WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Shell Creek Instream Flow Report, Segment Number 1

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INTRODUCTION

Data were collected during the 1985 field season to conduct instream flow analyses for a segment of Shell Creek located near Shell, Wyoming. The study and this report were prepared to support an instream flow water right application.

The goal of this study was to determine instream flows necessary to maintain or improve the existing trout fishery. The specific objectives of this study were to determine instream flows necessary to 1) maintain or improve hydraulic characteristics year-round that are important for survival of trout, fish passage and aquatic insect production, 2) maintain or improve physical habitat for rainbow trout spawning during the spring, and 3) maintain or improve adult trout production during the late summer months. Three habitat models were used to make these determinations.

METHODS

Study Area

The section of Shell Creek from Shell Falls upstream to the mouth of Adelaide Creek is considered a Class 3 trout stream by the Wyoming Game and Fish Department (WGFD). Trout stream classifications throughout Wyoming range from Class 1 (highest rating) to Class 5 (lowest rating). Class 3 trout streams are generally considered important trout fisheries on a regional basis within the state.

Shell Creek above Shell Falls contains naturally reproducing populations of rainbow trout (Oncorhynchus mykiss) and brook trout (Salvelinus fontinalis). The stream is currently managed as a basic yield fishery for the former species. This stream segment periodically receives plants of catchable rainbow trout. The entire segment of Shell Creek above Shell Falls is contained within the Big Horn National Forest and is highly accessible to the public. Because this section of Shell Creek supports an important trout fishery and has public access, the segment of Shell Creek from Shell Falls upstream to the mouth of Adelaide Creek was identified as a critical reach.

Data Collection

All of the field data used in this study were collected from a 310 foot long study site located within the Big Horn National Forest. This site is located approximately 15 miles east of the town of Shell (Figure 1). This was a fairly high gradient site that contained a combination of pool and riffle habitat for trout that was representative of trout habitat features found throughout this portion of the stream. Results and recommendations were applied to a portion of the stream extending from Shell Falls in Section 7, Township 53N, Range 89W upstream to the mouth of Adelaide Creek in the southeast 1/4 of Section 27, Township 53N, Range 88W. This is a distance of approximately 10.5 stream miles.

Models

A Habitat Retention Method (Nehring 1979; Annear and Conder 1984) was used to identify a maintenance flow. A maintenance flow is defined as a continuous flow that will maintain minimum hydraulic criteria at riffle areas in a stream segment. These criteria are important at all times of year to maintain passage between different habitat types for all life stages of trout. These criteria are also important for maintaining survival rates of fish and aquatic macroinvertebrates during the winter that approximate rates observed under natural stream flow conditions.

Data from single transects placed across three riffles within the study area were analyzed with the AVDEPTH computer program (Milhous et al. 1989). Flow data were collected at three different flow levels (Table 1). Based on extensive research on instream flow methods on Wyoming streams by Annear and Conder (1984), the maintenance flow is specifically defined as the discharge at which two of the three criteria in Table 2 are met for all riffles in the study area. Maintenance flows apply to all times of the year except when higher stream flows are required to meet other fishery management objectives.

Table 1. Dates and discharges when instream flow data were collected at Shell Creek instream flow segment.

Date	Discharge (cfs)
05-19-85	100
07-10-85	48
09-24-85	23

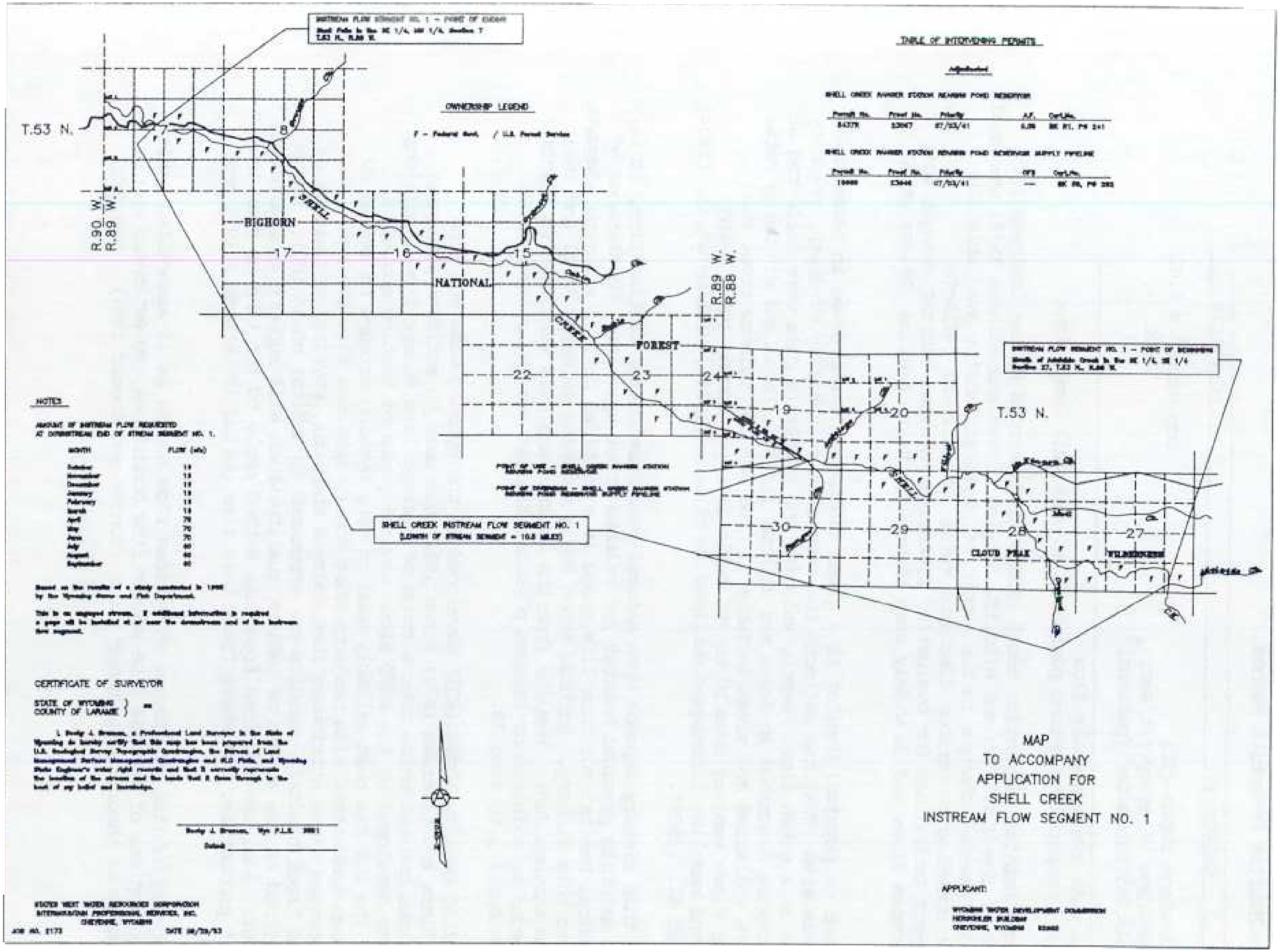

Figure 1 Shell Creek instream flow reach segment 1.

Table 2. Hydraulic criteria used to obtain an instream flow recommendation using the Habitat Retention Method.

Category	Criteria
Average Depth (ft)	Top width[1] x 0.01
Average Velocity (ft/sec)	1.00
Wetted Perimeter (percent)[2]	60

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

A physical habitat simulation model (PHABSIM) developed by the Instream Flow Service Group of the U.S. Fish and Wildlife Service (Bovee and Milhous 1978) was used to quantify incremental changes in the amount of physical habitat available for rainbow trout spawning at various discharge rates. This model reflects state-of-the-art technology for evaluating fisheries physical habitat changes with changes in stream flows and is widely used throughout North America (Reiser et al. 1989).

The amount of physical habitat 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. Depth, velocity and substrate data were collected at seven transects as described in Bovee and Milhous (1978). Dates and discharge rates when data were collected are given in Table 1. The WUA for rainbow trout was simulated for flows ranging from 10 to 300 cubic feet per second (cfs) using calibration and modeling techniques outlined in Milhous (1984), Milhous et al. (1984) and Milhous et al. (1989).

Because this fishery depends upon natural reproduction for continuation, it is important to maintain physical habitat for rainbow trout spawning. Maintenance of suitable physical habitat for this life stage is a critical part of ensuring adequate recruitment to this fishery. Rainbow trout begin spawning in early April and their eggs incubate through June. Results from the PHABSIM analysis were used to identify the flows needed to maintain or improve physical habitat for the rainbow trout spawning from April 1 to June 30.

The Habitat Quality Index (HQI) developed by the Wyoming Game and Fish Department (Binns and Eiserman 1979; Binns 1982) was used to estimate potential changes in trout habitat units over a range of average late summer flow conditions. This model was developed by the WGFD after several years of testing and model refinement. The HQI has been reliably used on many Wyoming streams to assess HU gains or losses associated with projects that modify instream flow regimes. This model incorporates seven attributes that address chemical, physical and biological components of trout habitat. Results are expressed in habitat units (HU). One HU is generally defined as the amount of habitat quality which will support approximately 1 pound of trout. Analyses obtained from this method apply to the time of year that governs trout production. On Shell Creek this time period is between July 1 and September 30.

By measuring habitat attributes at various flow events as if associated habitat features were typical of average late summer flow conditions, HU estimates can be made for a range of theoretical summer flows (Conder and Annear 1987). Habitat attributes on Shell Creek were measured on the same dates and flow levels that data were collected for the PHABSIM and Habitat Retention models (Table 1). To better define the relationship of discharge and trout production, some attributes were derived mathematically or obtained from existing gage data for flows in addition to those shown in Table 1. Other data were obtained from a U.S. Geological Survey gage (# 0627830) located on Shell Creek above Shell Creek Reservoir for the period 1957 to 1987.

RESULTS/DISCUSSION

Results from the Habitat Retention model showed that the hydraulic criteria in Table 2 are met at flows of 19, 13, and 4 cfs for riffles 1, 2, and 3, respectively (Table 3). The maintenance flow derived from this method is defined as the flow at which two of the three hydraulic criteria are met for all riffles in the study site which in this case is 19 cfs.

Table 3. Simulated hydraulic criteria for three riffles on Shell Creek. Estimated average daily flow = 57 cfs. Bank full discharge = 369 cfs.

Average Depth (ft)	Average Velocity (ft/sec)	Wetted Perimeter (ft)	Discharge (cfs)
	Riffle 1		
1.52	2.6	95.2	369
1.35	2.3	92.4	282
1.27	2.2	91.2	246
1.09	2.0	89.0	185
0.92	1.8	86.9	136
0.79	1.6	84.0	106
0.63	1.4	64.7	57
0.63	1.3	57.1[1]	48
0.56	1.0[1]	34.1	19[2]
0.45[1]	0.4	13.4	3
	Riffle 2		
2.32	3.9	48.7	369
2.16	3.3	45.6	286
2.03	2.8	43.0	215
1.80	2.3	42.4	158
1.57	1.9	41.7	113
1.38	1.6	41.2	84
1.17	1.3	40.2	57
1.00	1.0[1]	36.3	33
0.70	0.6	29.2[1]	13[2]
0.45[1]	0.31	18.2	3

Table 3. (continued)

Average Depth (ft)	Average Velocity (ft/sec)	Wetted Perimeter (ft)	Discharge (cfs)
	Riffle 3		
2.65	3.2	47.6	369
2.38	2.6	46.2	280
2.08	2.1	44.1	184
1.96	1.9	42.3	146
1.68	1.4	39.4	88
1.53	1.1	35.9	57
1.51	1.0[1]	34.4	50
1.16	0.6	32.7	23
0.54	0.2	28.6[1]	4[2]
0.45[1]	0.2	23.5	3

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

The maintenance flow is defined as a continuous flow that will maintain minimum hydraulic criteria in riffle areas within a stream segment. These criteria are important at all times of year to maintain passage between different habitat types for all life stages of trout. These criteria are also important for maintaining survival rates of fish and aquatic macroinvertebrates during the winter that approximate rates observed under natural stream flow conditions.

Low flow conditions during winter months (October through March) naturally limit the survival and growth of many trout populations. The extent of these impacts is dependent upon several factors including but not limited to snow fall, cold intensity and the duration of intense cold periods. These factors vary from year to year and affect fish populations depending on the amount of frazile ice and anchor ice formation (which can plug the gills of fish), the extent of snow bank collapse (and stream damming) and increased metabolic demands on fish (and increased stress).

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 trout and aquatic insect losses 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 causes of winter mortality discussed above are all greatly influenced by the quantity of winter flow in terms of its ability to minimize anchor ice formation (increased velocity and temperature loading) and dilute and prevent snow bank collapses and ice dam formation respectively. Any reduction of natural winter stream flows would increase trout mortality and effectively reduce the number of fish that the stream could support. Therefore protection of natural winter stream flows up to the recommended maintenance flow for each stream segment is necessary to maintain existing survival rates of trout populations.

It is possible that the discharge of 19 cfs identified by the Habitat Retention Method may not be present at times during the winter. Because the existing fishery is adapted to natural flow patterns, occasional periods of natural shortfall during the winter do not necessarily imply the need for additional storage. Instead, they illustrate the need to maintain all natural winter streamflows, up to 19 cfs, in order to maintain existing survival rates of trout populations.

Physical habitat for rainbow trout spawning is maximized at a discharge of 70 cfs (Figure 2). Gage data indicate that existing mean daily flows during the spring (April 1 to June 30) approximate 110 cfs. At this discharge, PHABSIM analyses indicate that physical habitat for rainbow trout spawning is reduced to 60% of the maximum amount available. Sharp reductions in WUA occur at flows below 70 cfs. Increases in discharge above the existing flow of 110 result in reductions in WUA from existing average levels. An instream flow of 70 cfs is therefore recommended for the period of April 1 and June 30 to improve physical habitat for rainbow trout spawning.

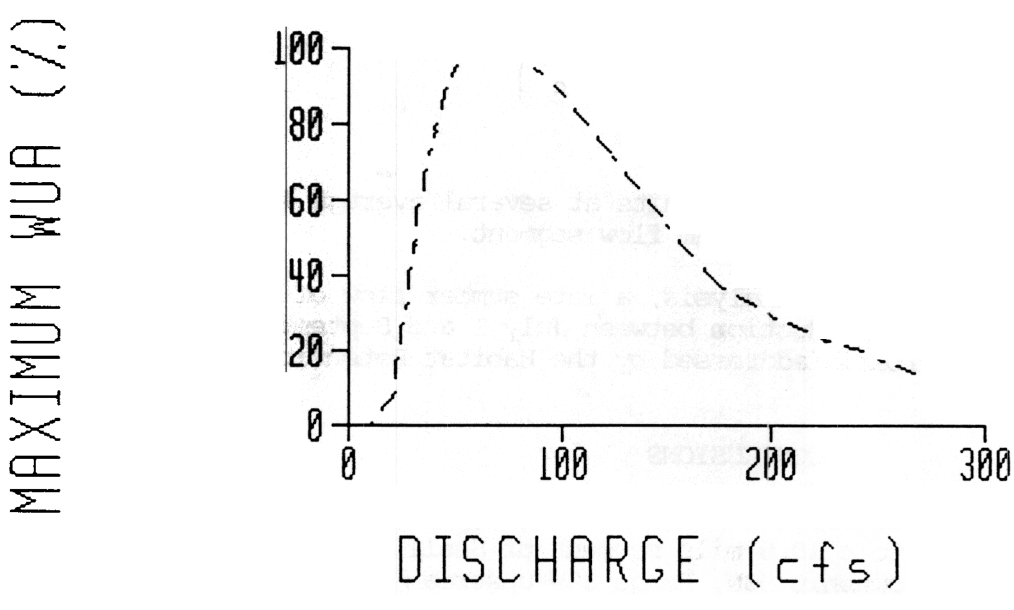

Figure 2. Percent of maximum weighted usable area for spawning life stage of rainbow trout.

Flows measured at the study site were regressed against flows determined at the USGS gage near Shell (#0627850) to determine average late summer flow levels at the study site. This regression indicated that late summer flows at the site approximate 53 cfs. Results from the HQI analyses (Figure 3) indicate that at a discharge of 53 cfs the stream presently supports about 80 HUs. The current fishery management objective is to maintain or improve the existing number of HUs. A discharge of 40 cfs is the minimum flow that will accomplish this objective. At average late summer flows below 40 cfs, the model indicates that reductions in the present fishery would occur. These reductions would largely be the result of reduced critical period stream flows. Artificial increases in stream flow to 60 cfs or higher would also result in reductions of trout HUs over present conditions.

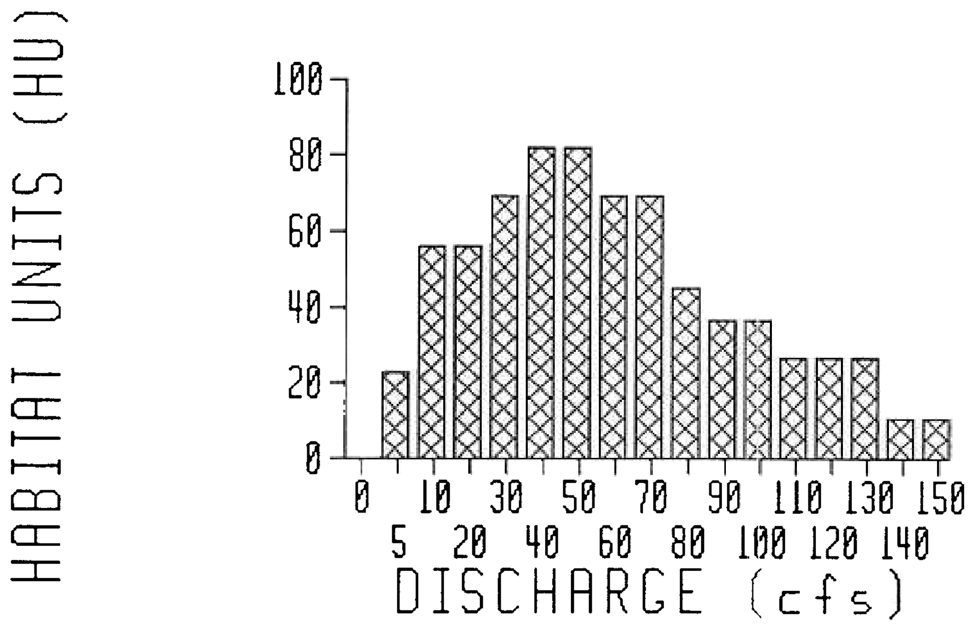

Figure 3. Number of potential trout habitat units at several average late summer flow levels in Shell Creek instream flow segment.

Based on the results from the HQI analysis, a late summer flow of 40 cfs will maintain existing levels of trout production between July 1 and September 30 and will meet or exceed the hydraulic criteria addressed by the Habitat Retention Method.

CONCLUSIONS

Based on the analyses and results contained in this report, the instream flow recommendations (Table 4) apply to a 10.5 mile segment of Shell Creek extending from Shell Falls in Section 7, Township 53N, Range 89W upstream to the mouth of Adelaide Creek in the southeast 1/4 of Section 27, Township 53N, Range 88W.

This analysis does not consider flushing flow needs for maintenance of channel geomorphology and trout habitat characteristics. Because this stream is presently unregulated, flushing flow needs are adequately met by natural runoff patterns. If the stream is regulated in the future, additional studies and recommendations may be appropriate for establishing flushing flow needs for channel maintenance.

Table 4. Summary of instream flow recommendations to maintain the existing trout fishery in Shell Creek above Shell Falls.

Time Period	Instream Flow Recommendation (cfs)
October 1 to March 31	19[1]
April 1 to June 30	70
July 1 to September 30	40

1 - To maintain existing natural stream flows

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