimum pool of at least 500,000 acre-feet year round. Maintain a minimum release during the nonirrigation season in the South Fork Snake River from Palisades Dam of at least 1,540 cfs. Flows greater than 2,300 cfs are preferred. Release water from Palisades during the post irrigation season to help achieve the desired flows. The post irrigation season has been identified as the most critical time period for the trout fishery in the river.

<u>Henrys Fork:</u>
If water is to be released from Island Park, release it during the post irrigation season to meet the

recommended minimum release of at least 300 cfs. A minimum release of 700 cfs is preferred. Also, maintain a minimum pool of at least 40,000 acre-feet in Island Park Reservoir year round.

Willow Creek:
Maintain a minimum pool in Ririe Reservoir of at least 35,000 acre-feet year round. Release a minimum of at least 49 cfs from the Dam from January through September, and 58 cfs from October through December.

Snake River at Idaho Falls

Maintain a minimum flow of greater than 2,070 cfs in the Snake River from Idaho Falls to American Falls Reservoir.

Middle Snake River (Milner Dam to Brownlee Reservoir)

Maintain a minimum flow in the river channel at Milner Dam according to the table below.
Flows are rounded to the nearest 10cfs.

	Q (cfs)
Oct.	4,850
Nov.	4,080
Dec.	3,800
Jan.	3,800
Feb.	3,800
March	6,700
April	7,230
May	12,300
June	13,530
July	8,400
Aug.	5,600
Sep.	5,050

These values represent the estimated flow past Milner Dam required to meet sturgeon life history requirements downstream. IPC data indicate flows of ≥ 15,000 cfs below Bliss Dam in the spring to insure successful sturgeon spawning and egg and larval survival (Lepla and Chandler 1995). Interpretation of the sturgeon habitat versus flow curves developed by IPC for the Snake River below Lower Salmon Falls Dam indicate a flow of ≥ 10,000 cfs would be an adequate flow for adult and juvenile sturgeon in that reach (Addley and Hardy 1995). Based on this information, the fact that sturgeon need a rising hydrograph to trigger spawning behavior, and the recognition of the importance of reestablishing a natural hydrograph to the ecological health and functioning of the river and the entire native aquatic community living there, linear regression equations were developed to estimate the flows needed past Milner Dam to reach the sturgeon flow targets. For example, we want a flow of at least 15,000 cfs below Bliss Dam (measured at the King Hill gage) in March. What is the flow required to pass Milner Dam to reach that flow at King Hill? Based on the regression equation, a flow of 6,700 cfs past Milner would equate to 15,054 cfs at King Hill.

Boise River Basin

The standard operating procedures for the Boise Basin salmon water component is to release 400cfs (a total of approximately 40 KAF) in addition to irrigation demand during the summer (July and August). This flow comes at a time when flows in the river are not limiting for fish. Riggin and Hansen (1992) identified low flows during the post irrigation season (October – March) as a factor limiting salmonid survival.

IDFG recommends maintaining post irrigation releases out of Lucky Peak Reservoir greater than 600cfs. Flows of 1,100 - 1,200 are preferred and should be the flow target. These flows represent the historic (pre-Arrowrock Dam) minimum flows during the nonirrigation season in the Boise River in the general area of Lucky Peak Dam.

These flows can be achieved in several ways. First, relax flood control rule curves. This would allow additional water to be released in the fall and early winter. Salmon flow water would not be used. Existing stream channel maintenance flow water (IDFG and BOR storage) and the additional water made available from relaxing the rule curves would be used to meet flow targets. The second option would be to shift salmon flow releases to the post irrigation season. The existing stream channel maintenance flow water would also be used. The third option would be a combination of the previous two. This is the most likely scenario to meet the 1,100 - 1,200 cfs target. Using the salmon flow water in the post irrigation season would minimize the changes needed to the flood control rule curves. It would also require Idaho Power to draft Brownlee a little further to store the salmon flow component until the following spring or summer.

Brownlee Reservoir

Flood control operations pose a major problem for the fisheries in Brownlee Reservoir, especially in wet years. Flood control is not as serious a problem in dry and normal years. In order to protect the resident fisheries in the reservoir, system flood control needs to be shifted elsewhere in the Columbia Basin in normal and dry water years. In wet years, Brownlee is needed for flood control. Reservoir fluctuations need to minimized between May 1 and June 15 to protect bass and crappies spawning and early rearing. Water needs to be on the boat ramps from April through November so that boaters have access to the reservoir.

FLOW SCENARIO # 2.

If water must be moved from the Payette Basin due to increased flow demands stemming from Endangered Species Act requirements for listed salmon, or both the BOR and IDFG agree after reviewing all possibilities that there is no other choice, then move the Cascade Reservoir contribution (~110 - 130 KAF) in the fall after the reservoir mixes (late October) and continue the releases through March. The established winter minimum pool of 300,000 acre-feet has been identified as not being adequate to protect the fisheries resources in the reservoir. The pool in Cascade needs to be at least 475 - 525 KAF at the end of the irrigation season. By the end of March the pool should be no less than 375 KAF. This would also require drafting of Brownlee to store the salmon water.

Deadwood releases (approximately 25KAF) should be shifted to the nonirrigation season. Summer releases above irrigation demand typically result in a loss of useable bull trout and redband trout habitat. The nonirrigation season has been identified as a critical period for salmonids with low flows being the limiting factor (Riggin and Hansen 1992). Maintain a minimum pool of at least 50 KAF, and a minimum

flow from the Dam of at least 125 cfs at all times. Credit this 125 cfs release to salmon flows.

Maintain Boise, Upper Snake, and Brownlee operations the same as in the preferred option (minus the extra water shifted from the Payette to Upper Snake Basin).

Additional Recommendations

Additional recommendations include:

1) The BOR and IDWR should continue to monitor the 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.

2) 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) is 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 diverted water is also subject to warming as well as additional nutrient loading from agricultural fields the canals irrigate.

3) 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.

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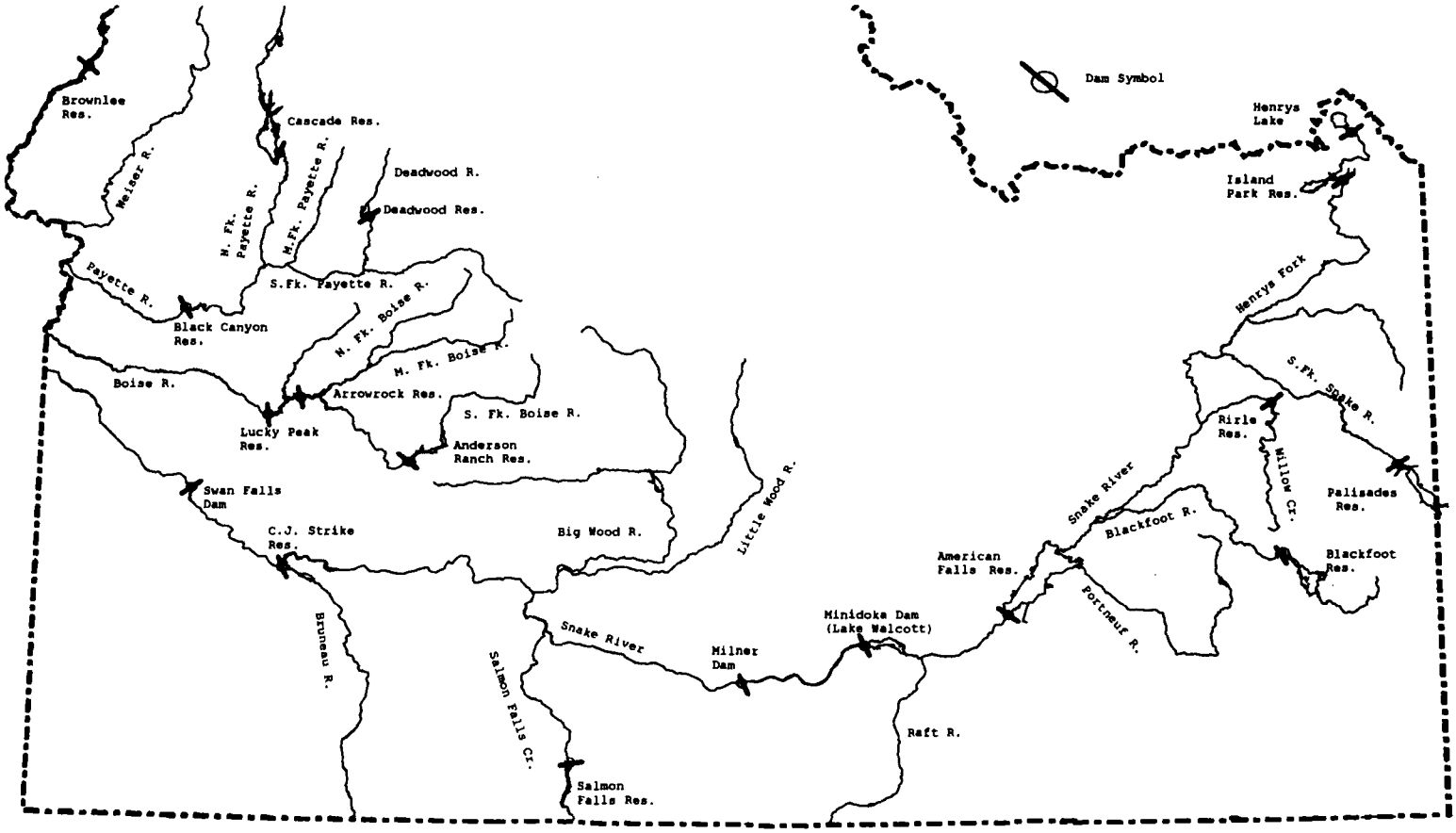

Figure 1. The Idaho water rental project study area.

Table 1. Stored water provided for salmon flow augmentation from Bureau of Reclamation reservoirs in acre-feet, 1999 (data from Bureau of Reclamation and IDWR).

SYSTEM/RESERVOIR	Reclamation Power Head	Space Uncontracted	Rental Pool	Natural Flows	Total
Upper Snake*					
American Falls		8,884			
Jackson		3,795			
Palisades		9,145			
Water District 01			148,397		
Sho-Ban**			38,000		
Subtotal		21,824	186,397		208,221
Payette***					
Cascade		69,600			
Deadwood		25,400			
Subtotal		95,000	65,000		160,000
Boise****					
Lucky Peak		40,932			
Subtotal		40,932			40,932
Oregon					
Skyline Farms				17,649	
Oregon Water Trust				198	
Subtotal				17,847	17,847
GRAND TOTAL		157,756	251,397	17,847	427,000

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

** The sho-Ban rented water was moved out of American Falls Reservoir.

*** The Payette release was split roughly 60/40 between summer and winter releases. The summer releases were both Cascade and Deadwood storage. The winter release was exclusively Cascade release. A total of 85,000 acre-feet was released in the summer, 65,000 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.

Table 3. Water provided for flow augmentation from the Snake River Basin upstream of Hells Canyon Dam, 1987-1998. Values are in acre-feet.

System	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Upper Snake													
USBR Space	0	0	0	0	0	0	206,617	285,954	22,396	22,396	22,396	22,896	21,824
Rentals	150,000	50,000	100,000	63,000	0	0	65,000	44,325	232,839	194,667	202,104	200,326	186,397
BPA Purchase	0	0	0	0	50,000	49,000	0	0	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	224,500	223,222	208,221
Payette													
USBR Space	0	0	0	0	0	90,000	95,000	61,883	94,242	95,000	95,000	95,000	95,000
Rentals	0	0	0	0	0	0	34,971	0	50,758	56,300	60,000	50,043	65,000
BPA Purchase	0	0	0	0	51,000	51,000	0	0	0	0	0	0	0
Subtotal	0	0	0	0	51,000	141,000	129,971	61,883	145,000	151,300	155,000	145,043	160,000
Boise													
USBR Space	0	0	0	0	0	0	23,000	35,950	25,000	38,000	38,000	40,932	40,932
Rentals	0	0	0	0	0	0	0	0	2,000	0	2,000	0	0
Subtotal	0	0	0	0	0	0	23,000	35,950	27,000	38,000	40,000	40,932	40,932
Natural Flows													
Skyline Farms	0	0	0	0	0	0	0	0	0	15,714	17,649	17,649	17,649
OR Water Trust	0	0	0	0	0	0	0	0	0	64	132	198	198
Subtotal	0	0	0	0	0	0	0	0	0	15,778	17,781	17,847	17,847
Upper Snake Contribution	150,000	50,000	100,000	63,000	101,000	190,000	424,588	428,112	427,235	422,141	437,281	427,044	427,000
Brownlee	0	0	50,000	87,000	174,000	110,000	102,000	326,270	235,000	298,810	332,191	302,561	269,722
Grand Total	150,000	50,000	150,000	150,000	275,000	300,000	526,588	754,382	662,235	720,951	769,472	729,605	696,722

Table 4. Changes in white sturgeon habitat in the Snake River from C.J. Strike Dam to Swan Falls Reservoir resulting from salmon flow augmentation releases during the summer of 1999. 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 7/5-7/31	7,220	1,536	5,684	22.51	16.83	4.85	14.33	19.95	15.88	2.95	11.89	+2.56 (12.83)	N/A	N/A	N/A
Aug. 8/1-8/31	7,883	1,551	6,332	23.50	16.91	5.73	15.27	21.08	16.40	3.73	12.99	+2.43 (11.53)	N/A	N/A	N/A
Sept. 9/1-9/11	8,571	1,403	7,168	24.42	16.73	6.66	16.19	22.43	16.82	4.78	14.26	+1.99 (8.87)	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 1999. 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 7/6-7/31	7,083	1,535	5,548	3.85	2.57	1.77	3.00	3.57	2.74	1.27	2.73	+0.29 (8.12)	N/A	N/A	N/A
Aug. 8/1-8/31	7,726	1,550	6,176	3.94	2.47	1.95	3.11	3.69	2.69	1.48	2.85	+0.25 (6.78)	N/A	N/A	N/A
Sept. 9/1-9/12	8,345	1,417	6,928	4.02	2.38	2.12	3.19	3.83	2.59	1.73	2.98	+0.19 (4.96)	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 1999. 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 7/6-7/31	7,083	1,535	5,548	38.69	34.34	3.03	9.88	32.49	30.05	1.68	6.95	+6.20 (19.08)	N/A	N/A	N/A
Aug. 8/1-8/31	7,726	1,550	6,176	41.12	35.69	3.67	10.95	35.08	31.98	2.19	8.22	+6.05 (17.25)	N/A	N/A	N/A
Sept. 9/1-9/12	8,345	1,417	6,928	43.46	36.75	4.36	12.04	38.09	33.97	2.88	9.61	+5.37 (14.10)	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 1999. 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 7/9-7/31	8,998	1,864	7,134	45.38	35.11	2.82	12.01	38.84	32.66	1.33	8.52	+6.55 (16.86)	N/A	N/A	N/A
Aug. 8/1-8/31	8,879	1,889	6,990	44.98	34.97	2.72	11.83	38.30	32.44	1.22	8.18	+6.69 (17.47)	N/A	N/A	N/A
Sept. 9/1-9/13	10,846	1,430	9,416	50.43	36.25	4.58	14.23	46.54	35.45	3.20	12.51	+3.89 (8.36)	N/A	N/A	N/A

Table 8. Changes in white sturgeon habitat in the Snake River from the Payette River to Brownlee Reservoir resulting from salmon flow augmentation releases during the summer of 1999. 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 7/2-7/5	16,550	110	16,440	48.01	27.91	14.94	23.81	48.00	28.01	14.81	23.74	+0.01 (0.02)	N/A	N/A	N/A
July 7/6-7/31	12,219	2,702	9,517	45.58	30.38	9.58	19.82	41.23	29.94	6.36	16.05	+4.35 (10.55)	N/A	N/A	N/A
Aug. 8/1-8/31	12,306	2,936	9370	45.68	30.37	9.69	19.92	40.91	29.89	6.18	15.82	+4.76 (11.64)	N/A	N/A	N/A
Sept. 9/1-9/14	12,621	1,662	10,959	46.03	30.30	10.07	20.29	43.89	30.31	8.08	18.16	+2.14 (4.88)	N/A	N/A	N/A
Sept. 9/15-9/21	12,629	110	12,519	46.04	30.30	10.08	20.30	45.92	30.32	9.95	20.17	+0.12 (0.26)	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 Reservoir resulting from salmon flow augmentation releases during the summer of 1999. 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 7/5-7/31	7,220	1,536	5,684	43.58	16.20	2.69	7.09	41.37	18.21	2.50	7.53	+2.22 (5.37)	-2.01 (11.04)	N/A	-0.43 (5.71)
Aug. 8/1-8/31	7,883	1,551	6,332	44.14	15.54	3.06	7.01	42.54	17.30	2.53	7.33	+1.60 (3.76)	-1.76 (10.17)	N/A	-0.32 (4.37)
Sept. 9/1-9/11	8,571	1,403	7,168	44.61	15.04	3.37	6.41	43.54	16.25	2.66	7.10	+1.07 (2.46)	-1.21 (7.45)	N/A	-0.69 (9.72)

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 1999. 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 7/6-7/31	7,083	1,535	5,548	7.93	6.45	0.34	2.87	6.30	6.22	0.48	3.40	+1.64 (26.03)	+0.23 (3.70)	N/A	-0.53 (15.59)
Aug. 8/1-8/31	7,726	1,550	6,176	8.42	6.37	0.37	2.48	7.05	6.42	0.46	3.20	+1.38 (19.57)	-0.05 (0.78)	N/A	-0.72 (22.50)
Sept. 9/1-9/12	8,345	1,417	6,928	8.80	6.45	0.38	2.12	7.80	6.46	0.35	2.94	+1.00 (12.82)	-0.23 (3.56)	N/A	-0.83 (28.23)

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 1999. 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 7/6-7/31	7,083	1,535	5,548	223.52	85.16	91.16	39.07	196.70	97.32	73.77	52.30	+26.82 (13.63)	-12.17 (12.51)	N/A	-13.23 (25.30)
Aug. 8/1-8/31	7,726	1,550	6,176	231.18	78.78	99.39	33.00	207.48	92.78	78.54	47.08	+23.71 (11.43)	-14.00 (15.09)	N/A	-14.09 (29.93)
Sept. 9/1-9/12	8,345	1,417	6,928	236.90	72.98	106.50	28.22	221.21	86.57	89.09	40.48	+15.69 (7.09)	-13.60 (15.71)	N/A	-12.26 (30.29)

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 1999. 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 7/7-7/31	8,998	1,864	7,134	231.04	66.41	91.34	29.21	212.53	74.48	73.74	38.09	+18.50 (8.70)	-8.07 (10.84)	N/A	-8.87 (23.29)
Aug. 8/1-8/31	8,879	1,889	6,990	230.18	67.01	80.94	29.81	210.63	74.94	73.03	38.60	+19.55 (9.28)	-7.93 (10.58)	N/A	-8.79 (22.77)
Sept. 9/1-9/13	10,846	1,430	9,416	230.87	58.94	74.62	23.42	231.91	64.30	79.84	27.59	-1.04 (0.45)	-5.36 (8.34)	N/A	-4.17 (15.11)

Table 13. Changes in rainbow trout habitat in the Snake River from the Payette River to Brownlee Reservoir resulting from salmon flow augmentation releases during the summer of 1999. 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 7/2-7/5	16,550	110	16,440	125.61	33.91	41.88	8.73	125.88	34.15	42.05	8.82	-0.27 (0.21)	-0.24 (0.70)	N/A	-0.10 (1.13)
July 7/6-7/31	12,219	2,702	9,517	131.54	46.68	38.25	14.34	126.81	59.39	28.87	21.73	+4.73 (3.73))	-12.71 (21.40)	N/A	-7.39 (34.01)
Aug. 8/1-8/31	12,306	2,936	9370	131.56	46.32	38.54	14.18	126.25	60.10	28.26	22.24	+5.30 (4.20)	-13.78 (22.93)	N/A	-8.06 (36.24)
Sept. 9/1-9/14	12,621	1,662	10,959	131.60	45.00	39.58	13.62	129.93	52.54	33.50	17.79	+1.68 (1.29)	-7.54 (14.35)	N/A	-4.17 (23.44)
Sept. 9/15-9/21	12,629	110	12,519	131.60	44.97	39.61	13.60	131.59	45.43	39.24	13.80	+0.02 (0.02)	-0.46 (1.01)	N/A	-0.20 (1.45)

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 Reservoir
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. Changes in bull trout habitat in the Deadwood River from Deadwood Dam to the mouth resulting from salmon flow augmentation releases during the summer of 1999. Juv. = juvenile; Spawn = spawning; N/A = not applicable, life stage not present during that month.

Habitat estimates – Weighted Usable Area in square feet per one thousand linear feet of stream.

				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 7/4-7/31	676	123	553	29,007	30,676	N/A	N/A	30,011	31,655	N/A	N/A	-1,004 (3.35)	-979 (3.09)	N/A	N/A
Aug. 8/1-9/1	897	132	765	28,506	29,454	N/A	N/A	28,666	30,247	N/A	N/A	-160 (0.56)	-793 (2.62)	N/A	N/A

Table 16. Changes in rainbow trout habitat in the Deadwood River from Deadwood Dam to the mouth resulting from salmon flow augmentation releases during the summer of 1999. Juv. = juvenile; Spawn = spawning; N/A = not applicable, life stage not present during that month.

Habitat estimates – Weighted Usable Area in square feet per one thousand linear feet of stream.

				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 7/4-7/31	676	123	553	55,187	27,444	N/A	32,740	58,441	31,149	N/A	34,594	-3,254 (5.57)	-3,705 (11.89)	N/A	-1,854 (5.36)
Aug. 8/1-9/1	897	132	765	51,787	22,681	N/A	30,905	53,738	25,409	N/A	32,092	-1,951 (3.63)	-2,727 (10.73)	N/A	-1,187 (3.70)

Table 17. Integrated (target) fish flow recommendations and the actual flows recorded at the Murphy Gage on the Snake River downstream of Swan Falls Dam during the flow augmentation period in 1994 - 1999. The integrated 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
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	--
1998	--	--	--	7,399	7,578	8,842	--
1999	--	--	--	7,083	7,726	8,345	--

* = Mean flows during the first and last month each year are not for the entire month, just the flow augmentation period. See previous tables for exact dates of the flow augmentation releases.

Table 18. Flow summary for years 1994 - 1999 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 (October - March)
	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 (October - March)
	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 (October - March)
	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 (October - March)
	1998	Middleton*	7/7 - 7/31 8/1 - 8/28	733 796	426 371	882 877	637 520	240 240	All All	non-irrigation season (October - March)
	1999	Middleton	7/4 - 7/31 8/1 - 8/29	703 652	389 336	764 757	599 506	240 240	All All	non-irrigation season (October - March)
Payette	1994	Cascade	6/30-7/31 8/1-8/17	1,754 1,545	681 241	1,940 1,920	1,020 1,300	1,400 1,400	27/32 12/17 (22/31 August)	50/50 split between summer and non-irrigation season (October - March)
	1994	Deadwood**	6/30-7/31 8/1-8/17	909 786	120 42	1,091 808	871 761	267 191	All All	Non-irrigation season (October – March)
	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 (October – March)

Table 18. 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	RECOMMENDED 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 (October – March)
	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 (October – March)
	1996	Cascade	7/23-7/31 8/1-8/31	1,346 1,342	944 554	1,460 1,410	1,320 1,300	1,400 1,400	1/9 3/31	50/50 split between summer and non-irrigation season (October – March)
	1996	Deadwood**	7/23-7/31 8/1-8/31	627 740	167 98	696 836	409 147	267 191	All 30/31	Non-irrigation season (October – March)
	1996	Letha	7/25-7/31 8/1-9/2	1,281 816	1,126 677	1,440 1,260	1,170 230	1,165 1,165	All 2/33	50/50 split between summer and non-irrigation season (October – March)
	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 (October – March)
	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 (October - March)
	1997	Cascade	7/12-7/31 8/1-9/1	1,532 1,462	757 529	1,540 1,550	1,520 1,360	1,400 1,400	All 19/32	50/50 split between summer and non-irrigation season (October - March)

Table 18. 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	RECOMMENDED RELEASE TIME
Payette	1997	Deadwood**	7/12-7/31 8/1-9/2	529 715	168 162	841 761	385 282	267 191	All All	Non-irrigation season (October – March)
	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 (October – March)
	1997/ 1998	Cascade	11/27-12/29	920	720	1,008	455	400	All	50/50 split between summer and non-irrigation season (October – March)
	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 (October - March)
	1998	Cascade	7/8 - 7/31 8/1 – 9/1	1,516 1,566	812 517	1,530 1,780	1,480 1,500	1,400 1,400	All All	50/50 split between summer and non-irrigation season (October -March)
	1998	Deadwood**	7/8 – 7/31 8/1 – 9/1	639 742	144 91	785 874	556 95	267 191	All 30/32	Non-irrigation season (October – March)
	1998	Letha	7/10 - 7/31 8/1 - 9/3	1,542 802	945 637	2,570 1,220	1,040 320	1,165 1,165	14/22 2/34	50/50 split between summer and non-irrigation season (October - March)
	1998/ 1999	Cascade	12/3-12/31 1/1-1/30	767 689	541 500	1,140 1,140	202 205	400 400	18/28 17/30	50/50 split between summer and non-irrigation season (October – March)

Table 18. 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	RECOMMENDED RELEASE TIME
Payette	1998/ 1999	Letha***	12/5-12/31 1/1-2/1	1,908 2,401	511 527	3,520 3,290	1,210 1,680	1,165 1,165	All All	50/50 split between summer and non-irrigation season (October – March)
	1999	Cascade	7/4-7/31 8/1-9/1	1,613 1,685	697 748	1,780 1,800	1,560 1,610	1,400 1,400	All All	50/50 split between summer and non-irrigation season (October – March)
	1999	Deadwood	7/4-7/31 8/1-9/1	676 897	123 132	810 1,007	555 164	267 191	All 31/32	50/50 split between summer and non-irrigation season (October – March)
	1999	Letha	7/6-7/31 8/1-9/3	1,844 1,080	803 890	2,980 1,320	1,100 388	1,165 1,165	23/26 10/34	50/50 split between summer and non-irrigation season (October – March)
	1999	Cascade	11/9-11/30 12/1-12/20	844 939	717 698	1,007 1,014	201 279	400 400	20/22 19/20	50/50 split between summer and non-irrigation season (October – March)
	1999	Letha	11/11-11/30 12/1-12/22	1,771 2,015	708 708	3,509 2,200	1,074 1,346	1,165 1,165	18/20 All	50/50 split between summer and non-irrigation season (October – March)
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, early rearing and incubation; summer - water quality

Table 18. 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	RECOMMENDED RELEASE TIME
Snake	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, early rearing and incubation; summer - water quality
	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, early rearing and incubation; 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, early rearing and incubation; summer - water quality
	1998	Murphy	7/12-7/31 8/1-8/31 9/1-9/22	7,399 7,578 8,842	1,544 1,558 1,516	8,060 8,630 10,100	6,820 6,610 7,640	12,500 12,500 12,500	0 0 0	spring - sturgeon spawning, early rearing and incubation; summer - water quality
	1999	Murphy	7/6-7/31 8/1-8/31 9/1-9/12	7,083 7,726 8,345	1,535 1,550 1,417	8,040 8,510 8,970	6,290 6,920 7,620	12,500 12,500 12,500	0 0 0	spring - sturgeon spawning, early rearing and incubation; summer - water quality

* = There were four days of missing data during the July flow augmentation period. ** = All Deadwood flows are for near the mouth and are equivalent to the release at the dam plus the average inflow of 142 cfs during July and 66 cfs during August. The flow recommendation is also for the mouth. It is the recommended release at the dam (125 cfs) plus the average inflow of 142 cfs during July and 66 cfs during August. *** = Includes 6 days in December and 2 days in January with zero flow augmentation.

Table 19. Summary of the percent change in habitat (WUA) for adult and juvenile white sturgeon in the Snake River between CJ Strike Dam and Brownlee Pool resulting from salmon flow augmentation releases.

	SNAKE RIVER PERCENT HABITAT CHANGES - ADULT AND JUVENILE STURGEON					
Year	CJ Strike Dam - Swan Falls Dam	Swan Falls Dam - Walters Ferry	Walters Ferry - Boise Rive	Boise River - Payette River	Payette River - Brownlee Pool	Mean
1994	+10.67	+6.39	+15.53	+13.68	+9.96	+11.25
1995	+7.85	+4.75	+12.23	+8.85	+5.35	+7.81
1996	+10.63	+6.48	+16.05	+13.18	+6.74	+10.62
1997	+6.06	+2.55	+10.60	+8.22	+6.27	+6.74
1998	+10.94	+6.44	+16.66	+10.01	+7.43	+10.30
1999	+11.00	+6.58	+16.68	+13.85	+5.17	+10.66
mean	+9.53	+5.53	+14.63	+11.30	+6.82	+9.56

Table 20. Summary of the percent change in habitat (WUA) for rainbow trout adults, juveniles, and fry in the Snake River between CJ Strike Dam and Brownlee Pool resulting from salmon flow augmentation releases.

	SNAKE RIVER PERCENT HABITAT CHANGES - ADULT, JUVENILE AND FRY RAINBOW TROUT																	
	CJ - Swan Falls			Swan Falls - Walters Ferry			Walters Ferry - Boise River			Boise River - Payette River			Payette River - Brownlee Pool			Mean		
Year	Adult	Juvenile	Fry	Adult	Juvenile	Fry	Adult	Juvenile	Fry	Adult	Juvenile	Fry	Adult	Juvenile	Fry	Adult	Juvenile	Fry
1994	+4.68	-9.13	-5.07	+19.71	+2.15	-16.89	+9.98	-11.62	-23.14	+7.36	-4.79	+0.72	+6.64	-7.37	-4.81	+9.67	-6.15	-9.84
1995	+2.47	-7.18	-6.81	+13.02	-1.21	-23.52	+7.48	-12.35	-29.18	+1.89	-8.26	-18.34	+2.32	-10.81	-20.22	+5.44	-7.96	-19.61
1996	+3.57	-9.49	-3.93	+18.54	-0.05	-21.37	+10.42	-14.18	-28.47	+5.16	-11.21	-22.16	+2.83	-15.45	-30.12	+8.10	-10.08	-21.21
1997	-0.05	-10.14	-13.20	+5.16	-6.76	-25.95	+2.18	-13.97	-27.56	-1.73	-8.14	-13.33	-0.85	-22.30	-32.94	+0.94	-12.26	-22.60
1998	+3.52	-9.48	-7.90	+17.70	-1.67	-23.73	+10.15	-15.16	-29.24	+2.11	-8.94	-17.83	+2.44	-17.31	-28.35	+7.18	-10.51	-21.41
1999	+3.84	-9.62	-6.56	+19.01	-0.26	-21.80	+10.59	-14.37	-28.30	+5.65	-9.99	-20.93	+1.79	-13.80	-26.26	+8.18	-9.61	-20.77
mean	+3.01	-9.17	-7.25	+15.52	-1.30	-22.21	+8.47	-13.61	-27.65	+3.41	-8.56	-15.31	+2.53	-14.51	-23.78	+6.59	-9.43	-19.24

Table 21. Summary of the percent change in habitat (WUA) for juvenile and adult bull trout, and rainbow trout adults, juveniles, and fry in the Deadwood River between Deadwood Dam and the mouth of the Deadwood River resulting from salmon flow augmentation releases.

	DEADWOOD RIVER PERCENT HABITAT CHANGES - ADULT AND JUVENILE BULL TROUT AND RAINBOW TROUT				
	Deadwood Dam - Mouth		Deadwood Dam - Mouth		
Year	Adult Bull Trout	Juvenile Bull Trout	Adult Rainbow Trout	Juvenile Rainbow Trout	Fry Rainbow Trout
1994	-0.39	-1.54	-2.24	-6.54	-2.18
1995*	--	--	--	--	--
1996	+0.80	-2.10	-2.98	-13.71	-4.95
1997	+1.96	-2.51	-1.54	-17.52	-4.52
1998	+0.02	-2.12	-3.52	-11.72	-4.60
1999	-1.98	-2.86	-4.64	-11.37	-4.56
mean	+0.08	-2.23	-2.98	-12.17	-4.16

* = No releases were made from Deadwood Reservoir during 1995.