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REPORT

ON THE FEASIBILITY OF

PROVIDING INSTREAM FLOW

IN SEGMENT NUMBER ONE OF THE

TONGUE RIVER

WYOMING WATER DEVELOPMENT COMMISSION

JANUARY, 1988

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REPORT
ON THE FEASIBILITY OF PROVIDING INSTREAM FLOW IN SEGMENT NUMBER ONE OF THE TONGUE RIVER

Wyoming Water Development Commission
January, 1988

Summary

As required by W.S. 41-3-1004(a), the Wyoming Water Development Commission has completed a determination of the feasibility of providing various amounts of unappropriated direct flow in a segment of the Tongue River. The Wyoming Game and Fish Department (WG&F) has requested a direct flow water right for 60 cubic feet per second (cfs) during the months of July through March, 80 cfs during April and 180 cfs for May and June for the purpose of instream flow for fisheries in the Tongue River.

Instream Flow Segment Number 1 of the Tongue River is defined by an upstream point located at the confluence of the North and South Forks of the Tongue River, Section 22, Township 56 North, Range 88 West and a downstream point located where the river crosses the east section line of Section 10, Township 56 North, Range 87 West, a stream length of 8.28 miles, all in Sheridan County, Wyoming. The segment location is shown in Figure 1.

A monthly flow analysis and a daily flow exceedence analysis were conducted. The monthly flow analysis showed that the requested flows of 80 cfs during April and 180 cfs during May and June are available as direct flow during an average year. The requested flow of 60 cfs is available as direct flow during July through December, but is not available during January through March of the average year. The daily flow analysis indicates that, on the average, the requested instream flows are equalled or exceeded at least 50 percent of the days during May through March, but only 38 percent of the days during April.

There are no existing reservoirs located upstream of the segment that are large enough to supply the missing flows. In addition, the Wyoming Game and Fish Department has stated that it is not their intention to cause a reservoir to be constructed in order to supply the missing flows that occur from January through April of the average year. Therefore, if a reservoir is constructed by others in a location upstream of Instream Flow Segment Number 1, then the Wyoming Game and Fish Department should consider participation in the funding and operation of the reservoir.

Water Rights

Tables 1 and 2 list all water rights and permits that are located upstream of the downstream end of the instream flow segment. Table 1 lists direct flow water rights and permits. Table 2 lists the water rights and permits for reservoirs located within the drainage area upstream of the instream flow segment. The total annual storage in these reservoirs is 390.3 acre-feet. This amount is less than one percent of the total annual runoff at the downstream end of the segment and is therefore considered to be insignificant in the estimation of water available for instream flow.

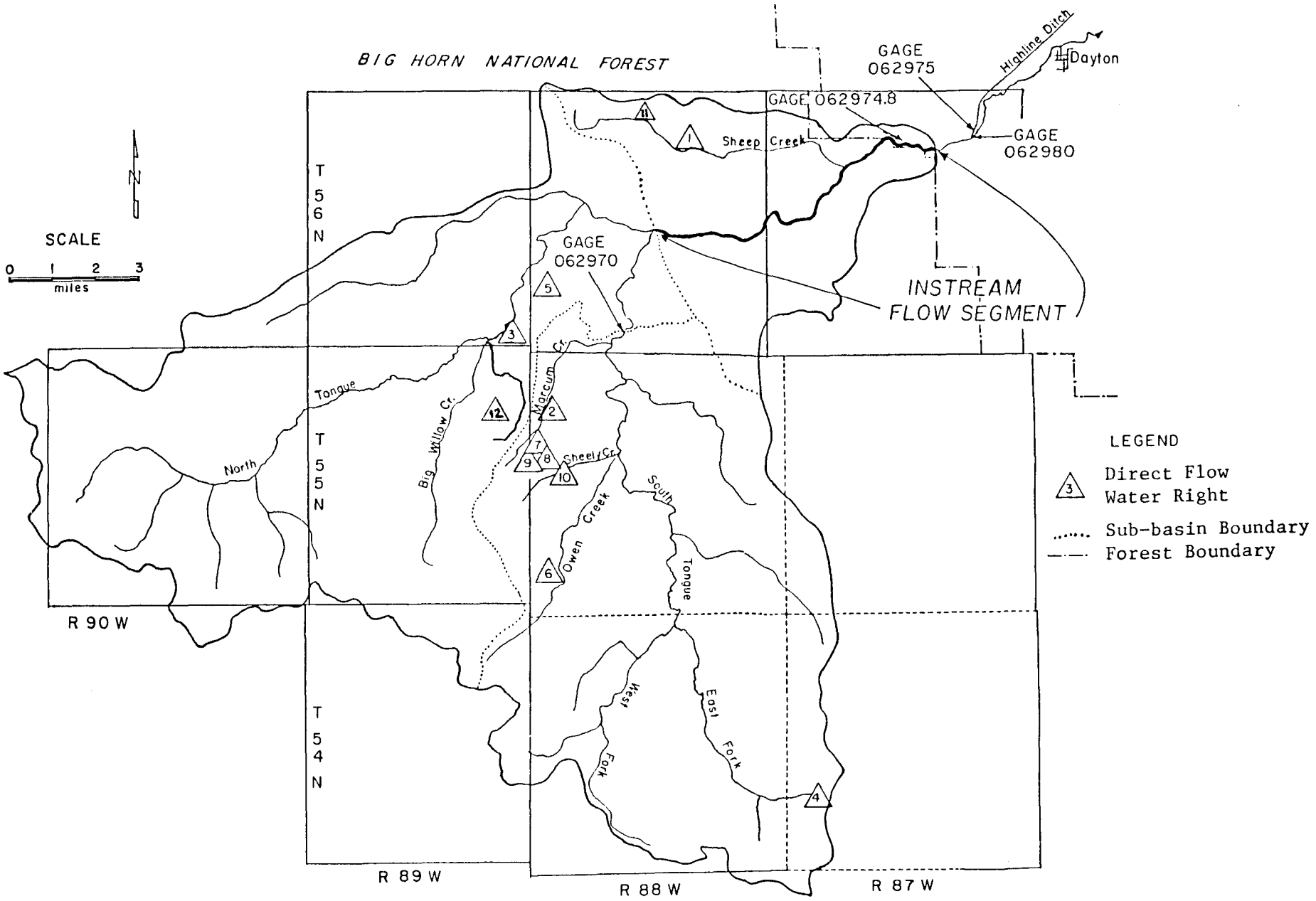


FIGURE 1. Map of the Tongue River Instream Flow Segment No. 1

Table 1. Direct Flow Water Rights and Permits Located Upstream of Instream Flow Segment No. 1 of the Tongue River as of September, 1987

MAP NUMBER (Fig.1)	PERMIT NUMBER	FACILITY	SOURCE	PRIORITY DATE			AMOUNT	USES		DIVERSION LOCATION			ADJ/ UNADJ	2 TIMES PRE-3/1/1985 IRR. RIGHTS	NON-IRRIG DIVERSIONS
				MONTH	DAY	YEAR	(cfs)	IRR.	CONTINUOUS	SEC	TNSHP	RNG			
11	2748	Eureka Ditch	Sheep Creek	7	20	1900	6.86	1		4	56	88	ADJ	13.72	0.00
10	3420	Star Ditch	South Mill Creek	8	20	1901	0.87	1		18	55	88	ADJ	1.74	0.00
12	3421	Little Willow	Little Willow Creek	9	14	1901	1.35	1		12	55	89	ADJ	2.70	0.00
2	3422	Star No. 2 Ditch	Marcum or Mill Cr.	9	14	1901	1.02	1		7	55	88	ADJ	2.04	0.00
11	2288E	Enl. Eureka	Sheep Creek	8	31	1910	3.28	1		4	56	88	ADJ	6.56	0.00
1	12158	Eureka Supply	South Sheep Creek	12	8	1913	2.14	1		10	56	88	ADJ	4.28	0.00
11	15518	Eureka Ditch	Freezeout Creek	7	12	1919	Sup. Sup.	1		11	56	88	ADJ	Sup. Sup.	0.00
3	19611	Swim N. Fk. CG.	Big Willow Creek	7	3	1941	Supply-5432R		2	36	56	89	UNADJ	0.00	Res. Sup.
5	22158	Twin Buttes Pipe	Twin Buttes Spring	7	28	1960	0.10		2	30	56	88	ADJ	0.00	0.10
4	22083	Tongue Divide	East Fk of South Fk	9	6	1960	3.00		2	29	54	87	ADJ	0.00	3.00
6	22339	Owen Ck CG Pipe	Owen Creek	12	7	1962	0.11		2	30	55	88	UNADJ	0.00	0.11
7	23360	Hanft Pipeline	Marcum or Mill Cr.	3	26	1969	0.10		2 3	18	55	88	ADJ	0.00	0.10
4	6490E	P.K. Enl. Tongue	South Prong No. 1	1	16	1974	Sup. Sup.	1		29	54	87	ADJ	Sup. Sup.	0.00
8	24824	Pump Point	Sheely Creek	9	3	1975	0.22		4	18	55	88	UNADJ	0.00	0.22
9	29347	ElkHorn Pipe	Marcum or Mill Cr.	1	14	1986	0.06		2	18	55	88	UNADJ	0.00	0.06

Max Irrigation Diversions= 31.04 CFS

Key to Uses:
1 = Irrigation
2 = Domestic
3 = Stock
4 = Highway Department

Non Irrigation Diversions = 3.58 CFS

Total Diversions = 34.62 CFS

Table 2. Reservoir Water Rights and Permits Located Upstream of Instream Flow Segment No. 1 of the Tongue River as of September, 1987

RESERVOIR PERMIT NUMBER	FACILITY	SOURCE	PRIORITY DATE			AMOUNT (ac-ft)	WATER USE	DIVERSION LOCATION			ADJ/ UNADJ
			MONTH	DAY	YEAR			SEC	TNSHP	RNG	
4853 R	Sibley Reservoir	Prune Creek	1	31	1938	379.28	I,S,F,D,R	10	55	88	ADJ
5432 R	N. Fork Swimming	Big Willow Creek	7	3	1941	0.24	S,D,F	36	56	89	ADJ
5439 R	Rearing Pond	Compartment Creek	7	3	1941	0.88	S,D,F	5	54	88	ADJ
5440 R	Rearing Pond	Marcum or Mill Creek	7	3	1941	0.81	S,D,F	6	55	88	ADJ
5444 R	Rearing Pond	Sheely Creek	7	3	1941	0.45	I,S,F,D	17	55	88	ADJ
5445 R	S. Fork Swimming	Marcum or Mill Creek	7	3	1941	0.30	S,D,F	32	56	88	ADJ
5448 R	Little Willow Res.	Little Willow Creek	7	3	1941	1.28	I,S,F,D,R	1	55	89	ADJ
5462 R	Rearing Pond 1	Burgess Gulch	7	3	1941	0.41	S,D,F	36	56	89	ADJ
5463 R	Rearing Pond 2	Burgess Gulch	7	3	1941	0.10	F	36	56	89	ADJ
6474 R	Evans Pond	Big Willow Creek	8	20	1958	0.53	R	1	55	89	UNADJ
8248 SR	Lackman #2	Lackman Draw	5	20	1977	0.61	S	15	55	88	ADJ
9263 SR	Top Reservoir	Spring Creek	6	6	1983	0.77	S	31	55	89	ADJ
9264 SR	Middle Res.	Spring Creek	6	6	1983	0.77	S	30	55	89	ADJ
9265 SR	Wallrock Res.	Wallrock Creek	6	6	1983	0.77	S	24	55	91	ADJ
9346 SR	Sucker Res.	Sucker Draw	3	5	1984	0.77	S	28	55	90	ADJ
9347 SR	West Trail Res.	West Trail Creek	3	5	1984	0.77	S	20	55	90	ADJ
9348 SR	W Wallrock Res.	West Fk. Wallrock Cr.	3	5	1984	0.77	S	18	55	90	ADJ
9349 SR	Maybe Res.	Stone Draw	3	5	1984	0.77	S	35	55	90	ADJ
					Total	390.28 acre-feet					

Key to uses

S = Stock
D = Domestic
F = Fish
R = Recreation
I = Irrigation

It is assumed that the streamflow gaging records discussed later reflect the diversions of the upstream water rights listed in Tables 1 and 2. Since instream flow water rights are non-consumptive, existing and future diversions downstream of the segment will not be affected by the instream flow segment. The Highline Ditch diversion is located within one mile of the downstream end. Although this ditch is important in the hydrologic analysis, the users of the ditch will not be impacted by the instream flow segment.

Flow Records

Four U.S. Geological Survey streamflow gaging stations were used to estimate the flows in the instream flow segment. Gage 062970 (South Fork Tongue River near Dayton, Wyoming) is located about three miles upstream from the segment and has a period of record of 1945 to 1973. Located downstream of the segment, Gages 062975 (Highline Ditch near Dayton, Wyoming) and 062980 (Tongue River near Dayton, Wyoming) have both been in operation, at least sporadically, since 1920 and are still operating. Since all water that exits Box Canyon must flow past one of these two gages, both gages are important in the hydrologic analysis. Gage 062974.8 (Tongue River at Tongue Canyon Campground near Dayton, Wyoming) was operational from 1975 through 1979 to measure changes in the river flow due to the Madison limestone formation.

Information for all of the streamflow gages used in this report are listed in Table 3.

Hydrology

A hydrologic analysis was conducted to estimate flowrates for the upstream and downstream ends of the instream flow segment. Computed mean annual flows for the drainage basin were found using USGS Water Resources Investigations 76-112, Techniques for Estimating Flow Characteristics of Wyoming Streams. The computed mean annual flows (Q_a) were obtained using the Basin-Characteristics method with mean basin elevation (E) and drainage area (A) as variables in the formula for Region 1 (mountainous region):

$$Q_a = 0.0036A^{0.96}E^{2.57}$$

where E is in thousands of feet and A is in square miles.

Table 3 lists the results of the mean annual flow computations and compares the computed values with actual mean annual flows from data for gages 062970 and 062980.

The Tongue River crosses the Madison Formation near the downstream end of the segment. Records for 1975 through 1977 from three gages were used to estimate flow changes across the formation. Gage 062980 is located one mile downstream from the downstream end of the segment. Gage 062975 measures the flowrate in the Highline Ditch whose diversion point is located between gage 062980 and the end of the segment (see Figure 1). Gage 062974.8 is located at the beginning of the Madison outcrop approximately one mile upstream from the downstream end of the segment. The sum of flows in the Highline Ditch and gage 062980 should roughly equal the flow at gage 062974.8. Any difference could be attributed to the Madison Formation. Of the three years of data, the river gained flow two years and lost flow one year. The monthly differences over the

Table 3. Streamflow Gaging Station Information and Characteristics of Gaged Basins

Gage Number	Gage Name	Gage Location	Period of Record	Actual Mean Annual Flow (cfs)	Drainage Area (Square Miles)	Mean Basin Elevation (Feet)	Computed Mean Annual Flow Qa (cfs) *	Percent Difference in Mean Annual Flows	Number of Direct Diversions Above Gage
062970.0	South (Fork) Tongue River, near Dayton, WY	SE1/4 SW1/4 NE1/4 Sec.33, T56N, R88W	1945-1973	79.0	85	8736	67	14.9%	7
062974.8	Tongue River at Tongue Canyon CG.,near Dayton,WY	SE1/4 NE1/4 NW1/4 Sec.10, T56N, R87W	1975-1979	213.0	202	8489	N/A	N/A	10
062975.0	Highline Ditch, near Dayton, WY	NE1/4 NE1/4 Sec.11, T56N, R87W	1920-1985 **	6.8	N/A	N/A	N/A	N/A	N/A
062980.0	Tongue River, near Dayton, WY	NE1/4 NE1/4 NE1/4 Sec.11, T56N, R87W	1919-1986 ***	186.3	204	8489	145	22.3%	10

* Computed using the Basin-Characteristics Method
** No data for 1924-1940, 1942, 1978-1979, data also missing in portions of other years
*** No data for 1930-1940

Table 4. Estimation of Flows at the Upstream End of Instream Flow Segment No. 1 of the Tongue River

	Average Year Case						Dry Year Case				
	Computed Mean Annual Flow Qa (cfs)	Actual Mean at Gages (cfs)	Ratio of Actual to Computed Mean	Average of Ratios	Adjusted Mean Annual Flow at Upstream End (cfs)	Adjusted Mean Annual Volume at Upstream End (ac-ft)	Actual Mean at Gages (cfs)	Ratio of Actual to Computed Means	Average of Ratios	Adjusted Mean Annual Flow at Upstream End (cfs)	Adjusted Mean Annual Volume at Upstream End (ac-ft)
Downstream End (Gages 062980 and 062975)	145 *	193 **	1.33				117 ***	0.81			
Upstream End	135	....	....	1.26	169	122,670	....	....	0.72	98	70,797
South Fork (Gage 062970)	67 *	79	1.18				43	0.64			

* From Table 3
** Equals sum of actual average case mean annual flows at gages 062980 and 062975
*** Equals sum of actual 1960 mean annual flows at gages 062980 and 062975

three year period are inconsistent as far as gains and losses and are small compared to the flow in the river. Therefore, the effects of the Madison Formation are not considered further in this report.

Since there are no actual flow measurements at the upstream end of the segment, the mean annual flowrate (Q_a) at the upstream end was estimated using the Basin-Characteristics method and compensating to match actual data. To achieve this, the formula on page 5 was first used to obtain a computed mean annual flowrate of 135 cfs for the basin located above the upstream end which has a drainage area of 175 square miles and a mean elevation of 8736 feet. Then, a computed Q_a was found for the downstream end as well as for the drainage area of the South Fork at gage 062970. Actual means from gage records were then divided by the computed means to obtain ratios as listed in Table 4.

The average of the ratios at gage 062970 and combined gages 062980/062975 was applied to the Q_a value calculated for the upstream end of the segment. This compensation resulted in an estimation of the average year case mean annual flow of 169 cfs at the upstream end of the instream flow segment after adjusting to match actual data at nearby gages. In the case of the driest year of record, 1960, the estimated mean annual flow at the upstream end was 98 cfs.

Monthly Flow Analysis

Mean monthly flows for the average year case are listed in Table 5. Mean monthly flows at the upstream end were estimated by distributing the mean annual flow from Table 4 across the twelve months according to the mean of the monthly-to-annual ratios at gages 062970 (South Fork) and 062980 (Tongue River). Mean monthly flows at the downstream end were obtained by adding mean monthly flows from actual data at gages 062980 (Tongue River) and 062975 (Highline Ditch). Figure 2 is a bar graph showing the average year case mean monthly flows at the upstream and downstream ends of the segment as well as the requested instream flow.

Mean monthly flows for the dry year case (1960) are listed in Table 6. The last column in Tables 5 and 6 list the shortfalls of monthly flow computed by subtracting the requested instream flow (column L) from the flows in column K. Shortfalls occur during January, February and March of the average and dry year cases.

Since it is assumed that the gage records reflect recent water use, the water rights in Table 1 and 2 were not subtracted from the mean monthly flows. These water rights are senior to the instream flow permit and, according to Wyoming prior appropriations water law, will not be damaged by the instream flow permit.

Daily Flow Exceedence Analysis

A daily flow analysis was conducted to determine the feasibility of using direct flow to meet the WG&F criteria of 50 percent exceedence of the requested 60 cfs during the months of July through September. A daily flow analysis was also conducted for the other three month groups for informational purposes. Table 7 summarizes the daily flow exceedence analysis.

Table 5. Computations of Mean Monthly Flows and Shortfalls for Average Year Case, Tongue River Instream Flow Segment No. 1

	A	B	C	D	E	F	G	H	I	J	K	L	M
	Gage 062980 Tongue River Near Dayton 1919-86			Gage 062970 South Fork Tongue River Near Dayton, 1945-73			Flow at Upstream End of Segment						
Month	Mean Monthly Flow at Gage (cfs)	Mean Monthly Volume at Gage (ac-ft)	Monthly as Percent of Annual Volume	Mean Monthly Flow at Gage (cfs)	Mean Monthly Volume at Gage (ac-ft)	Monthly as Percent of Annual Volume	Average Percent at gages 062980 & 062970	Distribute Mean Annual Flow Qa (cfs)	Mean Monthly Flow (cfs)	Mean Monthly Flow at Gage 062975 Highline Ditch (cfs)	Flow at Downstream End of Segment (A + J) (cfs)	Requested Instream Flow at Downstream End (cfs)	Shortfall at Downstream End (cfs)
Oct	83.6	5,143	3.8%	25.9	1,591	2.8%	3.3%	4,019	66.6	7.0	90.6	60	0
Nov	68.9	4,099	3.0%	20.1	1,195	2.1%	2.6%	3,125	51.8	0.4	69.3	60	0
Dec	62.0	3,815	2.8%	17.6	1,084	1.9%	2.4%	2,879	47.7	0.1	62.1	60	0
Jan	56.6	3,481	2.6%	14.6	899	1.6%	2.1%	2,530	41.9	0.0	56.6	60	3.4 **
Feb	53.4	3,069	2.3%	12.9	743	1.3%	1.8%	2,178	36.1	0.0	53.4	60	6.6 **
Mar	52.3	3,216	2.4%	12.5	772	1.3%	1.9%	2,276	37.7	0.0	52.3	60	7.7 **
Apr	106.8	6,356	4.7%	29.0	1,724	3.0%	3.9%	4,708	78.0	0.2	107.0	80	0
May	537.0	33,018	24.5%	240.5	14,788	25.8%	25.2%	30,672	508.4	5.4	542.4	180	0
June	743.4	44,234	32.8%	383.4	22,814	39.9%	36.3%	44,290	734.1	15.2	758.6	180	0
July	261.4	16,076	11.9%	112.9	6,940	12.1%	12.0%	14,657	242.9	10.5	279.9	60	0
Aug	116.9	7,187	5.3%	44.7	2,749	4.8%	5.1%	6,176	102.4	10.9	135.8	60	0
Sept	87.3	5,194	3.9%	32.1	1,912	3.3%	3.6%	4,384	72.7	15.3	102.6	60	0
		134,888	100.0%		57,210	100.0%		122,670 *					

* From Table 4
** Total annual shortfall = 1049 acre-feet

FIGURE 2. MEAN MONTHLY FLOWS AND REQUESTED

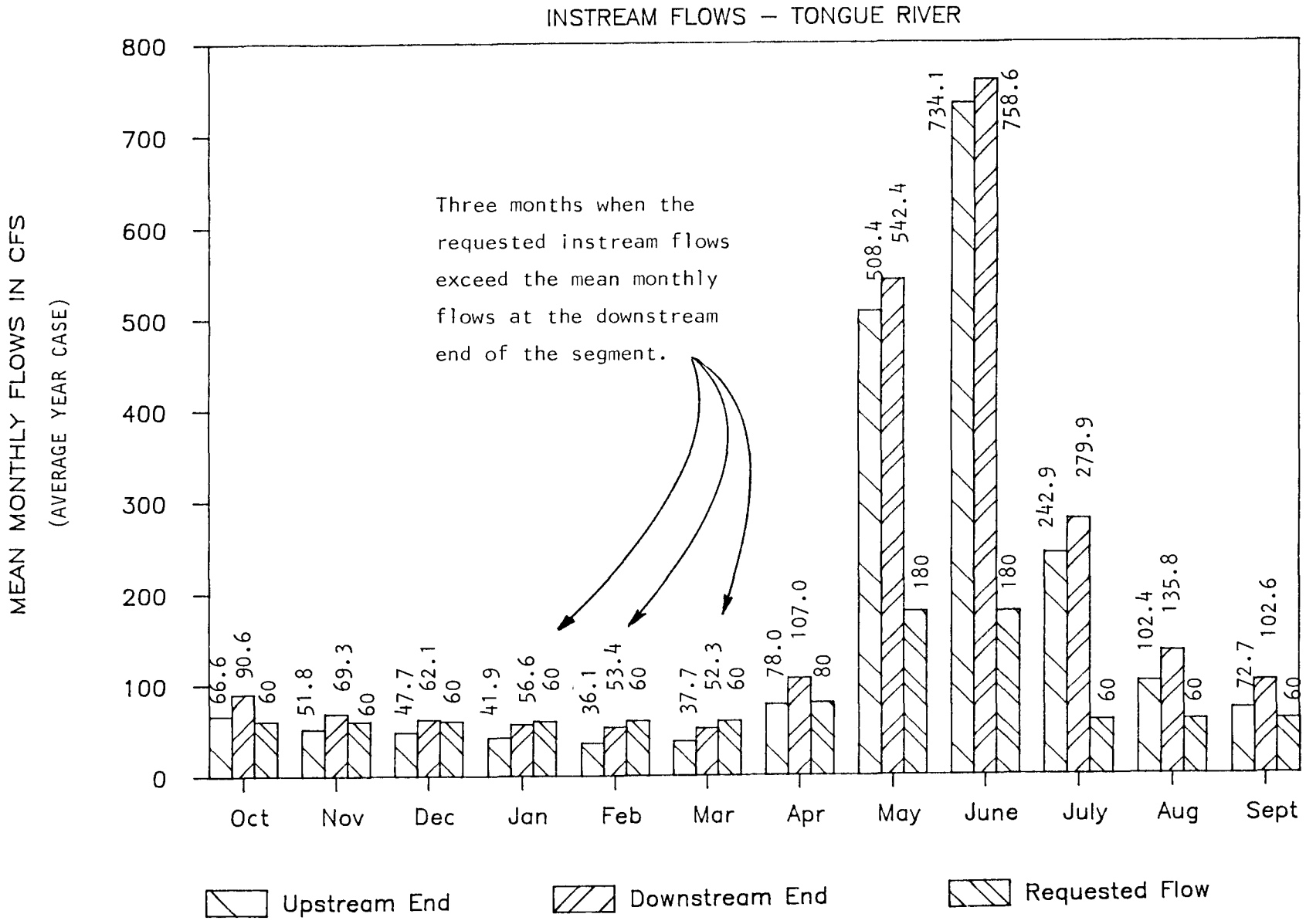


Table 6. Computations of Mean Monthly Flows and Shortfalls for Driest Year Case (1960), Tongue River Instream Flow Segment No. 1

	A	B	C	D	E	F	G	H	I	J	K	L	M
	Gage 062980 Tongue River Near Dayton 1960			Gage 062970 South Fork Tongue River Near Dayton, 1960			Flow at Upstream End of Segment			Mean Monthly Flow at Gage 062975 Highline Ditch (cfs)	Flow at Downstream End of Segment (A + J) (cfs)	Requested Instream Flow at Downstream End (cfs)	Shortfall at Downstream End (cfs)
Month	Mean Monthly Flow at Gage (cfs)	Mean Monthly Volume at Gage (ac-ft)	Monthly as Percent of Annual Volume	Mean Monthly Flow at Gage (cfs)	Mean Monthly Volume at Gage (ac-ft)	Monthly as Percent of Annual Volume	Average Percent at gages 062980 & 062970	Distribute Mean Annual Flow Qa (cfs)	Mean Monthly Flow (cfs)				
Oct	73.1	4,490	5.7%	22.4	1,370	4.3%	5.0%	3,504	58.1	11.52	84.6	60	0
Nov	65.2	3,880	4.9%	21.6	1,290	4.0%	4.5%	3,144	52.1	0.0	65.2	60	0
Dec	63.9	3,930	5.0%	22.7	1,400	4.4%	4.7%	3,287	54.5	0.0	63.9	60	0
Jan	56.3	3,460	4.4%	16.3	1,000	3.1%	3.8%	2,640	43.7	0.0	56.3	60	3.7 **
Feb	48.8	2,800	3.6%	10.3	592	1.8%	2.7%	1,899	31.5	0.0	48.8	60	11.2 **
Mar	57.9	3,560	4.5%	9.8	601	1.9%	3.2%	2,248	37.3	0.0	57.9	60	2.1 **
Apr	104.9	6,240	7.9%	31.8	1,890	5.9%	6.9%	4,855	80.5	0.0	104.9	80	0
May	290.0	17,830	22.7%	129.4	7,950	24.7%	23.7%	16,658	276.1	12.32	302.3	180	0
June	291.7	17,360	22.1%	163.2	9,710	30.2%	26.2%	18,371	304.5	23.77	315.5	180	0
July	120.8	7,430	9.5%	54.1	3,330	10.4%	9.9%	6,960	115.4	19.35	140.2	60	0
Aug	67.5	4,150	5.3%	29.0	1,780	5.5%	5.4%	3,800	63.0	19.06	86.6	60	0
Sept	57.0	3,390	4.3%	20.4	1,210	3.8%	4.0%	2,838	47.0	13.51	70.5	60	0
		78,520	100.0%		32,123	100.0%	100.0%	70,797					

* From Table 4
** Total annual shortfall = 978 acre-feet

Table 7. Summary of Daily Flow Exceedence Analysis, Tongue River

Month-Group	Requested Instream Flow (cfs)	Corresponding Flow at Gage 062980 (cfs)	WG&F Exceedence Criteria	Exceedence During Period of Record of Gage 062980
Oct-March	60	59	N/A	57.5%
April	80	80	N/A	38.4%
May-June	180	170	N/A	91.3%
July-Sept	60	43	50%	99.2%

Daily flow duration statistics for gaging station 062980 were obtained for four month groups; October through March, April, May through June, and July through September. Since the Highline Ditch diversion point is located between the downstream end of the instream flow segment and gage 062980, the Highline Ditch flow must be subtracted from the requested flow to give a corresponding flow at gage 062980.

Tables 8, 9, 10 and 11 were used to estimate the percent exceedence. Interpolation in Table 8 shows that the corresponding gage flow of 59 cfs was equalled or exceeded 57.5% of the days in October through March during the period of record of gage 062980. Similarly, interpolation in Tables 9 and 10 show that the corresponding gage flow of 80 cfs was equalled or exceeded 38.4 percent of the days in April and the corresponding flow of 170 cfs was equalled or exceeded 91.3 percent of the days for May through June. Also, interpolation in Table 11 shows that the corresponding flow of 43 cfs was equalled or exceeded 99.2 percent of the days for July through September during the period of record.

The WG&F criteria of a minimum of 50 percent exceedence during July through September is satisfied by direct flow.

Conclusions

In conclusion, the monthly flow analysis (using actual gage records in the vicinity) indicates that direct flows in Tongue River Instream Flow Segment No. 1 are sufficient to meet the requested instream flows only nine months of the year. The three months of January, February and March fall short of meeting the requested instream flow. Also, the daily flow analysis indicates that the requested flow of 80 cfs during April is available only 38 percent of the days during April.

The possibility of changing the operation of existing reservoirs upstream of the segment to compensate for the shortfalls was studied. Sibley Lake is the best possibility but it is too small to provide the missing flow. Although the feasibility of constructing a new reservoir to compensate for the shortage of direct flows during January through April was not studied, it is reasonable to assume that it is not economically feasible to construct a reservoir for the sole purpose of instream flow. However, if and when a reservoir is constructed upstream of the instream flow segment, the Wyoming Game and Fish Department may wish to propose participation in the funding and operation of the new reservoir.

TONGUE RIVER NEAR DAYTON, WYOMING — STATION NO. 062980.00
LATITUDE 44-50-58 LONGITUDE 107-18-14 NE1/4NE1/4NE1/4 SECTION 11 TOWNSHIP 56 N,RANGE 87 W 6TH P.M.
ELEVATION 4360.00 FT DRAINAGE AREA 204.00 SQ MI NONCONTRIBUTING 0.00 SQ MI BASIN C5C4C00C
SHERIDAN COUNTY DATA FROM USGS (P)

CLASS	SIZE* cfs	TOTAL DAYS	ACCUM DAYS	PERCENT	SIZE/DA	SIZE/MEAN
1	10.0	0.	9841.	100.00	.05	.16
2	15.0	1.	9841.	100.00	.07	.24
3	20.0	3.	9840.	99.99	.10	.32
4	25.0	7.	9837.	99.96	.12	.40
5	30.0	251.	9830.	99.89	.15	.48
6	40.0	1735.	9579.	97.34	.20	.64
7	50.0	6079.	7844.	79.71	.25	.80
8	75.0	1343.	1765.	17.94	.37	1.19
9	100.0	363.	422.	4.29	.49	1.59
10	150.0	33.	59.	.60	.74	2.39
11	200.0	7.	26.	.26	.98	3.18
12	250.0	4.	19.	.19	1.23	3.98
13	300.0	14.	15.	.15	1.47	4.78
14	400.0	1.	1.	.01	1.96	6.37
15	500.0	0.	0.	0.00	2.45	7.96
16	750.0	0.	0.	0.00	3.68	11.94
17	1000.0	0.	0.	0.00	4.90	15.92

59 > 57.5% <

* Each class size represents the lower limit of the flow range.

Table 8. Daily flow duration statistics for the months of October through March during the period of record of 1919 through 1986 at Gage 062980. (from Wyoming Water Research Center DURCUR Program)

TONGUE RIVER NEAR DAYTON, WYOMING — STATION NO. 062980.00
LATITUDE 44-50-58 LONGITUDE 107-18-14 NE1/4NE1/4NE1/4 SECTION 11 TOWNSHIP 55 N, RANGE 87 W 6TH P.M.
ELEVATION 4050.00 FT DRAINAGE AREA 204.00 SQ MI NONCONTRIBUTING 0.00 SQ MI BASIN DESCRIPTION
SHERIDAN COUNTY DATA FROM USGS (P)

CLASS	SIZE* cfs	TOTAL DAYS	ACCUM DAYS	PERCENT	SIZE/DA	SIZE/MEAN
1	10.0	0.	1680.	100.00	.05	.09
2	15.0	0.	1680.	100.00	.07	.14
3	20.0	3.	1680.	100.00	.10	.19
4	25.0	2.	1677.	99.82	.12	.23
5	30.0	15.	1675.	99.70	.15	.28
6	40.0	212.	1660.	98.81	.20	.37
7	50.0	744.	1448.	86.19	.25	.47
8	75.0	296.	704.	41.90	.37	.70
9	100.0	173.	408.	24.29	.49	.94
10	150.0	51.	235.	13.99	.74	1.41
11	200.0	44.	184.	10.95	.98	1.87
12	250.0	34.	140.	8.33	1.23	2.34
13	300.0	48.	106.	6.31	1.47	2.81
14	400.0	23.	58.	3.45	1.96	3.75
15	500.0	27.	35.	2.08	2.45	4.68
16	750.0	6.	8.	.48	3.68	7.03
17	1000.0	2.	2.	.12	4.90	9.37
18	1500.0	0.	0.	0.00	7.35	14.05
19	2000.0	0.	0.	0.00	9.80	18.74
20	2500.0	0.	0.	0.00	12.25	23.42
21	3000.0	0.	0.	0.00	14.71	28.10
22	4000.0	0.	0.	0.00	19.61	37.47
23	5000.0	0.	0.	0.00	24.51	46.84
24	7500.0	0.	0.	0.00	36.76	70.26
25	10000.0	0.	0.	0.00	49.02	93.68

80 — 38.4

* Each class size represents the lower limit of the flow range.

Table 9. Daily flow duration statistics for the month of April during the period of record of 1919 through 1986 at Gage 062980. (from Wyoming Water Research Center DURCUR Program)

TONGUE RIVER NEAR DAYTON, WYOMING — STATION NO. 062980.00
LATITUDE 44-50-58 LONGITUDE 107-18-14 NE1/4NE1/4NE1/4 SECTION 11 TOWNSHIP 56 N, RANGE 87 W 6TH P.M.
ELEVATION 4060.00 FT DRAINAGE AREA 204.00 SQ MI NONCONTRIBUTING 0.00 SQ MI BASIN 05C6C000
SHERIDAN COUNTY DATA FROM USGS (B)

CLASS	SIZE* cfs	TOTAL DAYS	ACCUM DAYS	PERCENT	SIZE/DA	SIZE/MEAN
1	10.0	0.	3416.	100.00	.05	.02
2	15.0	0.	3416.	100.00	.07	.02
3	20.0	0.	3416.	100.00	.10	.03
4	25.0	0.	3416.	100.00	.12	.04
5	30.0	0.	3416.	100.00	.15	.05
6	40.0	1.	3416.	100.00	.20	.06
7	50.0	33.	3415.	99.97	.25	.08
8	75.0	39.	3382.	99.00	.37	.12
9	100.0	154.	3343.	97.86	.49	.16
10	150.0	174.	3189.	93.35	.74	.24
11	200.0	159.	3015.	88.26	.98	.31
12	250.0	179.	2856.	83.61	1.23	.39
13	300.0	374.	2677.	78.37	1.47	.47
14	400.0	364.	2303.	67.42	1.96	.63
15	500.0	784.	1939.	56.76	2.45	.78
16	750.0	533.	1155.	33.81	3.68	1.18
17	1000.0	515.	622.	18.21	4.90	1.57
18	1500.0	92.	107.	3.13	7.35	2.35
19	2000.0	13.	15.	.44	9.80	3.13
20	2500.0	2.	2.	.06	12.25	3.92
21	3000.0	0.	0.	0.00	14.71	4.70
22	4000.0	0.	0.	0.00	19.61	6.27
23	5000.0	0.	0.	0.00	24.51	7.84
24	7500.0	0.	0.	0.00	36.76	11.75
25	10000.0	0.	0.	0.00	49.02	15.67

170 / 91.3%

* Each class size represents the lower limit of the flow range.

Table 10. Daily flow duration statistics for the months of May and June during the period of record of 1919 through 1986 at Gage 062980. (from Wyoming Water Research Center DURCUR Program)

TONGUE RIVER NEAR DAYTON, WYOMING — STATION NO. 062980.00
LATITUDE 44-50-58 LONGITUDE 107-18-14 NE1/4NE1/4NE1/4 SECTION 11 TOWNSHIP 56 N.RANGE 87 W 6TH P.M.
ELEVATION 4060.00 FT DRAINAGE AREA 204.00 SQ MI NONCONTRIBUTING 0.00 SQ MI BASIN 06040000
SHERIDAN COUNTY DATA FROM USGS (P)

CLASS	SIZE* cfs	TOTAL DAYS	ACCUM DAYS	PERCENT	SIZE/DA	SIZE/MEAN
1	10.0	0.	5152.	100.00	.05	.06
2	15.0	0.	5152.	100.00	.07	.10
3	20.0	0.	5152.	100.00	.10	.13
4	25.0	0.	5152.	100.00	.12	.16
5	30.0	16.	5152.	100.00	.15	.19
6	40.0	83.	5136.	99.69	.20	.26
7	50.0	897.	5053.	98.08	.25	.32
8	75.0	1000.	4156.	80.67	.37	.48
9	100.0	1405.	3156.	61.26	.49	.64
10	150.0	681.	1751.	33.99	.74	.96
11	200.0	372.	1070.	20.77	.98	1.28
12	250.0	192.	698.	13.55	1.23	1.60
13	300.0	250.	506.	9.82	1.47	1.92
14	400.0	110.	256.	4.97	1.96	2.56
15	500.0	116.	146.	2.83	2.45	3.21
16	750.0	20.	30.	.58	3.68	4.81
17	1000.0	8.	10.	.19	4.90	6.41
18	1500.0	2.	2.	.04	7.35	9.62
19	2000.0	0.	0.	0.00	9.80	12.82
20	2500.0	0.	0.	0.00	12.25	16.03
21	3000.0	0.	0.	0.00	14.71	19.24
22	4000.0	0.	0.	0.00	19.61	25.65
23	5000.0	0.	0.	0.00	24.51	32.06
24	7500.0	0.	0.	0.00	36.76	48.09
25	10000.0	0.	0.	0.00	49.02	64.12

43 / 99.2%

* Each class size represents the lower limit of the flow range.

Table 11. Daily flow duration statistics for the months of July through September during the period of record of 1919 through 1986 at Gage 062980. (from Wyoming Water Research Center DURCUR Program)

A P P E N D I X

THE STATE OF WYOMING

MIKE SULLIVAN
GOVERNOR

Game and Fish Department

June 11, 1987

BILL MORRIS
DIRECTOR

Mr. Michael Purcell, Director
Wyoming Water Development Commission
Herschler Building
Cheyenne, Wyoming 82002

Dear Mr. Purcell:

Enclosed find the completed instream flow right application for an 8.28 mile segment of the Tongue River in Johnson County. A seasonally adjusted direct flow right of 60 cfs from July 1 to March 31, 80 cfs from April 1 to April 30 and 180 cfs from May 1 to June 30 is requested.

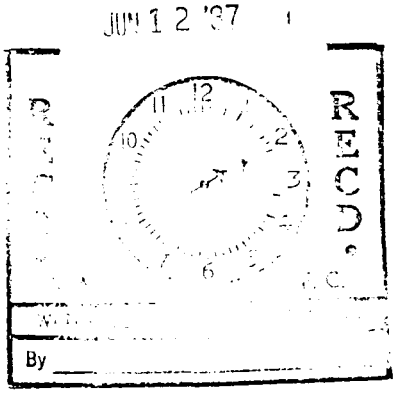
Please note that we do not feel storage is necessary to provide continuous, adequate flows between October 1 and June 30 even though flows equal to those requested in this application may not naturally be available on occasion during this period. Refer to previous letters regarding instream flow applications for the Clark's Fork and Middle Fork to assist you in determining the feasibility of this application.

If you have any questions regarding this application, please do not hesitate to contact my office.

Sincerely,

Bill Morris
Director

BM/TA/kw
Enclosure
cc: State Engineer's Office
Game and Fish Commissioners
Fish Division
John Mueller



Form S.W. 1
Rev. 10-85

NOTE: Do not fold this form. Use typewriter or print neatly with black ink.

STATE OF WYOMING

OFFICE OF THE STATE ENGINEER

APPLICATION FOR PERMIT TO APPROPRIATE SURFACE WATER

THIS SECTION IS NOT TO BE FILLED IN BY APPLICANT

Filing/Priority Date

THE STATE OF WYOMING, STATE ENGINEER'S OFFICE } SS.

This instrument was received and filed for record on the _____ day of _____, A.D. 19 ____, at _____ o'clock _____ M.

_____
State Engineer

Recorded in Book _____ of Ditch Permits, on Page _____.

Fee Paid $_____. Map Filed _____

WATER DIVISION NO. _____ DISTRICT NO. _____ Temp. Filing No. _____

PERMIT NO. _____

NAME OF FACILITY Tongue River - Instream Flow 1

1. Name(s), mailing address and phone no. of applicant(s) is/are Wyoming Water Development Commission, Herschler Building, Cheyenne, Wyoming, 82002

(If more than one applicant, designate one to act as Agent for the others)

2. Name & address of agent to receive correspondence and notices Francis Petera, Wyoming Game & Fish Department 5400 Bishop Blvd. Cheyenne, WY & Michael Purcell, WWDC, Herschler Building, Cheyenne, WY

3. (a) The use to which the water is to be applied is Instream Flow

(b) If more than one beneficial use of water is applied for, the location and ownership of the point of use must be shown in item 10 of the application and the details of the facilities used to divert and convey the appropriation must be shown on the map in sufficient detail to allow the State Engineer to establish the amount of appropriation. In multiple use applications, stock and domestic purposes are limited to 0.056 cubic feet per second.

4. The source of the proposed appropriation is Tongue River

5. The instream flow segment extends from the confluence of the North & South Forks of the Tongue River in the NE1/4, NW1/4 corner of Section 22 T. 56 N., R. 88 W., downstream to the East sec. line of Section 10 T. 56 N., R. 87 W. length of stream approximately 8.28 miles

6. Are any of the lands crossed by the proposed facility owned by the State or Federal Government? If so, describe lands and indicate whether State or Federally owned.

All lands crossed by this stream segment are owned by the State of Wyoming and the U.S. Department of Agriculture and the U.S. Forest Service.

7. The carrying capacity of the ditch, canal, pipeline or other facility at the point of diversion is downstream the reach (see remarks) cubic feet per second.

8. The accompanying map is prepared in accordance with the State Engineer's Manual of Regulations and Instructions for filing applications and is hereby declared a part of this application. The State Engineer may require the filing of detailed construction plans.

9. The estimated time required for the commencement of work is 30, for completion of construction is 30, and to complete the applicaton of water to the beneficial uses stated in this application is 30.

Permit No. _____ Page No. _____ (Leave Blank)

10. The land to be irrigated under this permit is described in the following tabulation. (Give irrigable acreage in each 40-acre subdivision. Designate ownership of land. Federal, State or private. If private, list names of owners and land owned separately.) If application is for stock, domestic, or for purposes other than irrigation, indicate point of use by 40-acre subdivision and owner.

			NE ¼				NW ¼				SW ¼				SE ¼				
Township	Range	Sec.	NE ¼	NW ¼	SW ¼	SE ¼	NE ¼	NW ¼	SW ¼	SE ¼	NE ¼	NW ¼	SW ¼	SE ¼	NE ¼	NW ¼	SW ¼	SE ¼	TOTALS
56	88	22	X	X		X	X												
56	88	23	X	X	X	X			X	X									
56	88	24	X		X	X	X	X	X	X									
56	87	19						X											
56	87	18									X	X	X	X			X	X	
56	87	17	X	X	X					X	X	X	X						
56	87	8													X			X	
56	87	9	Lot 1	X	X					X	X	X							
56	87	4																X	
56	87	10	X	X		X	X	X											
56	87	3											X						
			All of the above land which the stream flows through																
			are owned by the State of Wyoming, the U.S. Department																
			of Agriculture and the U.S. Forest Service.																

Number of acres to receive original supply _____

Number of acres to receive supplemental supply _____

Total number of acres to be irrigated _____

REMARKS

MONTHLY INSTREAM FLOW REQUESTED*

Month	Flow (cfs)
Oct	60
Nov	60
Dec	60
Jan	60
Feb	60
Mar	60
Apr	80
May	180
June	180
Jul	60
Aug	60
Sept	60

Based on the results of a study conducted by the Wyoming Game & Fish Department (attached) an instream flow water right of 60 cfs is requested from July 1 to March 31 to maintain summer production levels and winter survival rates of the existing trout fishery. An instream flow water right of 80 cfs is requested from April 1 to April 30 to improve rainbow trout spawning habitat and a water right of 180 cfs is requested from May 1 to June 30 to improve incubation conditions for rainbow trout.

The length of the stream segment is 8.28 miles.

Intervening Ditches - none

*Location of instream flow control gage: Existing U.S. Geological Survey Gage in the NE1/4 of Section 11, T. 56 N., R. 87 W.

Under penalties of perjury, I declare that I have examined this application and to the best of my knowledge and belief it is true, correct and complete.

Michael L. Russell
Signature of Applicant or Agent

6/15/87
Date

WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Tongue River Instream Flow Report

PROJECT: Contract No. YA-512-CT9-226

AUTHOR: Thomas C. Annear and Allen L. Conder

DATE: June 1987

Studies were conducted during the 1981 field season to obtain instream flow information from a portion of the Tongue River near the town of Dayton. The studies were designed to provide results which could be used to determine instream flow needs for trout as well as to evaluate potential flow-related impacts of future water development activities.

METHODS

All of the field data used in this study were collected from a 326 foot long study site located on State property in the northeast corner of Section 10, Township 56 North, Range 87 West. This site 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 the confluence of the North and South Forks of the Tongue River in the NW1/4 of S22 , T56N, R88W downstream to the east section line of Section 10, T56N, R87W. This is a distance of approximately 8.3 stream miles.

A physical habitat simulation (PHABSIM) model developed by the Instream Flow Service Group of the U. S. Fish and Wildlife Service (USFWS) (Bovee and Milhous 1978) was used to identify incremental changes in the amount of physical habitat (usable area) for rainbow trout spawning and incubation habitat with changes in flow. Data were collected at six transects which were placed across each habitat type within the study segment. Velocities and depths were measured at 1 to 2 foot intervals across each transect during 3 different flow events (Table 1). These data permitted simulation of physical habitat over a range of flows between 30 and 500 cfs.

Table 1. Dates and discharges when instream flow data were collected.

Date	Discharge (cfs)
07-08-81	205
08-05-81	105
09-15-81	75

The Habitat Retention method (Nehring 1979) was used to identify a flow for maintaining adequate levels of aquatic insect production and fish passage through riffle areas. Data from single transects placed across three riffles within the study area were analyzed using the IFG-1 computer program (Milhous 1979). Flow data were collected on the same dates that PHABSIM data were collected (Table 1). The instream flow recommendation for this method was determined by identifying the discharge at which two of the three hydraulic criteria in Table 2 were met at all riffle cross sections in the study segment.

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

Category	Criteria
Average Depth (ft)	Top width * 0.01
Average Velocity (ft per sec)	1.00
Wetted Perimeter (percent)*	70

* - Compared to wetted perimeter at bank full conditions.

The Habitat Quality Index (HQI) developed by the Wyoming Game and Fish Department (Binns and Eiserman 1978) was used to estimate potential changes in trout standing crops over a range of late summer flow conditions. This model incorporates seven attributes that address chemical, physical as well as biological components of trout habitat. Results are expressed in habitat units (HU) per acre. Analyses obtained from this method apply primarily to the time of year that governs trout production. On the Tongue River 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 late summer flow conditions, HU estimates can be made for a range of theoretical summer flows. Habitat attributes on the Tongue were measured on the same dates and at the flow levels that data were collected for the PHABSIM and Habitat Retention models (Table 1). To better define the potential impact of other, lower late summer flow conditions on the existing stream fishery, some attributes were derived mathematically or obtained from existing gage data for flows lower than those which were measured. Gage data were

obtained from a U. S. Geological Survey gage located near the downstream end of the instream flow segment for the period of 1919 to 1980.

Results from the HQI and Habitat Retention models were combined to identify the flow needed to maintain existing levels of trout production between July 1 and September 30. Results from the Habitat Retention model were used to identify a flow from October 1 to March 31 which would maintain or improve trout survival. Results from the PHABSIM model for spawning and incubation life stages were used to identify flows which would improve rainbow trout reproductive success. Rainbow trout generally spawn in April and their eggs hatch in June. The spawning flow recommendation therefore applies to the period from April 1 to April 30 and the incubation flow recommendation applies to the period between May 1 and June 30.

RESULTS

Results from the Habitat Retention model showed that flows of 59, 52 and 48 cfs are necessary to maintain aquatic insect production and fish passage at riffles 1, 2 and 3 respectively (Appendix A). 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 59 cfs.

Results from the HQI analyses (Figure 1) indicate that trout densities in this portion of the Tongue would be maximized at an average late summer flow of approximately 100 cfs. Gage data from the U. S. Geological Survey gage near the study site show that the lowest average monthly flow for late summer occurs in September and is approximately 90 cfs. The trout fishery in this stream segment is adapted to this flow regime and the stream presently provides between 155 and 183 HU's per acre. The density of trout would be only slightly reduced at a flow of 60 cfs in late summer; however, at lower flows significant reductions in the fishery would likely occur. These reductions would largely be the result of lower critical period flow, higher annual flow variation and higher stream water temperatures.

Based on the results of the above two models, an instream flow of 60 cfs is recommended to maintain existing levels of trout production between July 1 and September 30.

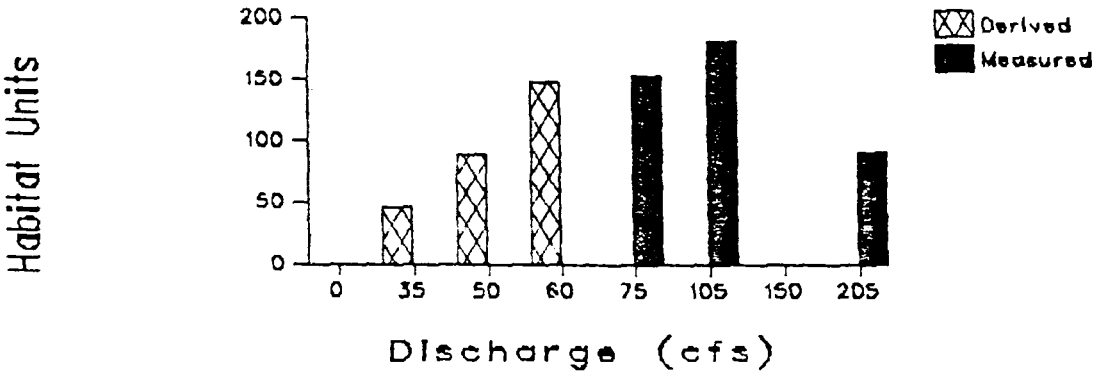


Figure 1. Number of potential trout habitat units at several late summer flow levels in the Tongue River.

It is a well documented fact that substantial losses of wild trout occur in the winter, particularly in relatively high elevation streams like the Tongue River. 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 Green River in Wyoming. Needham et al. (1945) documented overwinter losses of brown trout ranging up to 85 percent and averaging over 60 percent 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 to be the primary causes of trout winter mortality. These studies were all conducted on unregulated streams and illustrate the severe conditions that trout are exposed to naturally during the winter.

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. The fishery management objective for the time period from October 1 to March 31 is subsequently to protect all available natural stream flows in the instream flow segment.

The Habitat Retention method was developed to identify a flow that would provide adequate survival of aquatic insects in riffle areas and provide passage for trout between different habitat types in the stream. Maintenance of these features is important year round and as a consequence, the previously identified flow (60 cfs) that will maintain these features during

free-flowing conditions (when ice is not on the stream) also applies to the period between October 1 and March 31. Natural, undepleted flows during this time period that are less than 60 cfs will maintain trout survival at its current level since the existing trout population has evolved under these conditions. Stream flows greater than the winter survival maintenance flow will increase trout survival.

Preliminary analyses indicate that the recommended winter instream flow is not available naturally on occasion in the portion of the Tongue addressed by these studies. This does not indicate a need for storage to provide the recommended flow but instead shows that the entire available natural flow (up to 60 cfs) is needed through the winter to maintain trout survival at its present level.

Results from the PHABSIM model for rainbow trout spawning and incubation habitat (Figure 2) show that flows of 80 and 180 cfs respectively would provide the maximum amount of usable area for these life stages. Natural flows during the period when rainbow trout spawn are significantly greater than these flows under normal conditions. Although the present flow regime provides adequate recruitment to support the existing stream fishery, reductions in flow to 80 cfs from April 1 to April 30 and 180 cfs from May 1 to June 30 would improve spawning success and standing crop of rainbow trout in the stream.

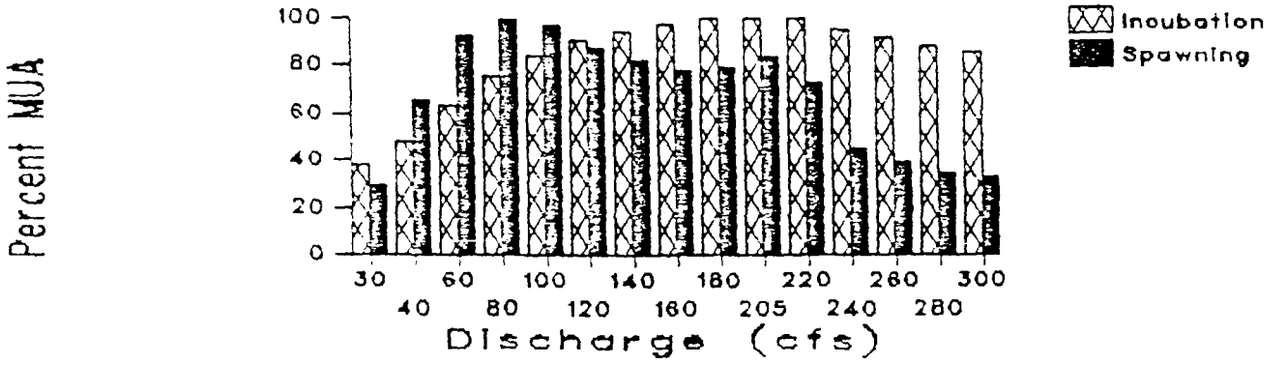


Figure 2. Percent of maximum usable area (MUA) for spawning and incubation life stages of rainbow trout.

CONCLUSIONS

Based on the analyses and results contained in this report, the instream flow recommendations in Table 3 apply to an 8.3 mile segment of the Tongue River extending downstream from the confluence of the North and South Forks of the Tongue River to the east section line of Section 10, T56N, R87W.

Table 3. Summary of instream flow recommendations for the Tongue River.

Time Period	Instream Flow Recommendation (cfs)
July 1 to September 30	60*
October 1 to March 31	60**
April 1 to April 30	80**
May 1 to June 30	180**

* Feasibility determined by availability at least 50 percent of this time period

** To maintain existing natural flows up to the specified amount

LITERATURE CITED

Bovee, K. and R. Milhous. 1978. Hydraulic simulation in instream flow studies: theory and technique. Instream Flow Information Paper 5. FWS/OBS 78/33. Cooperative Instream Flow Service Group, U.S. Fish and Wildlife Service. Fort Collins CO.

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APPENDIX A

Simulated hydraulic criteria for three riffles on the Tongue River.

Riffle 1

Average Depth (ft)	Average Velocity (ft/sec)	Wetted Perimeter (percent)	Discharge (cfs)
1.39*	0.47	67.2	27.8
1.47	0.55	68.2	34.8
1.51	0.59	68.6	38.8
1.56	0.64	68.9	43.2
1.60	0.64	69.3	47.9
1.68	0.79	70.0*	58.8**
1.77	0.91	70.7	71.7
1.85	1.04*	71.2	86.8

Riffle 2

0.75*	0.69	56.1	21.3
0.83	0.78	57.6	27.1
0.86	0.87	62.4	34.1
0.93	0.96	64.5	42.3
1.00	1.07*	66.5	52.0**
1.09	1.18	67.0	63.2
1.16	1.29	68.9	76.0
1.23	1.42	70.7*	90.6

Riffle 3

0.38	1.01*	35.2	10.3
0.55	1.18	47.4	22.8
0.61	1.24	50.8	28.4
0.65	1.29	56.3	34.7
0.72	1.34	59.1	41.8
0.77*	1.38	61.5	48.4**
0.84	1.45	65.0	58.4
0.98	1.57	70.0*	78.5

* - Minimum hydraulic criteria met
** - Maintenance flow