WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

COMPLETION REPORT

TITLE: Instream Flow Studies for the Salt River Hydroelectric Project Proposal

PROJECT: IF-1089-09-8901

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DATE: February 1990

INTRODUCTION

A proposal has been made to develop a small run-of-the-river hydroelectric project on the Salt River by rehabilitating existing facilities. These structures near Alpine, Wyoming were previously operated by the Lower Valley Power and Light Company and consist of diversion structures, a delivery canal and a powerplant building. A maximum of 240 cubic feet per second (cfs) has been proposed for diversion during some or all of the year (Heiner 1988), through a bypass section (headgate to powerplant) approximately 2.7 miles long.

Specific information on trout populations in this reach of the Salt River is limited, and fish population studies should be completed prior to final FERC authorization. However, it is known that the bypass section serves as a migration corridor for brown trout moving to spawning grounds in the upper Salt River Drainage. Additionally, resident populations of Snake River cutthroat trout and brown trout provide a variety of fishing opportunities for both resident and non-resident anglers (WGFD 1985).

Licensing this project under the jurisdiction of the Federal Energy Regulatory Commission (FERC) requires that potential fishery impacts be assessed, and that mitigation measures be developed prior to issuing an operating license. As partial compliance with these FERC requirements, the project sponsor has contracted with WGFD to assess potential impacts of flow reductions on the physical habitat of trout in the area affected by this project.

The specific objectives of this analysis were to 1) assess the amount of physical habitat available in the bypass section for various life stages of cutthroat trout and brown trout at different discharge rates and, 2) determine the discharge necessary to preserve the hydraulic characteristics of the river that are critical for maintenance of trout populations, and 3) determine the discharge necessary to maintain adult trout production during the late summer months.

Objectives 1 and 2 are fully addressed in this report. However, because specific information on fish population dynamics is not available for the bypass section and because flows remained unexpectedly high throughout the 1988 field season, it was not possible to assess potential impacts of this project on trout production.

STUDY AREA

The section of the Salt River potentially affected by this project is classified by the Wyoming Game and Fish Department (WGFD) as a Class 2 trout stream. Class 2 trout streams support fisheries of statewide importance and generally exhibit high rates of fish production. This section of the lower Salt River is managed primarily for Snake River cutthroat trout, brown trout and mountain whitefish under the basic yield concept. Trout populations are periodically supplemented with hatchery fish by the WGFD.

The study site was located in about the middle of the proposed bypass section in Township 36 North, Range 119 West, Section 16. The study site is within a Public Fishing Access area (PFA) maintained by the WGFD, and the entire PFA is within the proposed bypass reach (Figure 1). The bypass section is characterized by long stretches of swift, relatively shallow "runs" between an occasional large pool. Because the lower end of the study site contained a large pool, and the upper 60% of the reach consisted of a typical "run", the site was judged to represent conditions found throughout the proposed bypass section. Total length of the study reach was 912 feet.

METHODS

Two techniques were used to assess the potential impacts of flow reductions on trout habitat within the bypass section, the Physical Habitat Simulation Model (PHABSIM) and a Habitat Retention method. It should be noted that neither of these models is considered appropriate for addressing impacts to trout populations or production.

The PHABSIM model was developed by the Instream Flow Service Group of the U.S. Fish and Wildlife Service (Bovee and Milhous 1978) to examine incremental changes in the amount of physical habitat available at various discharge rates. The amount of physical habitat available at a given discharge is expressed in terms of weighted usable area (WUA) and reflects the composite suitability of depth, velocity and substrate at a given flow. This model is considered state-of-the-art technology and is the most commonly used method in North America for quantifying changes in physical habitat with changes in discharge (Reiser et al. 1989). Again, the PHABSIM model only addresses changes in physical habitat and is not appropriate for quantifying effects of changing discharge on trout production.

Depth, velocity and substrate data were collected from 10 transects in accordance with guidelines given by Bovee and Milhous (1978). Three stage-discharge pairs and one set of velocity data were collected for each transect over the course of three visits to the study site. Techniques given in Milhous (1984) and Milhous et al. (1984) were used to develop hydraulic simulations, and to determine the range of flows for which WUA could be reliably simulated.

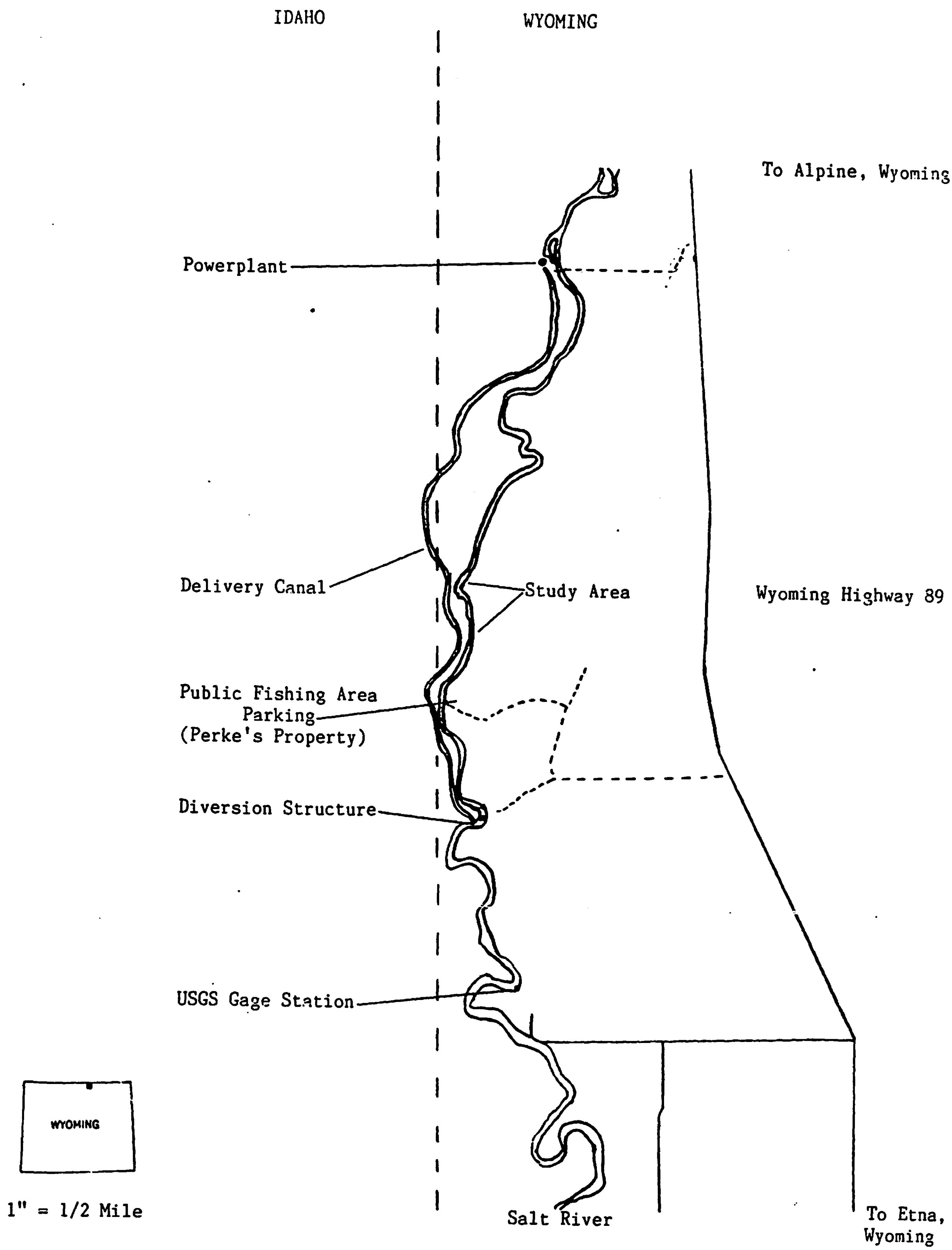

Figure 1. Location of study area on Salt River.

Using calibration and modeling techniques outlined in Milhous (1984) and Milhous et al. (1984), and Habitat Suitability Curves developed by Raleigh et al. (1986) and Hickman and Raleigh (1982), the WUA for cutthroat trout and brown trout adults, juveniles and fry was simulated for flows from 150 to 1000 cfs. Because spawning habitat is generally lacking in the study area the WUA for this life stage was not simulated for either species.

Based on stream gaging records compiled by Peterson (1988), the range of flows for which WUA was simulated appears to encompass the flows likely to be present in the bypass section after a maximum of 240 cfs has been diverted to the delivery canal (Table 1).

Table 1. Selected streamflow statistics for the Salt River for the years 1954-1984. Data are from USGS gage # 13027500, located about 1 mile above the upstream end of the proposed bypass section.

Month	Maximum (cfs)	Minimum (cfs)	Mean (cfs)
October	912	336	638
November	838	347	605
December	712	381	533
January	583	324	461
February	702	337	448
March	806	368	465
April	1560	503	929
May	3250	306	1800
June	3360	275	1510
July	1810	271	915
August	997	266	665
September	961	342	678
Annual	1250	432	805

A Habitat Retention method (Nehring 1979, Annear and Conder 1984) was used to identify a fisheries maintenance flow for the bypass section. A maintenance flow is defined as a continuous flow that will maintain minimum hydraulic criteria at riffle areas in a stream segment. Based on extensive research by Annear and Conder (1983), the maintenance flow is further defined as the discharge at which two of three hydraulic criteria are met for all riffles in the study area (Table 2). Meeting these criteria provides passage for all life stages of trout between different habitat types and maintains survival of trout and aquatic macroinvertebrates during the winter.

The Habitat Retention method was developed to identify a flow that would maintain survival rates of aquatic insects in riffle areas, maintain existing survival rates of trout, and provide passage for trout between different habitat types in streams during the winter. However, because maintenance of these features is important year round, the instream flow identified by the Habitat Retention method is regarded as the lowest flow that will maintain a fishery unless flow recommendations from other methods indicate that a higher stream flow is needed for a particular time of year or purpose.

Data for the Habitat Retention model were collected from transects placed across two riffles in the study area (transects 8 and 9) and analyzed using the IFG-1 computer program (Milhous 1978).

Table 2. Hydraulic criteria used to identify a fisheries maintenance flow using the Habitat Retention method.

Category	Criteria
Average Depth (feet)	Top width[1] X 0.01
Average Velocity (feet per second)	1.00
Wetted Perimeter (percent)[2]	60

1 - At average daily flow
2 - Compared to wetted perimeter at bankfull conditions

Data for both habitat models were collected over a narrow range of discharge rates after peak runoff had occurred (Table 3).

Table 3. Dates and discharge rates when instream flow data were collected from the lower Salt River in 1989.

Date	Discharge Cubic Feet Per Second (cfs)
06-29-89	574
07-13-89	511
11-16-89	452

RESULTS

PHABSIM Model

Within the range of simulations, physical habitat for adult cutthroat trout is maximized at 200 cfs. Reductions in physical habitat are rapid as discharge increases above 250 cfs, and at 1000 cfs, WUA is about 25% of the maximum that occurs at 200 cfs (Figure 2). These data apply to times of year that physical habitat parameters are the primary factors affecting the distribution and abundance of adults. This time of year is from October 1 to March 31.

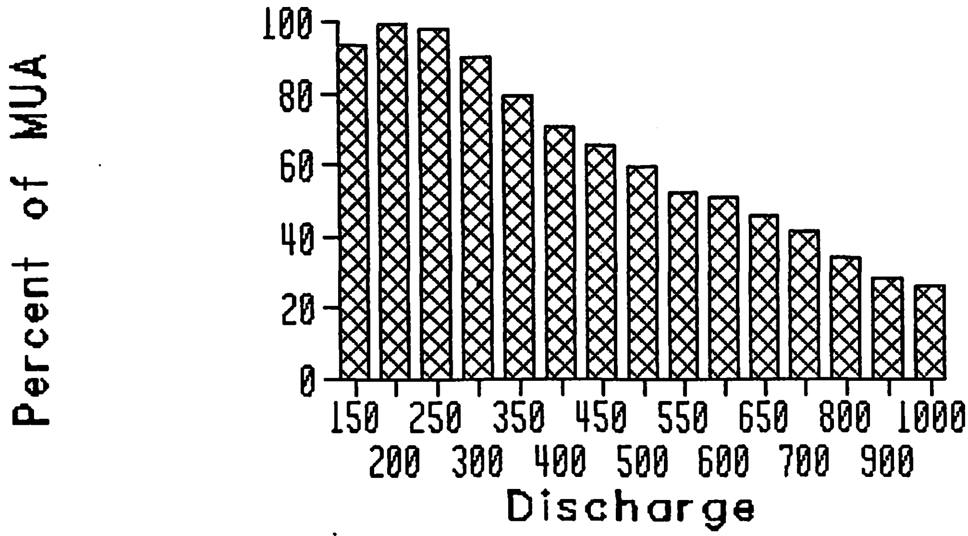

Figure 2. Percent of maximum weighted usable area (MUA) for cutthroat trout adults at the Salt River study site as a function of discharge.

Physical habitat for both cutthroat trout juveniles (Figure 3) and fry (Figure 4) is maximized at 150 cfs. There is a net decrease in availability of physical habitat by about 75% to 80% for both life stages over the range of flow simulations. Physical habitat for juvenile cutthroat trout decreases rapidly and consistently as flows increase to 1000 cfs (Figure 3). For cutthroat trout fry, physical habitat decreases rapidly as flows increase to about 450 cfs, after which reductions in physical habitat are more gradual (Figure 4).

These analyses apply to times of year when physical habitat components are the primary factors affecting these life stages. For juveniles and fry these time periods are from April 1 to April 30, and from May 1 to June 30, respectively. Management precedent is given to maintenance of physical habitat for juvenile and fry life stages over maintenance of physical habitat for adults because juvenile and fry are more heavily influenced by discharge than adults during these time periods.

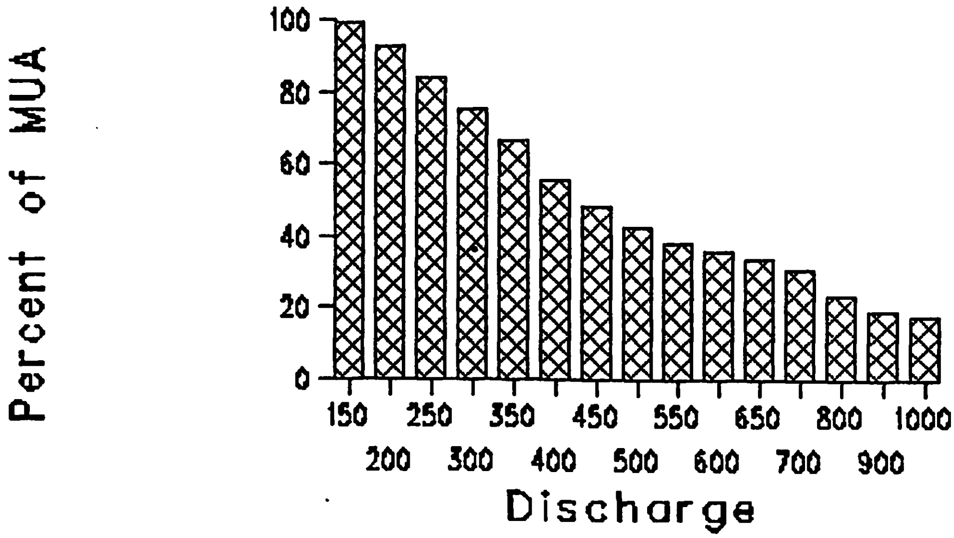

Figure 3. Percent of maximum weighted usable area (MUA) for cutthroat trout juveniles at the Salt River study site as a function of discharge.

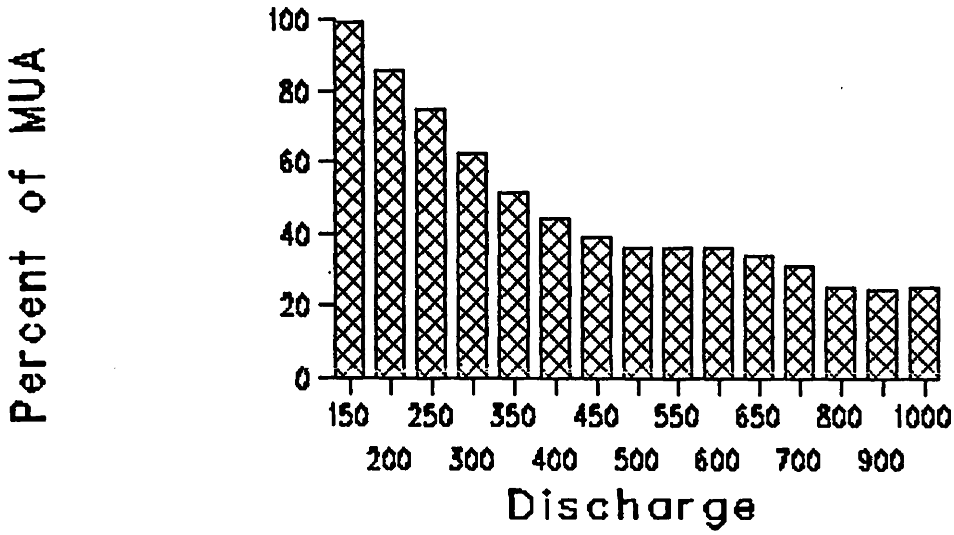

Figure 4. Percent of maximum weighted usable area (MUA) for cutthroat trout fry at the Salt River study site as a function of discharge.

Simulations of WUA for adult brown trout indicate maximum availability of physical habitat at 200 cfs. A gradual reduction in physical habitat of about 20% occurs as discharge increases to 1000 cfs (Figure 5).

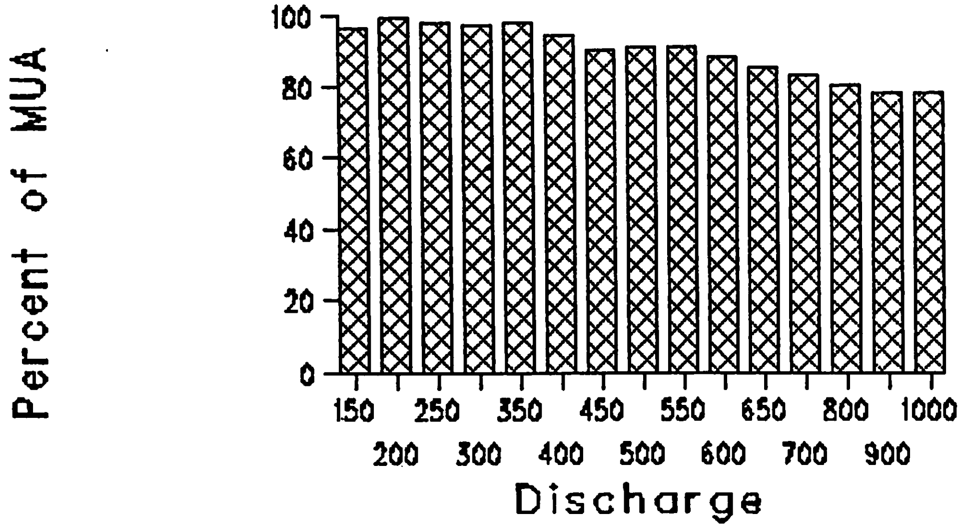

Figure 5. Percent of maximum weighted usable area (MUA) for brown trout adults at the Salt River study site as a function of discharge.

Simulations of WUA for brown trout juveniles and fry are very similar (Figures 6 and 7). Both exhibit reductions in physical habitat of about 75% from the maximum as flows increase from 150 cfs to 1000 cfs. The rate of decrease in physical habitat is rapid and fairly constant for juveniles. For brown trout fry, the rate of decrease in physical habitat is more rapid between 150 cfs and about 450 cfs than at higher flows.

As is the case with cutthroat trout, these analyses apply to times of year when physical habitat components are the primary factors affecting these life stages. For juveniles and fry these times periods are from April 1 to April 30, and from May 1 to June 30, respectively. Again, management precedent is given to maintenance of physical habitat for juvenile and fry life stages over maintenance of physical habitat for adults because juvenile and fry are more heavily influenced by discharge than adults during these time periods.

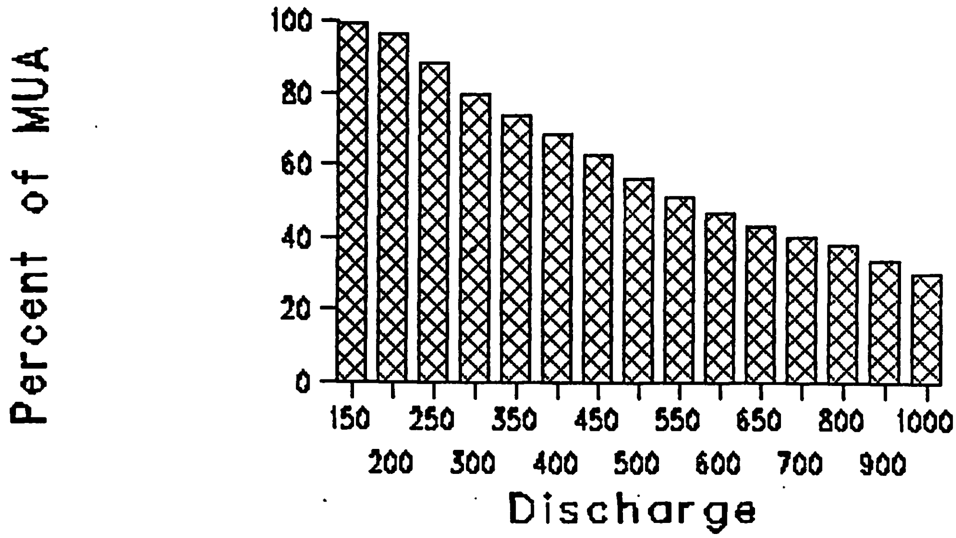

Figure 6. Percent of maximum weighted usable area (MUA) for brown trout juveniles at the Salt River study site as a function of discharge.

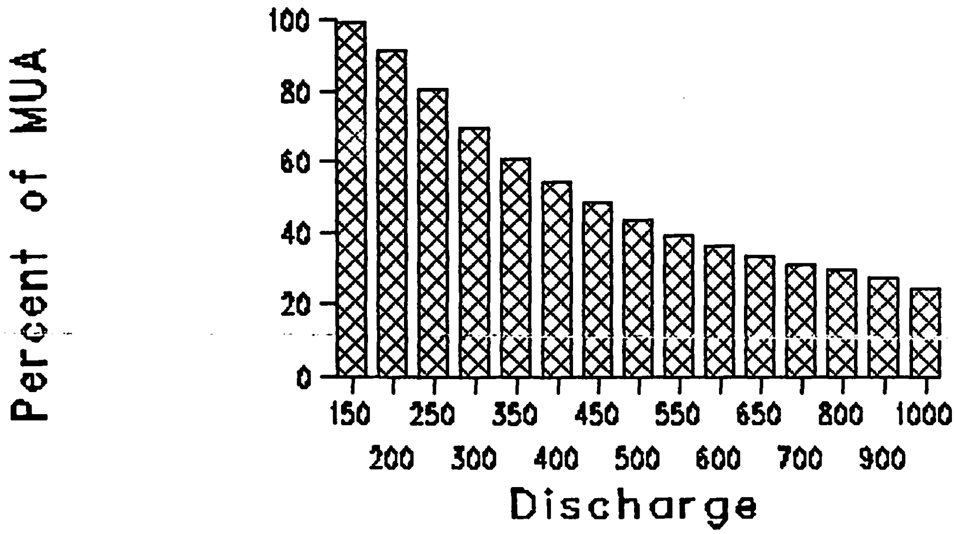

Figure 7. Percent of maximum weighted usable area (MUA) for brown trout fry at the Salt River study site as a function of discharge.

Habitat Retention Model

Results from the Habitat Retention model indicate that flows of 221 and 183 cfs are necessary to maintain winter survival of trout, aquatic insect production and fish passage at riffles 8 and 9, respectively (Table 4). The maintenance flow recommendation derived from this method is defined as the flow at which two of the three hydraulic criteria are met for the riffles modeled in the study site, which in this case is 221 cfs.

Table 4. Simulated hydraulic criteria for two riffles on the Salt River Bankfull discharge = 5,208 cfs; average daily discharge = 805 cfs. Velocity criteria met at discharges lower than simulated.

Average Depth (ft)	Average Velocity (ft/sec)	Wetted Perimeter (ft)	Discharge (cfs)
	Riffle # 8		
2.81	5.22	129.6	1887
2.12	4.34	125.9	1155
1.89	4.02	124.6	944
1.72	3.78	123.7	805
1.43	3.35	121.2	580
1.36	3.23	107.2	468
1.23[1]	3.02	104.2	389
1.16	2.91	102.5	346
0.96	2.56	98.3	240
0.92	1.83[1]	95.6[1]	221[2]
	Riffle # 9		
3.39	4.56	124.7	1908
2.95	4.16	122.2	1486
2.50	3.73	119.8	1109
2.09	3.31	117.4	805
1.82	3.02	115.5	634
1.39	2.52	110.8	387
1.17[1]	2.25	108.2	284
0.93	1.94	101.0[1]	183[2]
0.89	1.88[1]	84.9	142

1 - Minimum hydraulic criteria met
2 - Discharge at which 2 of 3 hydraulic criteria are met

DISCUSSION

As noted previously, specific information on fish population dynamics is not available for the bypass section. In addition, studies to assess potential impacts of the project on trout production were not possible in 1987 because flows remained unexpectedly high throughout the field season. Because of this, discussions of potential project impacts have been restricted to impacts occurring to physical habitat, and have not included predictions about impacts to trout populations or production. Additional information on population numbers, size structure, species composition and trout production are necessary for complete project impact assessment.

The PHABSIM analyses indicate that physical habitat for all life stages of cutthroat trout and brown trout decreases at discharges above 200 cfs, and that the maximum amounts of physical habitat will occur at 150 cfs to 200 cfs. A flow of 150 cfs is just below the recorded minimum daily streamflow of 160 cfs (Peterson 1988), and is substantially lower than the lowest average monthly discharge of 271 cfs (Table 1).

Although physical habitat is maximized at these low flows, maintaining extremely low flows during the winter is potentially damaging to the fishery in the bypass reach. Natural mortality that occurs during the winter can be a significant factor limiting a trout population. Kurtz (1980) found that the loss of winter habitat due to low flow conditions was an important factor affecting mortality rates of trout in the upper Green River, with mortality approaching 90% during some years. Needham et al. (1945) documented average overwinter brown trout mortality of 60% and extremes as high as 80% in a California stream. Butler (1979) reported significant losses of trout and aquatic insects caused by anchor ice formation. Reimers (1957) considered anchor ice, collapsing snow banks and fluctuating flows resulting from the periodic formation and breakup of ice dams, as the primary causes of winter trout mortality.

The PHABSIM model simulates physical habitat but does not account for impacts that may occur during the winter, and does not effectively address maintenance of fish passage between habitat types or aquatic insect survival. Because the Habitat Retention model more accurately accounts for these limiting factors, the maintenance flow value derived from the Habitat Retention model (221 cfs) is considered as the base flow necessary to maintain the fishery in the bypass section whenever other flows are not required to meet other fisheries needs.

The Wyoming Game and Fish Commission approved a Mitigation Policy (Table 5) on September 28, 1985. This policy established mitigation categories, designation criteria, and mitigation objectives for fisheries habitat values that could be impacted by project development. If developed, this project should be built and operated in a manner that meets these objectives.

Table 5. Mitigation categories and descriptions, and mitigation objectives used by the WGFD for fisheries.

Mitigation Category	Description	Mitigation Objective
Irreplaceable	Endangered species Class 1 streams Critical Habitat	No loss of existing habitat value.
High	State rare or protected species Native game fish Class 2 streams Wild (native) or Trophy management concept	No net loss of in-kind habitat value.
Moderate	Non-native game fish Class 3 streams Wild (non-native) game fish and basic yield management concept	No net loss of habitat value while minimizing loss of in-kind habitat value.
Low	Non-game fish Class 4 and 5 streams Put-and-Take management concept	Minimize loss of habitat value.

The bypass section of the Salt River is designated as a Class 2 stream and supports populations of native game fish (Snake River cutthroat trout). The mitigation objective for this situation requires that the WGFD work toward ensuring that "no net loss of in-kind habitat value" results from this project.

Meeting the maintenance flow of 221 cfs through the bypass section will require that no diversion take place during those times of year when diverting flows would reduce discharge below 221 cfs. Data compiled by Peterson (1988) indicates that a discharge of 221 cfs is equalled or exceeded 100% of the time. However, to divert the full 240 cfs from the bypass reach, a flow of 461 cfs would be needed in order to meet the maintenance flow recommendation. This flow is equalled or exceeded between 75% and 80% of the time. Depending on the final analyses addressing impacts to trout production, the amount of time that flow recommendations are exceeded may vary.

SUMMARY

1) A Habitat Retention model indicates that a maintenance flow of 221 cfs would meet the hydraulic criteria important for maintaining trout populations, fish passage and aquatic insect survival.

2) Physical habitat for cutthroat trout and brown trout was simulated for different life stages at flows ranging from 150 cfs to 1000 cfs. Physical habitat increased with decreasing discharge for both species and all life stages, with physical habitat maximized at 150-200 cfs.

3) To maintain physical habitat in the bypass reach and to maintain important hydraulic criteria, the following preliminary flow recommendations for the bypass reach have been determined.

Time Period	Instream Flow Recommendation (cfs)
October 1 to March 31	221
April 1 to April 31	221
May 1 to June 30	221
July 1 to September 30	Undefined*

* Additional field studies necessary

4) Although analyses of physical habitat indicate that a flow of 221 cfs is adequate for the entire year, these analyses do not reflect the importance of biological parameters affecting trout production during the summer months (July 1 to September 30). For this reason, a flow of 221 cfs from July 1 to September 30 should be considered tentative and subject to revision pending further analyses.

5) It is unknown if the maintenance flow of 221 cfs will satisfy the WGFD mitigation objective for Class 2 streams because not all of the information necessary to determine "no net loss in habitat value" is available. Additional information required to fully estimate potential impacts (positive or negative) to fish populations in the bypass section includes seasonal population estimates, simulations of flow reduction impacts during the summer on resident trout production, and detailed project design and operation data.

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