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Streamflow Needs of Rare and Endangered Fishes:
Yampa River Interim Flow Recommendations

FINAL REPORT

by

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Introduction

The Green River basin is the last remaining stronghold of the Colorado squawfish (Ptychocheilus lucius) and the razorback sucker (Xyrauchen texanus) in native riverine environments. It also supports populations of the humpback chub (Gila cypha) and is a recommended recovery area for the bonytail chub (Gila elegans). Flows of the Yampa River, last free-flowing river containing endangered fish habitat in the Upper Colorado River Basin, are considered critical to the maintenance of usable fish habitat of rare and endangered fishes (Figure 1) in the Green River basin (reviewed by Tyus and Karp 1989).

Typical flows in the Yampa River begin to rise from winter baseflows in late March and continue to rise through May. The annual peak at Deerlodge Park usually occurs during the end of May and continues into the first week of June. Peak flows at Deerlodge Park typically range from 7,748 to 20,476 cfs (75-25% exceedence values), and the lowest peak flow recorded was 3,821 cfs, and the highest was 33,200 cfs (1977 and 1984, respectively). In early to mid-June flows begin a steady decline through August, subside to base flows in September and continue at baseflow through the remainder of the year. The lowest base flow recorded at Deerlodge Park was 43 cfs on September 5 and 6, 1988.

The Recovery Implementation Program (RIP), a cooperative effort between Federal and State governments, water and power users, and conservationists (U.S. Fish and Wildlife Service 1987), outlined procedures to protect four rare and endangered fishes in the Upper Colorado River Basin. One of these is the provision and maintenance of instream flows at certain times, locations, and quantities, as necessary. The Yampa River was subsequently identified by the cooperators as the highest priority area for investigating opportunities to acquire instream water rights for the endangered fishes. A three-step process was recommended to quantify the flow need of the fish in the Yampa River: (1) an evaluation of habitat use, potential limiting factors, and general flow needs relative to the maintenance and recovery of the endangered fishes and supporting aquatic habitat; (2) quantification based on the best available information and knowledge of the identified flow needs with respect to the quantity, duration, and timing of flows; and (3) identification of future studies necessary to refine or corroborate existing flow recommendations developed in Step 2 above. Step 1 has been accomplished with a 1989 publication "Habitat use and streamflow needs of rare and endangered fishes, Yampa River, Colorado" (Tyus and Karp 1989). This report provides Step 2 by providing interim flow recommendations which are based on our best available data and understanding of the Yampa River system and the needs of the fishes in question.

Stream-flow needs of native fishes in the Yampa River are influenced by many factors including time of year, life history stage, and flow requirements of sympatric species. Reproductive activities of the target fishes, (i.e., Colorado squawfish, razorback sucker, and humpback chub) are closely associated with flow, temperature and other parameters associated with normal spring runoff conditions. Alteration of this hydrologic event may affect initiation of Colorado squawfish and razorback sucker migrations, and spawning of these and other native fishes, including bluehead (Catostomus discobolus) and flannelmouth (C. latipinnis) suckers. Maintenance of low, stable flows in late summer and fall is conducive to growth and survival of young Colorado squawfish, and young of other species as well. Stable winter flows through ice breakup are considered important to overwinter survival of young and adults in some locations. Abrupt fluctuations of water level from late summer to spring could strand larvae, stress adults, and influence reproduction. Life histories of target fishes are associated with natural flow events that comprise the Yampa River hydrograph.

Quantification of Instream Flows

The Service, and others, have expended substantial amounts of time and manpower in making instream flow recommendations using physical simulations of habitats, in developing temperature and flow models, in analyzing stream sediment-water flow relationships using historic and current flow patterns, and others. Physical modelling to date has not demonstrated predictive capability relative to cause-effect relationship with the distribution and abundance of the endangered fishes in the Green River basin (Rose and Hahn 1989). This is attributed to the variability of the environment (e.g. seasonal fluctuations in discharge, temperature, food base, species abundance, etc.) and interactions among environmental variables; logistical problems associated with studying fishes in large, turbid rivers; changing environmental conditions during study periods; and the introductions of nonnative fishes. In addition, where physical habitats have been measured, their use by the fish may only reflect temporary, seasonal, or marginal habitat use. Thus, caution must be exercised in determining flow requirements of fishes in decline. Ecological data and professional judgement must be recognized as critical in interpreting fish requirements in complex systems.

Flow recommendations to provide needed habitat and to satisfy life history requirements of endangered fishes in the Yampa-Green River system must be approached with great caution. Decline of the Colorado squawfish in other rivers of the upper basin apparently continues, as evidenced by very low numbers of young fish, and failure in detecting spawning areas. Recruitment of the razorback sucker is not sufficient to sustain the species anywhere at this time, but higher numbers of the fish, and the identification of two spawning areas in the Yampa and Green rivers offer some promise for recovery. Experimentation with flows to which the endangered fishes may not respond favorably should be conducted elsewhere; not in the Yampa River. A reduction in the 1989 year-class of Colorado squawfish in the upper Green River suggests that additional factors may influence successful recruitment in this species even if flow conditions in nursery habitats are presumably adequate. This is indicative of the precarious existence of the endangered Colorado River fishes.

Provision of sufficient water quantity and timing of flows delivered to certain river locations are considered of utmost importance for recovery of endangered fishes in the Yampa River. Delineation of critical river reaches are presented in Table 1. The following briefly reviews the needs of the endangered fishes (for further detail see Tyus and Karp 1989) by season (Julian dates represent the onset and end of each season). Because life history and flow requirements do not change precisely with Julian defined seasons, actual interim flow recommendations are made on a monthly basis (Table 2). Mean monthly flows hide the variability inherent in the natural river system and are used only to identify water volumes. The 50% exceedence flows (equalled or exceeded 50% of the time - see example Flow Duration Curve in Figure 2), which correlate closely with average monthly flows for the period of record, are presented in Table 2 and Figure 2. Flow events considered important toward recovery of the rare Colorado River fishes in the Yampa and Green rivers are presented. In making its recommendation, the Service recognized that protection of a single species or life history stage does not adequately protect all species, because each has different requirements for survival.

1. Spring (March 21-June 21)

<u>Colorado squawfish</u>

The reproductive cycle in Colorado squawfish presumably begins soon after spawning, but gonadal activity increases in spring in response to endogenous and exogenous factors. In early spring, adults move into flooded or protected areas where they feed and ostensibly prepare for spawning. Annual spawning migrations are associated with high spring flows, and on the average, radiotagged adults in the Yampa River initiated migrations with flows ranging from about 4,200 cfs to 8500 cfs (Tyus and Karp 1989). Spring migrations were also associated with increasing water temperatures that exceeded about 14C (range 9.2-19.4C), and a long period of daylight (summer solstice, June 19). These relationships are similar in the Green River as well, and chemical imputs from flooded lands, and other cues may act in concert or in sequence with flows, temperatures, and photoperiod to influence timing of the spawning migrations. Spawning of Colorado squawfish in the Yampa River, 1981-1988 occurred about 26 days (range 17-33 d) after the start of spawning migrations, with minimum water temperatures of 19C and maximum temperatures of 24C. Spawning generally occurred earlier in low water years and later in high water years--presumably in response to changes in the annual distribution hydrograph. Although all of the environmental conditions required in the spawning reaches remain unknown, some requirements include cleaning and preparation of cobble beds, and formation of eddy habitats used by staging fish. In addition, high spring flows mobilize and deliver sediment downstream, creating and maintaining nursery habitats in the Green River.

<u>Razorback sucker</u>

Reproduction of the razorback sucker is not well understood with respect to riverine conditions needed for migration cues, vitellogenesis, final maturation, egg deposition, and larval survival. However, spawning in the lower Yampa and upper Green rivers (1975, 1981, 1988 and 1989) occurred with increasing flows and temperatures associated with highest spring runoff (average 14C, range 9-17C). Curtailment of high spring flows in the Green

River due to operations of Flaming Gorge Dam may be associated with a loss of effective recruitment to the juvenile stage. Normal seasonal inundation of low-lying lands provides a food base for adults and may be important for future dispersal and rearing of young. Unless higher, warmer flows can be released from Flaming Gorge Dam than are presently occurring with current operations, such seasonal flooding can only be accomplished by flows of the Yampa River.

Humpback chub

Spawning of humpback chub occurred shortly after highest spring discharge at temperatures of about 19.5C (range 14.5-23C) in 1987-1989. These flows are also important to promote development of shoreline eddy habitat used by the fish, and deepening of habitats used later in the year. Interspecific hybridization between chubs may result from alterations of historic conditions during spawning.

Spring recommendations

Spawning migrations of Colorado squawfish and razorback suckers require free channel access in their occupied Yampa River range. Uninterrupted flow (no stream blockage without proven fish passage capabilities) should be maintained in the Yampa River from its mouth to Craig, Colorado.

Spring peak flows are associated with reproduction of all the target fish species, and this occurs with ascending (razorback sucker), peak (Colorado squawfish), and descending (humpback chub and Colorado squawfish) flows. Spring peak flows of the Yampa River provide seasonal bottomland habitats, and maintain Colorado squawfish nursery habitats. The loss of razorback sucker recruitment may be related to a reduction of flooded lands. Because all approved projects in the Yampa River are not yet fully operational, it is anticipated that some additional change in these flows and associated effects on the aquatic environment will occur as the environmental baseline flows are implemented. The environmental baseline includes all existing projects, and all projects which have received favorable opinions under Section 7 consultation but are not yet operating (Table 3). Loss of natural spring peaks due to flow regulations were associated with decline or loss of native fish populations in the upper Green, San Juan, and lower Colorado rivers.

High flows are also implicated in restricting the growth of the introduced salt cedar (Tamarix ramosissima), an exotic plant that competes with native riparian vegetation (e.g., cottonwood and willow) and alters important riparian habitat via shoreline stabilization. Changes brought by this plant are not conducive to providing good humpback chub spawning habitat. There is also evidence that high spring flows limit the proliferation of fish species introduced from more mesic environments, while little affecting the more adapted native fish community.

High spring flows mobilize sediments that are delivered to downstream areas, and provide the basis for creating nursery habitat for Colorado squawfish in the upper Green River. Native fishes are adapted to this high sediment load, and the resultant turbidity presumably reduces the efficiency of more visually dependent predators, such as northern pike and walleye.

Protecting what remains of the best habitat conditions for the rare fishes in the Yampa River basin during the Spring may be achieved by not further altering the magnitude, frequency, duration, or timing of spring flows as described under current environmental baseline conditions (Table 2). Major deviations from the current environmental baseline flows will likely eliminate any hope for recovery and maintenance of the rare fishes in the Yampa and Green River basins. The Yampa-Green ecosystem constitutes the best remaining riverine habitat for Colorado squawfish and razorback sucker. Caution was exercised in providing flow recommendations for these fishes for fear they will be driven to further decline.

2. Summer (June 22 - September 22)

<u>Colorado squawfish</u>

Spawning and egg deposition of Colorado squawfish occur in association with the declining flows, decreasing sediment transport, and increasing temperatures of summer. A gradual decline in summer flows following spring scouring of spawning substrate would maintain a natural sediment transport equilibria, and prevent siltation of spawning substrate. The growth, development, emergence, and downstream drift of larvae are also related to this regimen. Downstream nursery areas are created by high spring flows, but maintained as productive fish habitats by the declining flows.

<u>Razorback sucker</u>

Late spring and early summer is presumably the time when recruitment fails in this species. This failure has been linked elsewhere with predation by introduced species, and may be associated with loss of flooded bottomlands and lower river temperature. Lower flows tend to favor establishment and proliferation of potential competitor species by creating shallow habitats and warmer temperature regimens.

<u>Humpback chub</u>

Rapidly declining summer flows could adversely affect spawning and nursery habitat of the humpback chub in Yampa Canyon by concentrating fishes in suboptimal habitats and increasing the potential for disease, competition, predation, and hybridization. Low flows probably aid the growth of channel catfish, a presumed competitor. Gradual decline of flow from peak spring condition is favored for this species.

<u>Summer recommendations</u>

Gradual decline from spring peak flows are needed to maintain favorable habitat conditions. Present flows should be maintained for the period June 22-August 1, followed by flows near the 50% exceedence value. These flows would be compatible with larval transport for the remaining summer period (August 1-September 22) and maintenance of nursery habitats for Colorado squawfish in the Green River in August and September (flows of about 1800 cfs at Ouray, Utah).

3. Autumn (September 23 - December 21).

Colorado squawfish

Flows of the Yampa River that favor nursery habitats in the downstream Green River should be maintained until at least November 1 of each year, for growth and survival of young. Higher Yampa River flows (about 50% exceedence or more) are desirable for adults and juveniles until ice cover, and these would reduce frequency of ice breakup, ice jams and shoreline scouring. It is preferable not to increase flows and disrupt this cover until the following spring (see winter recommendations).

Razorback sucker

High, fluctuating flows in late autumn resulted in increased fish activity and presumably stressed on the fish. This may be most critical with ice conditions.

Moderate to average, stable flows are recommended (50-75% exceedence values).

Humpback chub

Low flows (in 1989) resulted in poor habitat conditions for humpback chub in Yampa Canyon. Field inspections indicated that the river consisted of semi-isolated runs and pools which effectively limited fish movement and reduced occupied habitat to a low level. Flows lower than about the 75% exceedence value are not recommended.

Autumn recommendations

Stable flow conditions at the 50% exceedence value are recommended to provide nursery habitat for the Colorado squawfish and humpback chub until ice formation. High flows that would cause ice breakup and jamming should be avoided.

4. Winter (December 22 - March 20)

Colorado squawfish

Stable winter flows reduce the scouring of shoreline habitats by ice. Flows at the 50% exceedence value (about 400 cfs) were acceptable for adult habitat during the 1986-88 winter study, when Colorado squawfish were actively foraging in shallow shoreline habitats.

Razorback sucker

Fluctuating winter flows with icy conditions may stress the overwintering fish.

Humpback chub

Little is known about conditions needed for overwintering humpback chub. However, it is presumed that these fish occupy the same habitats in the winter as in autumn.

Winter recommendations

Stable winter flows near the 50% exceedence value are recommended. Flows lower than 75% exceedence (Table 2) caused loss of habitat and may result in winterkill of smaller fish in pools.

LITERATURE CITED

Rose, K.L., and D.R. Hann. 1989. A summary of historic habitat modeling on the Yampa River using the Physical Habitat Simulation System. U.S. Fish and Wildlife Service, Grand Junction, Colorado. 18pp. + App.

Tyus, H.M., and C.A. Karp. 1989. Habitat use and streamflow needs of rare and endangered fishes, Yampa River, Colorado. U.S.Fish and Wildl.Serv., Biol. Rep. 89(14). 27pp.

U.S. Fish and Wildlife Service. 1987. Recovery implementation program for endangered fish species in the Upper Colorado River Basin. U.S. Fish and Wildlife Service, Region 6, Denver, Colorado. 82pp.

Table 1. Delineation of critical river reaches for rare and endangered Colorado River fishes in the Yampa River, with notes on potential limiting factors.

Life history	Location(RM)[a]	Season	Potential limiting factors
		Colorado Squawfish	
Adult	0-140	All Year	Spring peak flows; overbank flooding; seeps in spawning reaches; number of ripe females; angling or other incidental takes; siltation of spawning substrate; competition and predation with nonnative fishes; food availability; stream blockage; low flows late summer, fall, and winter; stability of winter flows.
Concentration	51-124	August-May	
Migration	0-140	May-August	
Spawning	4-31	June-August	
Larval	0-31	July-August	
Juvenile	0-140	All Year	
		Humpback Chub	
Adult	0-56	All Year	Spring peak flows; availability of shoreline eddy habitat and deep canyon habitat; competition and predation by nonnative fishes.
Concentration	4-40	All Year	
Spawning	12-40	May-July	
Larval	0-40	May-July	
Juvenile	0-56	All Year	
		Bonytail Chub	
Adult	0-10	All Year	Factors unknown
		Razorback Sucker	
Adult	0-13	All Year	Spring peak flows; overbank flooding; number of reproducing adults; competition and predation by nonnative fishes; lack of substantive recruitment to juvenile life history stage.
Spawning	0-4	April-June	
Larval	0-4	April-June	

[a] Numbers represent river miles (rounded) upstream from the mouth of the Yampa River.

Table 2. Historic, environmental baseline, and rare fish recovery flows for the Yampa River at Deerlodge Park, CO (RM 32). Units = cfs

Month	Historic[1] 25%[3]	50%	75%	Environmental baseline[2] 25%	50%	75%	Flows needed for aquatic resource recovery and maintenance.
APR	4,882	3,583	2,278	4,531	3,139	1,976	Environmental baseline flows; percentile which occurs naturally in any given year.
MAY	10,484	9,089	6,189	9,680	7,856	5,604	
JUN	9,316	7,247	5,143	8,585	6,198	4,416	
JUL	2,295	1,427	789	1,908	1,161	598	
AUG	627	370	278	514	364	251	364 (50% exc.)
SEP	384	231	148	323	254	177	254 (50% exc.)
OCT	604	386	244	439	339	245	339 (50% exc.)
NOV	588	424	310	474	385	326	385 (50% exc.)
DEC	480	373	267	437	327	278	327 (50% exc.)
JAN	419	338	275	404	327	276	327 (50% exc.)
FEB	512	390	337	450	373	333	373 (50% exc.)
MAR	1,168	860	705	913	659	554	659 (50% exc.)

1 Historic flow (cfs) is actual flow record from 1922-86.

2 Environmental baseline simulates conditions with existing water projects (1930-82) and projects which have received favorable biological opinions.

3 Values given as % exceedence flow.

Table 3. Projects in the environmental baseline for the Little Snake and Yampa Rivers.

	Depletion
Yampa River	
Hayden Power Station	7.1 K Acre-feet
Craig Power Station	19.2 K Acre-feet
Private Actions	5.9 K Acre-feet
Stagecoach Reservoir	12.8 K Acre-feet
Little Snake River	
Cheyenne Stage I	8.0 K Acre-feet
Cheyenne Stage II - Little Snake	15.8 K Acre-feet
Total Depletion Above Green River Confluence	68.8 K Acre-feet

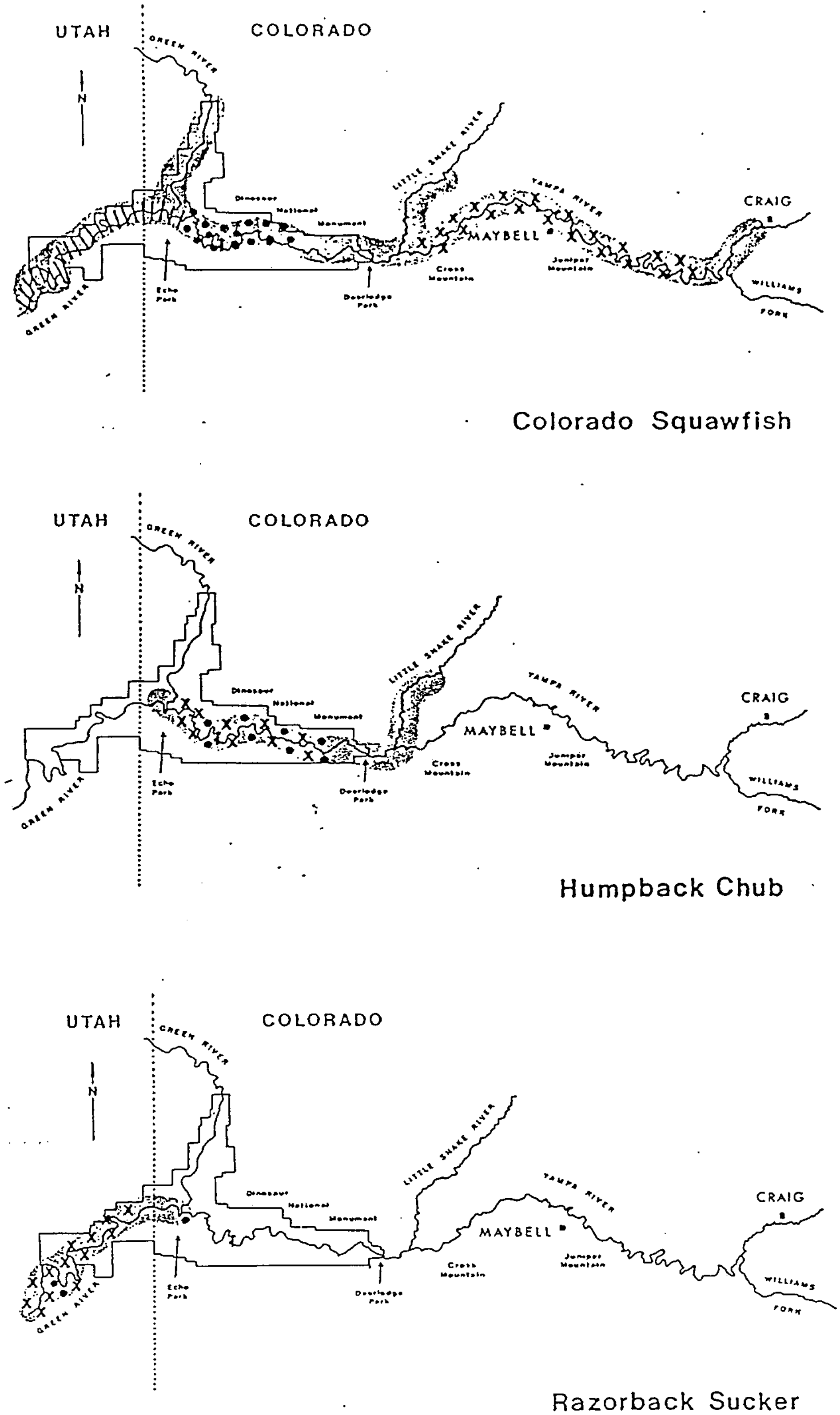
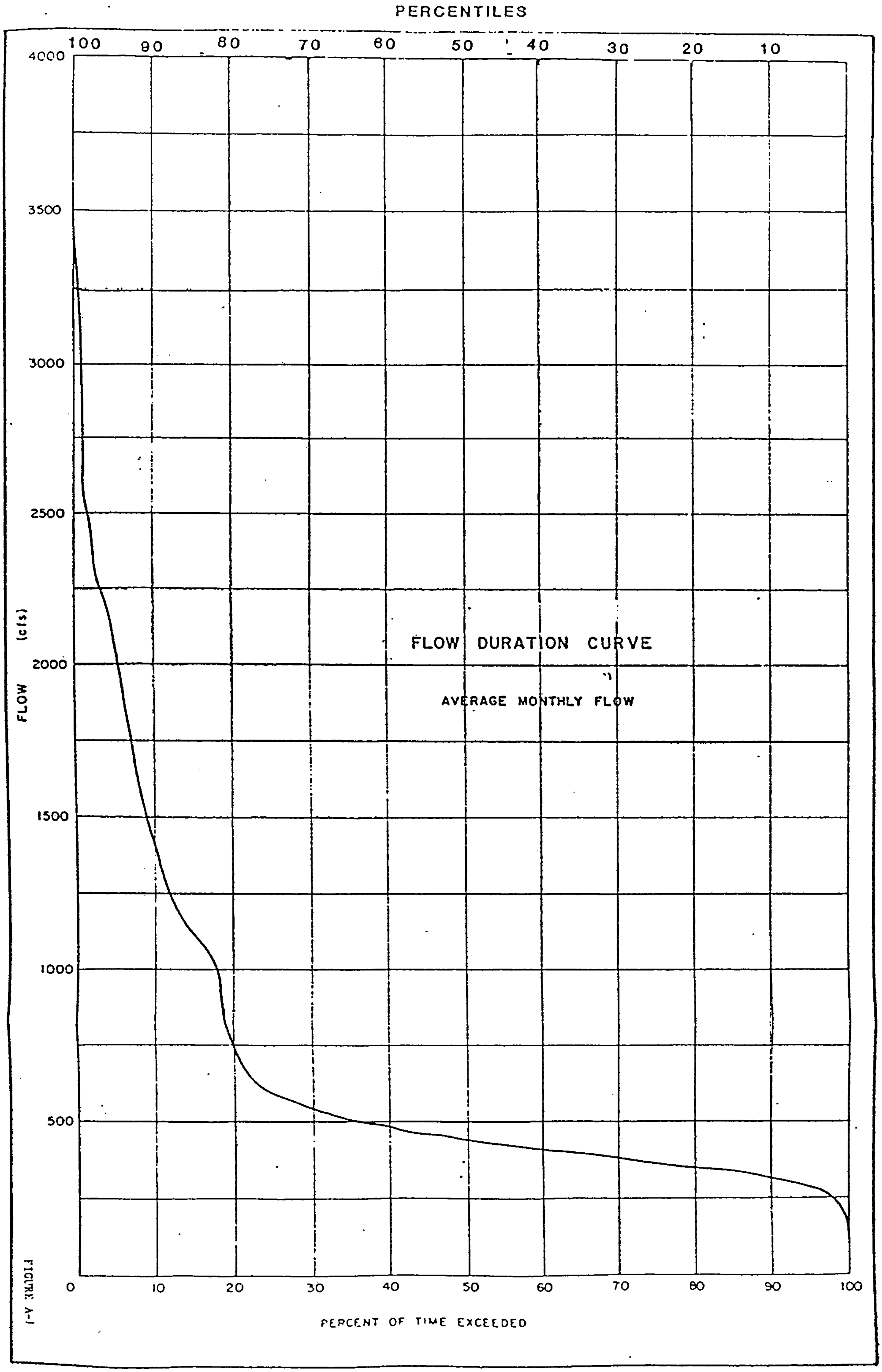


Fig. 1. Important river reaches for Colorado squawfish, humpback chub, and razorback sucker in Yampa and Green Rivers, Colorado and Utah. Shading=distribution; dots=spawning areas; X's=winter concentration, and //'s=larval drift.

Figure 2

Example - Flow Duration Curve



APPENDIX I

YAMPA RIVER HISTORIC AND ENVIRONMENTAL BASELINE CONDITION

The historic condition for the Little Snake River was derived by using U.S. Geological Survey (USGS) gage data for the Little Snake River near Lily. The historic condition for the Yampa River above the confluence with the Little Snake was derived by using the USGS gage record for Maybell. Gage records for the Yampa River are good except in the winter when the record is fair. At Lily on the Little Snake River the record is fair except in the winter when the record is poor. Both gages have quite extensive records, dating back to the early 1900's.

The historic flow of the Yampa River at Deerlodge Park is also of interest, but no gage existed there until 1978. Deerlodge Park is below the confluence of the Yampa and Little Snake Rivers and generally reflect condition on both Rivers, and is widely accepted as being above important spawning habitat areas. Yampa flow at Deerlodge Park can be accurately estimated by summing the gage record for Little Snake near Lily and Yampa River near Maybell. The data and statistical analysis are presented in Attachment 1.

The development of the environmental baseline (baseline) for the Yampa River was accomplished using the Service's HYDROSS computer model. The baseline condition was modeled with all existing and permitted major water development projects on the Little Snake River and Yampa River up to and including Stagecoach Reservoir. These projects are modeled as if they were on line and operating for the entire period of record, 1930 to 1982. On the Yampa River all depletions were modeled up to the year the actual depletion commenced. For example, the operations of the Hayden and Craig thermoelectric power plants were staged to reflect their operations through the entire period of record. The Hayden unit was operated in the model from 1930 to 1965, when the unit actually came on line. Likewise, the Hayden II unit was operated from 1930 to 1976.

Table 1 displays the projects in the baseline for the Little Snake and Yampa Rivers.

Table 1

	Depletion
Yampa River	
Hayden Power Station	7.1 K acre-feet
Craig Power Station	19.2 K acre-feet
Private Actions	5.9 K acre-feet
Stagecoach Reservoir	12.8 K acre-feet
Little Snake River	
Cheyenne Stage I	8.0 K acre-feet
Cheyenne Stage II - Little Snake	15.8 K acre-feet
Total Depletion Above Green River Confluence	68.8 K acre-feet

The Service's HYDROSS model was then used to quantify the effects of the above depletions on the Yampa River at Deerlodge Park. The model begins with gage flows for the period 1930 to 1982 and subtracts depletions based on water rights and availability. The results of the HYDROSS run were statistically analyzed and are displayed in Attachment 2.

Several general trends can be identified by comparing Attachments 1 and 2. The general trend is downward, with major reductions taking place in the peak flow months, with smaller depletions in other months. There is also a trend toward augmentation of flows from September through January of dryer years. Table 2 displays these trends.

TABLE 2

Yampa River at Deerlodge Park

CFS

		Historic Period			Baseline Period		
Percent exceedence		25%	50%	75%	25%	50%	75%
Spring	April	4882	3583	2278	4531	3139	1976
	May	10484	9089	6189	9680	7856	5604
	June	9316	7247	5143	8585	6198	4416
Summer	July	2295	1427	789	1908	1161	598
	August	627	370	278	514	364	251
	September	384	231	148	323	254	177
Fall	October	604	386	244	439	339	254
	November	588	424	310	474	385	326
	December	480	373	267	437	327	287
Winter	January	419	338	275	404	327	276
	February	512	390	337	450	373	333
	March	1168	860	705	913	659	554

ATTACHMENT 1

YAMPA RIVER AT DEERLODGE PARK HISTORIC

UNITS:CFS/MO

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
1922	365.	439.	1020.	2481.	10634.	8054.	1354.	403.	205.	233.	320.	425.	25933.
1923	418.	434.	706.	4015.	11234.	9150.	2267.	685.	502.	621.	456.	320.	30800.
1924	315.	360.	470.	4114.	8015.	6159.	985.	256.	231.	473.	558.	474.	22410.
1925	381.	392.	1038.	4984.	7337.	4721.	1508.	687.	747.	925.	610.	563.	23893.
1926	531.	514.	1258.	5912.	9953.	5871.	1110.	395.	324.	448.	389.	411.	27116.
1927	401.	382.	818.	5024.	12160.	7994.	2162.	561.	433.	688.	1036.	784.	32442.
1928	599.	711.	2229.	4347.	14193.	7799.	1516.	482.	378.	713.	643.	500.	34110.
1929	550.	550.	2850.	6941.	16810.	13069.	3146.	959.	1232.	952.	717.	565.	48343.
1930	410.	500.	1039.	5632.	5867.	4995.	624.	717.	519.	783.	716.	530.	22333.
1931	392.	505.	1360.	4824.	6132.	4341.	923.	278.	167.	476.	560.	387.	20345.
1932	382.	405.	2050.	5705.	12786.	9086.	2602.	687.	302.	477.	574.	335.	35390.
1933	186.	318.	860.	3006.	8031.	11214.	1076.	279.	166.	184.	225.	260.	25805.
1934	131.	358.	735.	2033.	2927.	585.	21.	26.	28.	121.	195.	213.	7373.
1935	327.	404.	634.	1570.	5317.	8001.	1288.	311.	193.	171.	292.	345.	18854.
1936	338.	378.	751.	5518.	10458.	5162.	795.	589.	139.	269.	306.	229.	24931.
1937	224.	278.	811.	2848.	9829.	6150.	1940.	370.	280.	386.	467.	488.	24071.
1938	484.	589.	1138.	4051.	10281.	8160.	1305.	353.	572.	340.	497.	530.	28300.
1939	361.	391.	1760.	3866.	8332.	3572.	343.	144.	223.	347.	297.	197.	19834.
1940	176.	296.	788.	3254.	8298.	4031.	399.	78.	121.	546.	382.	283.	18653.
1941	261.	352.	977.	2325.	10285.	5301.	898.	874.	337.	977.	715.	570.	23872.
1942	461.	457.	1262.	5810.	8121.	7511.	1128.	230.	84.	219.	318.	255.	25856.
1943	254.	336.	983.	4427.	5249.	6813.	1286.	366.	151.	183.	305.	272.	20625.
1944	233.	252.	419.	1357.	7510.	8564.	1281.	137.	33.	221.	326.	286.	20620.
1945	263.	267.	541.	2138.	9832.	9567.	3471.	1127.	407.	376.	455.	349.	28792.
1946	296.	469.	970.	5117.	5410.	4889.	772.	311.	154.	486.	592.	410.	19878.
1947	292.	364.	1767.	3726.	11157.	7247.	2277.	610.	398.	530.	587.	696.	29652.
1948	670.	704.	1009.	3916.	9672.	5087.	938.	321.	97.	285.	378.	373.	23450.
1949	364.	406.	959.	4558.	10465.	10067.	2349.	354.	187.	584.	460.	353.	31107.
1950	323.	357.	733.	3411.	6998.	7871.	1563.	230.	207.	303.	389.	341.	22726.
1951	295.	413.	772.	2449.	7326.	6750.	1926.	489.	218.	577.	358.	283.	21857.
1952	299.	335.	395.	7292.	13212.	10897.	1427.	664.	274.	220.	259.	287.	35561.
1953	312.	295.	709.	1648.	5043.	7944.	927.	456.	104.	160.	359.	261.	18219.
1954	312.	390.	597.	2612.	4510.	1741.	299.	122.	223.	423.	336.	272.	11839.
1955	259.	250.	728.	2595.	6481.	4316.	580.	306.	70.	136.	332.	468.	16522.
1956	393.	335.	1729.	4770.	9129.	5558.	578.	362.	64.	133.	275.	241.	23568.
1957	265.	315.	677.	2699.	9594.	15063.	6919.	1181.	495.	572.	632.	513.	38926.
1958	423.	669.	983.	3493.	12479.	7204.	641.	183.	181.	245.	308.	276.	27086.
1959	278.	344.	603.	1922.	5434.	5829.	929.	415.	475.	839.	694.	462.	18225.
1960	286.	289.	813.	5509.	6208.	5718.	645.	158.	101.	231.	297.	255.	20511.
1961	236.	269.	588.	1268.	4805.	4066.	361.	141.	591.	1214.	725.	508.	14774.
1962	461.	1196.	1993.	9159.	9873.	6531.	2090.	301.	113.	301.	341.	275.	32633.
1963	259.	514.	699.	1806.	5541.	3222.	287.	291.	256.	124.	251.	177.	13428.
1964	188.	218.	301.	1519.	7765.	6834.	1642.	338.	181.	178.	306.	375.	19847.
1965	362.	361.	476.	3583.	8872.	10375.	3051.	931.	815.	828.	567.	456.	30678.
1966	470.	376.	2547.	3049.	5400.	2463.	313.	127.	48.	322.	284.	295.	15694.
1967	255.	309.	1032.	2010.	5754.	7602.	2214.	378.	296.	348.	311.	299.	20808.
1968	324.	372.	716.	2085.	8466.	11075.	1898.	693.	285.	445.	430.	369.	27158.
1969	374.	371.	848.	5655.	9174.	5003.	1512.	370.	380.	598.	547.	445.	25278.
1970	444.	584.	729.	2025.	11805.	10427.	2456.	485.	349.	652.	604.	478.	31040.

YAMPA RIVER AT DEERLODGE PARK HISTORIC

UNITS:CFS/MO

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
1971	514.	543.	1693.	6255.	9771.	11362.	2485.	344.	310.	429.	502.	464.	34673.
1972	487.	860.	1926.	2925.	5945.	6497.	640.	157.	199.	473.	535.	457.	21102.
1973	405.	375.	555.	2687.	11261.	8538.	2713.	625.	289.	347.	504.	489.	28788.
1974	414.	383.	765.	4848.	13835.	8749.	1517.	361.	96.	263.	384.	216.	31832.
1975	291.	394.	704.	1976.	8044.	9796.	4146.	628.	256.	335.	432.	411.	27414.
1976	370.	674.	950.	2116.	7385.	5397.	1293.	424.	174.	294.	248.	188.	19514.
1977	175.	275.	454.	1270.	2368.	1821.	156.	92.	88.	200.	247.	308.	7456.
1978	338.	425.	1071.	4184.	9089.	12093.	3614.	592.	268.	241.	299.	252.	32466.
1979	282.	337.	711.	3665.	10540.	9232.	2388.	474.	141.	296.	395.	281.	28743.
1980	333.	531.	879.	4632.	12273.	8596.	1688.	277.	172.	315.	373.	275.	30345.
1981	246.	377.	595.	1639.	4579.	4095.	585.	141.	65.	579.	424.	436.	13761.
1982	421.	511.	1015.	3317.	10071.	10268.	3854.	739.	482.	861.	642.	417.	32599.
1983	366.	428.	1316.	2567.	9194.	14456.	5316.	1191.	409.	819.	733.	640.	37432.
1984	632.	599.	888.	4693.	19973.	15536.	4522.	1298.	903.	1014.	979.	794.	51831.
1985	628.	667.	1557.	7919.	13059.	7109.	1573.	626.	331.	916.	951.	697.	36033.
1986	641.	1666.	2699.	6612.	10443.	9779.	2580.	660.	656.	1072.	984.	553.	38346.
MEAN	360.	453.	1041.	3775.	8892.	7430.	1709.	459.	295.	466.	471.	394.	25746.
MEDIAN	338.	390.	860.	3583.	9089.	7247.	1427.	370.	231.	386.	424.	373.	25278.

THE MAXIMUM VALUE 19973. OCCURED IN MAY OF 1984
THE MINIMUM VALUE 21. OCCURED IN JUL OF 1934

YAMPA RIVER AT DEERLODGE PARK HISTORIC

UNITS:CFS/MO

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
NO. OF DATA	65	65	65	65	65	65	65	65	65	65	65	65	65
MINIMUM	131.	218.	301.	1268.	2368.	585.	21.	26.	28.	121.	195.	177.	7373
MAXIMUM	670.	1666.	2850.	9159.	19973.	15536.	6919.	1298.	1232.	1214.	1036.	794.	51831
ARITH. MEAN	360.	453.	1041.	3775.	8892.	7430.	1709.	459.	295.	466.	471.	394.	25746
STD. DEV.	119.	220.	561.	1757.	3187.	3115.	1288.	285.	222.	270.	196.	143.	8372
SKEWNESS	1.	3.	1.	1.	1.	0.	2.	1.	2.	1.	1.	1.	0
KURTOSIS	0.	14.	2.	0.	1.	0.	3.	1.	4.	0.	1.	0.	1
10.0 PCTILE	233.	278.	541.	1648.	5249.	4031.	361.	141.	84.	178.	275.	241.	15694
25.0 PCTILE	275.	337.	705.	2278.	6189.	5143.	789.	278.	148.	244.	310.	276.	20228
50.0 PCTILE	338.	390.	860.	3583.	9089.	7247.	1427.	370.	231.	386.	424.	373.	25278
75.0 PCTILE	419.	512.	1168.	4882.	10484.	9316.	2295.	627.	384.	604.	588.	480.	31057
90.0 PCTILE	531.	669.	1926.	5912.	12786.	11214.	3471.	874.	572.	916.	717.	565.	35561

YAMPA RIVER AT DEERLODGE PARK HISTORIC

ANNUAL MEDIAN, MAXIMUM, AND MINIMUM

YEAR	MEDIAN	MAXIMUM	MINIMUM	YEAR	MEDIAN	MAXIMUM	MINIMUM	YEAR	MEDIAN	MAXIMUM	MINIMUM
1922	432.	10634.	205.	1944	306.	8564.	33.	1966	349.	5400.	48.
1923	653.	11234.	320.	1945	498.	9832.	263.	1967	363.	7602.	255.
1924	473.	8015.	231.	1946	539.	5410.	154.	1968	569.	11075.	285.
1925	836.	7337.	381.	1947	653.	11157.	292.	1969	573.	9174.	370.
1926	522.	9953.	324.	1948	687.	9672.	97.	1970	628.	11805.	349.
1927	801.	12160.	382.	1949	522.	10465.	187.	1971	529.	11362.	310.
1928	712.	14193.	378.	1950	373.	7871.	207.	1972	587.	6497.	157.
1929	1096.	16810.	550.	1951	533.	7326.	218.	1973	529.	11261.	289.
1930	716.	5867.	410.	1952	365.	13212.	220.	1974	399.	13835.	96.
1931	532.	6132.	167.	1953	407.	7944.	104.	1975	530.	9796.	256.
1932	630.	12786.	302.	1954	363.	4510.	122.	1976	549.	7385.	174.
1933	298.	11214.	166.	1955	400.	6481.	70.	1977	261.	2368.	88.
1934	204.	2927.	21.	1956	377.	9129.	64.	1978	508.	12093.	241.
1935	374.	8001.	171.	1957	655.	15063.	265.	1979	435.	10540.	141.
1936	483.	10458.	139.	1958	532.	12479.	181.	1980	452.	12273.	172.
1937	477.	9829.	224.	1959	649.	5829.	278.	1981	507.	4579.	65.
1938	581.	10281.	340.	1960	293.	6208.	101.	1982	800.	10268.	417.
1939	354.	8332.	144.	1961	589.	4805.	141.	1983	1005.	14456.	366.
1940	390.	8298.	78.	1962	828.	9873.	113.	1984	996.	19973.	599.
1941	886.	10285.	261.	1963	289.	5541.	124.	1985	933.	13059.	331.
1942	459.	8121.	84.	1964	322.	7765.	178.	1986	1369.	10443.	553.
1943	351.	6813.	151.	1965	821.	10375.	361.	1987	0.	0.	0.

ATTACHMENT 2

YAMPA RIVER AT DEERLODGE PARK SRPOUT 87/06/05. 17.00.47. STAGECOACH PROJECT

UNITS:CFS/MO

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
1930	413.	461.	913.	5180.	5808.	4953.	608.	668.	502.	767.	807.	610.	21690.
1931	420.	470.	945.	3848.	6117.	4425.	517.	245.	223.	359.	372.	327.	18268.
1932	259.	274.	1179.	5050.	12230.	8385.	2169.	709.	348.	401.	473.	316.	31793.
1933	233.	371.	565.	2124.	6065.	8914.	859.	310.	225.	226.	247.	243.	20382.
1934	161.	407.	599.	2351.	2393.	436.	21.	65.	87.	177.	283.	262.	7242.
1935	337.	439.	599.	1650.	5704.	8475.	1213.	328.	205.	219.	310.	287.	19766.
1936	308.	341.	555.	5406.	9327.	4437.	764.	391.	198.	263.	313.	277.	22580.
1937	256.	331.	750.	2292.	8944.	5576.	1293.	362.	262.	403.	478.	503.	21450.
1938	464.	571.	1040.	4345.	9740.	7714.	1161.	357.	469.	331.	427.	462.	27081.
1939	355.	373.	1407.	4009.	7421.	3017.	371.	183.	277.	362.	333.	233.	18341.
1940	220.	343.	701.	3430.	7856.	3336.	423.	115.	151.	411.	409.	334.	17729.
1941	303.	397.	898.	2233.	9763.	4662.	847.	380.	255.	850.	642.	514.	21744.
1942	448.	447.	961.	5986.	7947.	6914.	990.	269.	149.	229.	352.	308.	25000.
1943	264.	337.	968.	4640.	4577.	5669.	1181.	367.	208.	224.	331.	275.	19041.
1944	231.	270.	405.	1161.	6847.	7675.	1081.	178.	101.	198.	360.	281.	18788.
1945	274.	270.	488.	1978.	10009.	9087.	2989.	995.	423.	403.	491.	412.	27819.
1946	350.	469.	914.	5293.	4443.	4277.	738.	300.	212.	426.	528.	418.	18368.
1947	311.	375.	1685.	3601.	10716.	6422.	1982.	582.	351.	453.	570.	752.	27800.
1948	727.	755.	1053.	4161.	9241.	4390.	873.	361.	159.	322.	387.	363.	22792.
1949	350.	389.	849.	4495.	10034.	9556.	2010.	391.	254.	526.	462.	361.	29677.
1950	352.	397.	599.	3369.	6633.	7420.	1319.	268.	262.	331.	407.	379.	21736.
1951	332.	364.	700.	2512.	6856.	5999.	1800.	520.	279.	435.	347.	288.	20432.
1952	327.	350.	405.	5955.	12871.	10245.	1228.	590.	312.	253.	306.	316.	33158.
1953	334.	323.	566.	1643.	4343.	7323.	878.	439.	165.	204.	357.	275.	16850.
1954	322.	370.	508.	2663.	3829.	1338.	276.	141.	242.	432.	358.	285.	10764.
1955	277.	262.	487.	2606.	6039.	3735.	537.	287.	128.	178.	362.	435.	15333.
1956	376.	334.	727.	4772.	8656.	4895.	571.	320.	124.	170.	310.	270.	21525.
1957	295.	326.	482.	2630.	9344.	14870.	6416.	1130.	539.	598.	614.	522.	37766.
1958	446.	647.	867.	3540.	12401.	6374.	606.	217.	227.	265.	321.	293.	26204.
1959	303.	359.	474.	1796.	4821.	5164.	820.	393.	267.	801.	627.	444.	16269.
1960	301.	288.	828.	5628.	5619.	4995.	626.	195.	158.	240.	328.	278.	19484.
1961	256.	285.	509.	1265.	4322.	3415.	387.	169.	593.	1156.	736.	472.	13565.
1962	423.	942.	958.	9073.	9660.	6004.	1883.	343.	181.	339.	343.	275.	30424.
1963	262.	501.	735.	1727.	5039.	2457.	301.	253.	257.	157.	274.	192.	12155.
1964	195.	225.	221.	1415.	7332.	6198.	1394.	367.	247.	226.	316.	356.	18492.
1965	350.	345.	277.	3061.	8404.	9931.	2543.	831.	590.	777.	560.	443.	28112.
1966	443.	382.	1802.	3139.	5000.	1799.	317.	162.	107.	318.	310.	303.	14082.
1967	285.	323.	866.	2021.	5244.	6926.	1842.	416.	319.	362.	358.	293.	19255.
1968	316.	337.	589.	1821.	8173.	10864.	1597.	661.	334.	476.	439.	384.	25991.
1969	392.	397.	553.	5724.	8809.	4196.	1262.	390.	407.	574.	550.	483.	23737.
1970	456.	512.	654.	1946.	11674.	9931.	2070.	512.	371.	622.	583.	477.	29808.
1971	509.	501.	1316.	6159.	9295.	10808.	2073.	398.	343.	403.	462.	405.	32672.
1972	420.	530.	1401.	3080.	5558.	5911.	574.	193.	260.	491.	444.	469.	19331.
1973	418.	413.	589.	1972.	10463.	7987.	2215.	593.	294.	341.	473.	467.	26225.
1974	409.	386.	783.	5550.	14290.	8155.	1280.	364.	158.	278.	385.	231.	32269.
1975	321.	398.	622.	1915.	7172.	9917.	4002.	587.	269.	333.	412.	371.	26319.
1976	332.	436.	659.	2062.	7085.	4786.	1047.	411.	237.	286.	261.	192.	17794.
1977	178.	274.	350.	1324.	1828.	1402.	71.	95.	141.	222.	304.	265.	6454.
1978	309.	362.	648.	4196.	8475.	11767.	3240.	598.	289.	261.	340.	301.	30786.

YAMPA RIVER AT DEERLODGE PARK SRPOUT 87/06/05. 17.00.47. STAGECOACH PROJECT

UNITS:CFS/MO

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
1979	327.	359.	643.	3485.	10247.	9383.	2080.	481.	210.	247.	400.	313.	28175.
1980	303.	533.	651.	3732.	11310.	8087.	1369.	317.	220.	295.	310.	264.	27391.
1981	231.	288.	428.	1786.	3785.	3358.	551.	162.	123.	426.	395.	409.	11942.
1982	402.	487.	905.	3448.	9640.	9648.	3334.	673.	450.	752.	624.	430.	30793.
MEAN	337.	402.	760.	3401.	7725.	6483.	1370.	397.	267.	392.	419.	361.	22314.
MEDIAN	327.	373.	659.	3139.	7856.	6198.	1161.	364.	254.	339.	385.	327.	21690.

THE MAXIMUM VALUE 14870. OCCURED IN JUN OF 1957
THE MINIMUM VALUE 21. OCCURED IN JUL OF 1934

YAMPA RIVER AT DEERLODGE PARK SRPOUT 87/06/05. 17.00.47. STAGECOACH PROJECT

UNITS:CFS/MO

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
). OF DATA	53	53	53	53	53	53	53	53	53	53	53	53	53
1INIMUM	161.	225.	221.	1161.	1828.	436.	21.	65.	87.	157.	247.	192.	6454.
1AXIMUM	727.	942.	1802.	9073.	14290.	14870.	6416.	1130.	593.	1156.	807.	752.	37766.
\RITH. MEAN	337.	402.	760.	3401.	7725.	6483.	1370.	397.	267.	392.	419.	361.	22314.
3TD. DEV.	94.	124.	324.	1646.	2746.	2954.	1112.	216.	121.	202.	124.	108.	6827.
3KEWNESS	1.	2.	1.	1.	0.	0.	2.	1.	1.	2.	1.	1.	0.
(URTOSIS	4.	6.	2.	1.	-1.	0.	6.	2.	1.	3.	1.	2.	0.
10.0 PCTILE	231.	274.	423.	1649.	4339.	2905.	360.	162.	127.	203.	306.	258.	13283.
25.0 PCTILE	276.	333.	554.	1976.	5604.	4416.	598.	251.	177.	245.	326.	278.	18323.
50.0 PCTILE	327.	373.	659.	3139.	7856.	6198.	1161.	364.	254.	339.	385.	327.	21690.
75.0 PCTILE	404.	450.	913.	4531.	9680.	8585.	1908.	514.	323.	439.	474.	437.	27805.
90.0 PCTILE	446.	531.	1206.	5647.	11383.	9994.	2632.	669.	454.	755.	616.	487.	30993.

ANNUAL MEDIAN, MAXIMUM, AND MINIMUM

YEAR	MEDIAN	MAXIMUM	MINIMUM	YEAR	MEDIAN	MAXIMUM	MINIMUM	YEAR	MEDIAN	MAXIMUM	MINIMUM
1930	717.	5808.	413.	1948	741.	9241.	159.	1966	350.	5000.	107.
1931	445.	6117.	223.	1949	494.	10034.	254.	1967	389.	6926.	285.
1932	591.	12230.	259.	1950	402.	7420.	262.	1968	532.	10864.	316.
1933	340.	8914.	225.	1951	477.	6856.	279.	1969	551.	8809.	390.
1934	272.	2393.	21.	1952	377.	12871.	253.	1970	602.	11674.	371.
1935	388.	8475.	205.	1953	398.	7323.	165.	1971	505.	10808.	343.
1936	366.	9327.	198.	1954	364.	3829.	141.	1972	510.	5911.	193.
1937	490.	8944.	256.	1955	398.	6039.	128.	1973	531.	10463.	294.
1938	520.	9740.	331.	1956	355.	8656.	124.	1974	397.	14290.	158.
1939	366.	7421.	183.	1957	606.	14870.	295.	1975	499.	9917.	269.
1940	410.	7856.	115.	1958	526.	12401.	217.	1976	423.	7085.	192.
1941	744.	9763.	255.	1959	550.	5164.	267.	1977	269.	1828.	71.
1942	447.	7947.	149.	1960	314.	5628.	158.	1978	480.	11767.	261.
1943	352.	5669.	208.	1961	551.	4322.	169.	1979	440.	10247.	210.
1944	320.	7675.	101.	1962	682.	9660.	181.	1980	425.	11310.	220.
1945	489.	10009.	270.	1963	287.	5039.	157.	1981	417.	3785.	123.
1946	498.	5293.	212.	1964	336.	7332.	195.	1982	712.	9648.	402.
1947	667.	10716.	311.	1965	683.	9931.	277.	1983	0.	0.	0.