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The Yellowstone River Instream Reservation

Dec. 15, 1979 - Dec. 15, 1980

SECOND ANNUAL REPORT

Compiled By

Larry Peterman

Ecological Services Division

Department of Fish, Wildlife and Parks

THE YELLOWSTONE RIVER

INSTREAM

RESERVATION

SECOND ANNUAL REPORT

for the period

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January, 1981

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INTRODUCTION

The Order of the Board of Natural Resources and Conservation establishing water reservations for the Yellowstone basin was signed on December 15, 1978. As a result of that Order, the Department of Fish, Wildlife and Parks was granted an instream reservation for the Yellowstone at Sidney of approximately 5.5 million acre-feet of water with varying amounts granted in upstream areas and tributaries.

The department applied for instream reservations on many streams and tributaries where little, if any, flow data were available. In granting an instream reservation for those waters, the Board frequently granted a percentile flow rather than a specifc amount of water in acre-feet or cfs. In such areas the department was directed by the Board through condition 116 to develop and submit to the Board within 5 years of December 15, 1978, a plan to convert the minimum flow instream reservation quantities into cubic feet of water per second and acre-feet of water per month.

Condition 117 states that the reservant shall submit to the Board an annual progress report setting forth accomplishments toward completion of such work as outlined in condition 116, a schedule of anticipated progress and other information as may be required. This report is designed to fulfill the requirement of the second-year annual progress report. The first annual progress report outlined a tentative plan for accomplishing the objectives outlined in condition 116. Since then, the tentative plan has been reviewed, commented on and revised. A finalized plan is submitted in this report for approval.

In addition, this report will comment on events pertaining to the reservations which occurred in the past year. Biological studies pertaining to the Yellowstone basin are included and ongoing department investigations in the basin are summarized. Problems peculiar to the Tongue River are also discussed. Additional information from the department may be obtained upon request.

METHODOLOGY FOR DEFINING PERCENTILE FLOWS

The following section contains a plan to convert the minimum-flow instream reservation on the Yellowstone River and its tributaries into cubic feet of water per second and acre-feet of water per month using hydrologic modeling techniques. This plan is intended to satisfy a portion of the requirements set forth in condition 116 of the Order of the Board of Natural Resources establishing water reservations and was prepared for the Department of Fish, Wildlife and Parks by Systems Technology, Inc. of Helena. The report was reviewed by the technical staff of Department of Natural Resources and Conservation and US Geological Survey and their comments were incorporated into the final copy. Copies of correspondence related to concurrence in the technical aspects of the methodology by DNRC are included at the end of this section.

Plan to Convert the Minimum-flow Instream Reservation on the Yellowstone River into Cubic Feet of Water per Second and Acre Feet of Water per Month Using Hydrologic Modeling Techniques

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January, 1981

I. INTRODUCTION

As a result of the Board of Natural Resources and Conservation (BNRC) order for establishing water reservations on the Yellowstone River (Ref. 1), specifically Condition 116(b), the Montana Department of Fish, Wildlife and Parks (MDFWP) with the support and concurrence of the Department of Natural Resources and Conservation (DNRC) is instructed to submit to BNRC within five years of the effective date of the adoption of the minimum-flow instream reservation, a plan to convert the minimum-flow instream reservation percentile exceedences into quantities expressed as cubic feet of water per second and acre-feet of water per month for those streams with less than ten consecutive years of acceptable streamflow records. The order indicates the plan is to include the following:

1. A listing of streams or portions of streams where the alternative conversion method, hydrologic modeling techniques, will be used in converting minimum-flow instream reservation percentiles into quantities expressed as cubic feet of water per second and acre-feet of water per month. Upon approval of the Board, hydrologic modeling techniques may be used for ungauged streams on sites, or for streams with less than ten consecutive years of record. The plan shall specify modeling techniques, the reach of stream to which modeling will be applied, schedules, cost estimates, agency undertaking the modeling, and the agencies which will benefit from the modeling results. All modeling results shall be adjusted to the 1978 level of development.

2. A listing of streams or portions of streams where hydrologic modeling techniques cannot be used and new stream gaging stations are essential in obtaining the necessary streamflow data to convert the minimum-flow instream reservation percentiles into quantities expressed as cubic feet of water per second and acre-feet of water per month. The plan shall identify sites for new gages, the reach of the stream to which the gaging station applies, the proposed future periods of record to be used, the types of gages to be installed, installation schedules, cost estimates, the agency responsible for operating and maintaining the gages and other agencies that will benefit from the additional gaging records. At least ten consecutive years of gaging records obtained and analyzed using USGS methods will be acceptable. However, upon prior approval of BNRC, differing periods of record and/or differing gaging methods may be used. In the conversion plan, all gaging data shall be adjusted to the 1978 level of development.

The purpose of this report is to identify those streams for which simulated flow data (hydrologic modeling) could be used to convert the minimum-flow instream percentile exceedences into flow values; and specify the simulation method to be used for the various streams or stream segments. In addition, those streams or stream segments for which modeling techniques are not appropriate will be identified along with the proposed stream gage location and future periods of record to be obtained.

Table 1 lists the streams for which analysis is needed. These streams are organized by major drainage basin.

Table 1. Summary of Streams in Need of Analysis.

Major Drainage Basin	Stream Designation
Tongue River	Hanging Woman Creek
	Otter Creek
	Pumpkin Creek
Middle Yellowstone River Mainstem	Rosebud Creek
Clark's Fork River	Butcher Creek
	Willow Creek
	Red Lodge Creek
	Clear Creek
	Dry Creek
	Rock Creek
	Sage Creek
	Bluewater Creek
Stillwater River	Castle Creek
	Picket Pin Creek
	W. F. Stillwater River
	Little Rocky Creek
	W. Fishtail Creek
	E. Rosebud Creek
Upper Yellowstone River Mainstem (Stillwater to Shields)	Bridger Creek
	Lower Deer Creek
	Upper Deer Creek
	Sweet Grass Creek
	Mission Creek
	Little Mission Creek
Shields River	Smith Creek
	Flathead Creek
	Cottonwood Creek
	Rock Creek
	Brackett Creek
	Shields River at mouth
Upper Yellowstone River Mainstem (above Shields)	Bear Creek
	Cinnibar Creek
	Mol Heron Creek
	Cedar Creek
	Tom Miner Creek
	Rock Creek
	Big Creek
	Six Mile Creek
	Fridley Creek
	Eight Mile Creek
	Mill Creek

Table 1 continued. Summary of Streams in Need of Analysis

Major Drainage Basin	Stream Designation
Upper Yellowstone River Mainstem (above Shields)	Trail Creek
	Suce Creek
	Coke Creek
	Billman Creek
	Fleshman Creek
	Armstrong Creek
	Nelson Spring Creek
	McDonald Spring Creek
	Emigrant Spring Creek

II. METHODOLOGY

A. General Overview

The major task set forth by 116(b) of the BNRC's Order Establishing Water Reservations is the determination of those quantities corresponding to the various percentile exceedence levels, stipulated in the order, on streams or stream segments for which less than ten consecutive years of acceptable streamflow records exist. For the streams to be analyzed, this can be accomplished in one of two ways:

1. On streams where gaging stations are currently being operated, their operation can be continued until ten years of consecutive, acceptable streamflow records are obtained, and

2. On streams where gaging stations are inactive, removed or were never established, hydrologic modeling techniques may be used, or re-activation or new gaging stations may be established to obtain the necessary flow data.

A major requirement of an acceptable methodology, as set forth in 116(b), involves the adjustment of flow data used in the conversion process in 1978 level of development. This results in a set of flow data that would have been obtained if development had been at the 1978 level of water usage for the entire period of record being considered. In order to determine 1978 level of development flows for a stream or stream segment, data on the historical water usage must be compiled so the magnitude of the adjustment to each year can be determined. Thus, besides obtaining data on streamflows, data on water usage must also be obtained.

After at least ten years of consecutive, acceptable 1978 level of development flow data have been determined, frequency curves are prepared which relate a flow quantity (e.g., cubic feet of water per second) to a percentile exceedence level. These curves are then used to convert the minimum-flow instream percent exceedences granted by the BNRC into quantities expressed as cubic feet of water per second and acre-feet of water per month.

In summary, to comply with the Board's Order, the following three basic steps are required to convert the minimum-flow instream percent exceedences granted by the BNRC into the appropriate flow quantities.

1. Obtain at least ten years of consecutive, acceptable streamflow data either from measurements or by hydrologic modeling.

2. Obtain historical water use data to adjust the streamflow data to the 1978 level of development; and

3. Prepare frequency curves of the 1978 level of development flows which relate percentile exceedence levels to flow quantities.

B. Modeling Techniques

A number of hydrologic modeling techniques are currently in accepted usage. The applicability of a technique generally depends upon the drainage basin characteristics (e.g., geology and meteorology) of the stream or stream segment being analyzed, and the proximity of long-term (i.e., greater than ten consecutive years) gaging stations. The following discussion describes the various techniques employed in the synthesis of stream flow.

1. Streams With Some Continuous Flow Records. Simple or multiple regression analysis may be used to synthesize additional flow data. This may be done by a. relating the existing flow data to precipitation records, or b. relating the existing flow data to streamflow records from a long-term (greater than ten years) gaging station in the area. Analysis with precipitation involves the use of a rainfall-runoff computer model to simulate missing flow data. For the relation involving a long-term gaging station, the flow of the long-term station is related to the flow of the stream segment being analyzed. Occasionally the previous period's (e.g. previous month) flow at a long-term station is also used (Ref. 3). The regression technique employed is generally selected on the basis of the relationship having the largest correlation coefficient (e.g. greater than .75) and minimum standard error. However, since low flows are of importance, some of the regression equations may be rejected if the constant (intercept) is too high, biasing low-flow estimates. If no acceptable correlation can be found, then the necessary streamflow data is obtained by re-activation or continuation of the gaging station.

2. Streams With No Continuous Flow Records. For streams with partial flow records (e.g., occasional flow measurements or crest gage readings), the techniques discussed above (1) generally are not applicable.

Where good information exists on the drainage basin characteristics, multiple regression analysis can be used to relate streamflow data from nearby, long-term gaging stations to basin characteristics. Analysis with basin characteristics would include such factors as: drainage area, precipitation, main channel slope, mean basin elevation, percent forest cover and soil storage index (Ref. 2). The equation is then used to generate the desired streamflow characteristics for the stream in question. However, as was the case with regression techniques described in (1), the equation may be rejected if resulting intercept is too high, thus biasing low flow estimates. When no acceptable modeling technique can be found, some collection of streamflow data will be necessary.

The Riggs method consists of measuring concurrent flows on the stream being analyzed and at the long-term station. The flow measured at the long-term station is then related to the flow characteristic in question, at the long-term station. The relationship for the long-term station is then applied to the flow measured in the stream being analyzed to obtain the desired flow characteristic.

C. Data Collection

1. Streamflow. Because of the large expense associated with establishing, operating and maintaining a gaging station and the relatively long time (at least ten years) that may be required to obtain the necessary streamflow data, data collection is aimed at providing enough information to use one of the modeling techniques previously described. For example, where no or too few streamflow records exist for a stream, but basin characteristics indicate that the streamflow should correlate well to a nearby long-term station, a once monthly streamflow measurement may be sufficient. For a stream where a substantial amount of streamflow data exists but there is no adequate near-by long-term station or insufficient data on basin characteristics, it may be more cost effective to gather and compile data on the basin characteristics than to establish, operate and maintain a streamflow gaging station.

2. Water Use. As was previously discussed, the BNRC's order (Ref. 1) requires that flows be adjusted to the 1978 level of development. In order to accommodate this requirement, historical water use would be needed on the streams to be analyzed and the streams whose long-term gaging records are to be used. Some information as to water use on the various streams is available at the DNRC. In addition, more information is becoming available through the implementation of Senate Bill 76 (SB-76; the adjudication process). This data needs to be compiled and assessed, however, for each stream being considered. Where data is lacking or inadequate, values will have to be assumed or field investigations made. Where assumptions concerning water use cannot be made with a certain degree of assurance or where the range of uncertainty in the assumed value has a consequential effect on the ultimate result (i.e. the minimum-flow instream quantity), then field investigation is warranted. Since field investigations are vastly more expensive, assumptions will generally be employed.

The following lists some of the assumptions that have commonly been used for similar analysis on other streams.

1. Diversion of water for small irrigation projects is assumed to affect natural flow downstream in the month of use.

2. The consumptive uses of small storage and stockwatering projects are assumed to accumulate as storage depletion after spring runoff. These consumptive uses would affect natural flow in the first month of runoff in the following year. Large reservoirs are treated individually in detailed simulations.

3. Diversions from flow are assumed to influence all downstream points in the same time period (month).

4. Consumptive uses are estimated using the following assumptions.

   a. Stockwatering uses would average one acre-foot per year for every head of livestock.

   b. Spring backflood uses would average ten inches over the flooded area.

   c. Gravity or pump diversion uses will be estimated from present cropping, soils and water availability. The gross irrigation depletion per irrigation is 7.7 inches.

5. Annual evaporation losses from small storage projects are assumed to be the product of net evaporation of feet times 60 percent of the area at full supply level. This assumption is based on average operating levels determined by previous studies of similar small projects.

6. Net monthly evaporation will be assumed to be the difference between gross monthly evaporation and monthly precipitation. An incomplete record of precipitation generally exists for specific streams. This record will be completed with precipitation recorded from nearby stations and transferred to the stream basin using ratios of mean annual precipitation. Evaporation losses at small projects are estimated using the total annual net evaporation. Evaporation losses at the larger projects will be estimated by monthly simulation.

As is readily apparent from this list of assumptions, the reliability of values will be small and the cost and time required to gather the needed information may be large. Generally, the determination of historical water usage to facilitate the calculation of development flows has not yet reached an acceptable level of confidence in the water resource community. In fact the general consensus of professionals interviewed (e.g. USGS and DNRC personnel) in preparation of this plan, was one of skepticism regarding the utility of adjusting historical flows to the 1978 level of developments, especially when the flows have been simulated. Their skepticism does not rise from the concept but rather from a consideration that simulation of flow data is in itself only an estimate and further adjustment to an estimate may be meaningless. Basically, for this reason, the plan does not propose to address the adjustment to 1978 level of development. In further support of this position, it should be recognized that the Board's Order establishing minimum-flow instream quantities for all other streams was based upon historical flow records. Thus adjusting the streams designated in this plan to a 1978 level of development would make the values generated inconsistent and incomparable to the other streams. Further, the Board's Order states quite explicitly that all reserved rights (including minimum-flow instream) are "subject to . . . prior existing water rights . . ." Thus, the 1978 level of development, although not specifically reflected in the minimum-flow instream quantities, is accounted for by the Board's Order.

III. RECOMMENDED PLAN

A. General Plan

The first phase of the plan is to compile and evaluate the adequacy of the available information and data for each stream or stream segment. This information will include available streamflow records for the streams to be analyzed and nearby, long-term gaging stations, and basin characteristics such as precipitation, drainage area, mean basin elevation, percent forest cover, main channel slope and soil storage index.

For streams with currently active USGS gaging stations that are expected to continue in the future and almost have ten years of consecutive streamflow records, the plan will be to wait until ten years of data are available and then proceed with the preparation of frequency curves and determination of the appropriate minimum-flow instream quantity. For some streams, the inadequacy of the data will become apparent during this phase. The area of inadequacies will suggest the level of data collection activities needed, and data collection programs (e.g., establishment of stream gaging stations) can be developed for these streams at an early date.

The next phase will involve an attempt to use modeling techniques to generate the necessary monthly flows for all the remaining streams. After simulation of the appropriate monthly flows, frequency curves will be prepared for each month and the flow quantities for the granted minimum-flow instream percentile exceedence levels will be determined. The frequency curves will be prepared using the Log Pearson Type III method (Ref. 4).

A summary of the streamflow data available for the various streams is given in Table 2. This table gives the applicable stream reach; the percentile exceedence level granted by BNRC; the USGS station number, designation and period of record of gaging stations on the stream; and any nearby gaging stations.

TABLE 2
Summary of Streamflow Data

Stream and Reach	Percent Flow Granted	Number and Location of Gage[1/]	Period of Continuous Daily Record[2/]	Nearest GS Station With Greater than 10 Years Number and Location	Remarks
Hanging Women-Mouth of E.F.-Tongue	Hist. Min.	6-3076; H.W. nr Birney	73-Present[b]	Tong. R. @ TRD	Tong. R. @ Ashland 67-74; Tong. R. @ Miles City
Otter-Mouth of Bear Ck-Tong. R.	Hist. Min.	3-30774; Otter @ Ashland	73-Present[b]	Tong. R. @ TRD	Same as above
Pumpkin-Mouth of Deer Ck-Tong. R.	Hist. Min.	6-3084; Pumpkin nr M.C.	73-Present[b]	Tong. R. nr M.C.	
Rosebud-Mouth of Cottonwood to Y.R.	80%	6-29525; Rosebud nr Colst.	73-Present[b]	Yellowstone @ M.C.	
		6-296003; Rosebud @ Mouth	73-Present[b]	Yellowstone @ M.C.	Rosebud nr Forsyth (49-53); Rosebud @ Rosebud
Clarks Fork Yellowstone	90% 70%[3/]	6-2075; C.F.Yell. nr Belfry	21-Present		Some records published as "at chance"
		6-2088; C.F. Yell. @ Edgar	21-69		Some records: Clarks Fork @ Fromberg (04-13)
		6-2088; C.F. Yell. nr Silesia	70-Present	Yellowstone @ Blgs.	Not equivalent to "@ Edgar"
Butcher-Headwater-W. Butcher-Mouth	85%	6-2043; Butcher nr Absarok.	61-62[c]	(35-69) Rosebud nr Absarok.	
Willow-Forest Boundary to Cooney	85%	6-2115; Willow nr Boyd	37-70[c]	Rock Ck @ Joliet	Seasonal; Rock Ck @ (Rockvale-9 yrs, Red Lodge)
Red Lodge-Custer For. Boundary to Cooney	85%	6-2110; Red Lodge nr Boyd	37-70[c]	Rock Ck @ Joliet	Same as above.
Clear Ck - Headwaters to Mouth	85%	None	N/A[c]	Rock Ck @ Joliet	Also known as Alkali Ck; Rockvale 9 yrs; Red Lod.
Dry Ck - Headwaters to Mouth	85%	None	N/A[c]	Rock Ck @ Joliet	Rock Ck @ Rockvale 9 yrs Rock Ck nr Red Lodge
Rock Ck - Custer For. Bndry. to Mouth	85%	6-2095; Rock Ck nr Red Lodge	34-Present[b,c]		
		6-2135; Rock Ck @ Joliet	46-53[c]	Rock Ck nr Red Lodge	
		; Rock Ck @ Rockvale	34-40[c]	Rock Ck nr Red Lodge	
Sage Ck-Headwater to Crow Reserv.	85%				Nr Warren? nr Pryor? (Custer Forest Service)
Bluewater-Headwaters to Mouth	85%	6-2078; nr Bridger	60-70[c]	Clarks Fork @ Edgar	
		; @ Fromberg	61-64[c]	Clarks Fork @ Edgar (70-76)	
Castle Ck Abv Picket Pin to Mouth	85%	; nr Nye	72-73(I)[a,b,c]	Stillwater @ Nye	
Picket Pin-Swamp Ck to Mouth	85%	None	N/A[b/c]	Same as above	

TABLE 2 (continued)
Summary of Streamflow Data

Stream and Reach	Percent Flow Granted	Number and Location of Gage1/	Period of Continuous Daily Record2/	Nearest GS Station With Greater than 10 Years Number and Location	Remarks
W.F Stillwater-Tumble Ck to Mouth	85%	; blw Castle Ck	70-73 (I)^{a,b,c}	(70-76) Stillwater @ Nye	
		; at Nye	70-72 (I)^{a,b,c}	Same as above	
L. Rocky Ck-Fst. Bndry. to Mouth	85%	; at Nye	70 (I)^{a}	Same as above	
W. Fishtail-R.K. ditch to Mouth	85%	None	N/A^{b,c}	(1965-Present) W. Rosebud nr Roscoe	
E. Fishtail-E.F.E. Fishtail to Mouth	85%	None	N/A^{b,c}	Same as above	
Fishtail-E&W Fishtail Cks to Mouth	85%	; @ Fishtail	72(I)^{a,b,c}	Same as above	
W. Rosebud-Fst Bndy to Fiddler to Mouth	85%	6-20405; nr Roscoe	65-Present^{b,c}		
E. Rosebud-Fst Bndy to W. Rosebud	85%	6-2035; nr Roscoe	20-24^{b,c}	Rosebud nr Absarokee (35-69) W. Rosebud nr Roscoe	
Bridger-Headwaters to Krone Ditch	90%	6-2016; nr Greycliff	60-74 (I)^{a,b,c}		
U. Deer-Headwater to I-90 Brdg	90%	None	N/A		
L. Deer-Headwater to I-90 Brdg	90%	SCS 1969 (I)			
Sweet Grass-Fst Bndry to Mouth	90%	6-2005; abv Melville	13-71(I)		
		6-2010; blw Melville	07-52(I)		
Mission-L. Bear Draw to Mouth	50% 90%	None			
L. Mission-L. Mission Forks to Mouth	50% 90%	None			
Shields R. at Mouth	90%	; nr Livingston	1978-Present^{b,c}	6-1935 (21-67) Shields at Clyde Park	6-1930; Shields @ Wilsall (1935-57)
Smith Ck-Bitter Ck to Mouth	50%	None	N/A^{c}	Shields @ Wilsall (35-57)	Brackett Ck (6-1940) (34-57)
Flathead Ck-S. F. to Mouth	50%	None	N/A^{c}	Same as above	Same as above
Cottonwood Ck-Trespass to Mouth	50%	; @ Clyde Park	1974- (I)^{c}	Shields @ Clyde Park	Same as above
Rock Ck-Smeller to Mouth	50%	; nr Clyde Park	1979- (I)^{c}	Same as above	Brackett Ck (6-1949) (34-57) Bangtail Ck 3/23-6/23
Brackett Ck-Conf. M,N,S to Mouth	50%	6-1940; nr Clyde Park	34-57^{c}	Same as above	Brackett Ck (6-1940) (34-57)
Bear Ck-Fish Ck to Mouth	20% 50%3/	6-1895; nr Jardine	46-49^{c}	6-1910 (38-70) Gardner R. nr Gard.	6-1915 (10-Present) Yellowstone R. @ Corwin Spring
Cinnabar Ck-8S7W32 to Mouth	20% 50%3/	None	N/A^{b,c}	6-1915 (10-Present) Yellowstone R. @ Corwin Springs	6-1918 (73-Present) Big Creek nr Emigrant

TABLE 2 (continued)

Summary of Streamflow Data

Stream and Reach	Percent Flow Granted	Number and Location of Gage[1/]	Period of Continuous Daily Record[2/]	Nearest GS Station With Greater than 10 Years Number and Location	Remarks
Mol Heron Ck-Y. Park Bndy to Mouth	20% 50%[3/]	None	N/A[b,c]	6-1915 (10-Present) Yellowstone @ Corwin Springs	6-1918 (73-Present) Big Creek nr Emigrant
Cedar Ck: N.F. to Mouth	20% 50%	None	N/A	Same as above	Same as above
Tom Miner: Trail Ck to Mouth	20% 50%	None	N/A[b,c]	6-1918 (73-Present) Big Ck nr Emigrant	
Rock Ck: Steele Ck to Mouth	20% 50%	None	N/A[b,c]	Same as above	
Big Ck: Bark Cabin to Mouth	20% 50%	6-1918; nr Emigrant	73-Present[b,c]	6-1919 (10-Present) Yellowstone @ Corwin Springs	
Six Mile: N.F. to Mouth	20% 50%	----; nr Chico	77(I)[c]	6-1918 (73-Present) Big Ck nr Emigrant	
Fridley Ck: Needle Ck to Mouth	20% 50%	None	N/A[c]	Same as above	6-1920 (51-56) Mill Ck nr Pray
Eight Mile: N.F. to Mouth	20% 50%	----; nr	77(I)[c]	6-1920 (51-56) Mill Ck nr Pray	
Mill Ck: E.F. to Mouth	20% 50%	6-1920; nr Pray	(51-56)[b,c]	6-1925 (37-Present) Yllwstn nr Livingston	6-1918 (73-Present) Big Creek nr Emigrant
		----; nr mouth	77(I)[c]		
		----; abv diversion	77(I)[b,c]		
Trail Ck: 3S8E35 to Mouth	20% 50%	None	N/A[b,c]	6-1925 (37-Present) Yllwstn nr Livingston	6-1918 (73-Present) Big Creek nr Emigrant
Suce Ck: Lost Ck to Mouth	20% 50%	None	N/A	Same as above	Same as above
Coke Ck: Minor Ck to Mouth	20% 50%	None	N/A	Same as above	Same as above
Billman Ck: 2S8E20 to Mouth	20% 50%	None	N/A[b,c]	Same as above	Same as above
Fleshman: Perkins to Mouth	20% 50%	None	N/A[b]	Same as above	Same as above
Armstrong Spring: Origin to Mouth	10% 50%	None	N/A[c]	Same as above	Same as above
Nelson Spring: Origin to Mouth	10% 50%	None	N/A	Same as above	Same as above
McDonald Spring: Origin to Mouth	10% 50%	None	N/A[c]	Same as above	Same as above
Emigrant Spring: Origin to Mouth	10% 50%	None	N/A[c]	Same as above	Same as above

Notes:
1. The number is the USGS station number and location is the USGS location description.
2. The superscripts, a,b and c refer to sporadic data collected by the USGS, the WQB or the MDFWP, respectively (I) indicates intermittent data collection.
3. The split percentile refers to the nonirrigation and irrigation season, respectively.

B. Specific Plan

Table 3 shows a list of the streams grouped according to the amount of continuous, consecutive streamflow record available. Those streams listed in column A should not need a collection program for flow data. Sufficient data presently exists to determine the desired flows for these streams.

For Hanging Woman, Otter, Pumpkin, Rosebud (Yellowstone) and Big Creeks only three more years of record are required. These are currently active stations and should be continued. No other data collection should be required and the necessary analysis can be performed when the additional data becomes available.

As Table 2 reflects, only a small number of the remaining streams in columns B and C of Table 3 would probably have sufficient data to yield acceptable results from modeling techniques without the collection of additional data. Therefore the hydrologic technique proposed for these streams is the method developed by H. C. Riggs (Ref. 4). This method would require the collection of concurrent flow data once monthly for a year from both the streams to be analyzed and the streams to be used as the nearby, long-term gaging stations. This will not require the installation of a USGS type continuous recording station. The needed flow data can be obtained from instantaneous measurements taken monthly and semi-monthly during the high flow period. For those streams where some data exists, collection may only be necessary in those months with no or too little data. The selection of the appropriate long-term station to be used for a specific stream will be based on a favorable comparison of drainage basin characteristics. For example, similar flow densities may indicate the appropriateness of the long-term station. Frequency curves are developed for the long-term stations. A relationship is then determined between the concurrent flow value for the long-term station and the appropriate percentile exceedence level flow quantity from the frequency curve. This relationship is then applied to the concurrent flow value for the stream being analyzed to yield an estimate of the percentile flow quantity. Figure 1 schematically shows the proposed method. When possible the Riggs method will be used on two long-term stations to verify the validity of the procedure.

TABLE 3
Stream Grouping According to Available Flow Data

A Streams With 10 or More Years of Record	B Streams With Less Than 10 Years of Record	C Streams With No Streamflow Record
Willow Creek (no winter record)	Hanging Woman Creek	Clear Creek
Red Lodge Creek	Otter Creek	Dry Creek
Rock Creek	Pumpkin Creek	Castle Creek
Bluewater Creek	Rosebud Creek (Yellowstone)	Little Rocky Creek
W. Rosebud Creek	Butcher Creek	West Fishtail Creek
Sweet Grass Creek	Picket Pin Creek	East Fishtail Creek
Brackett Creek	W.F. Stillwater Creek	Bridger Creek
Clarks Fork Yellowstone	Mainstem Fishtail	L. Deer Creek
	E. Rosebud Creek	U. Deer Creek
	Cottonwood Creek	Mission Creek
	Rock Creek (Shields)	L. Mission Creek
	Tom Miner Creek	Smith Creek
	Rock Creek (Upper Yellowstone)	Flathead Creek
	Big Creek	Mol Heron Creek
	Fridley Creek	Cedar Creek
	Mill Creek	Six Mile Creek
	Shields River at mouth	Eight Mile Creek
	Bear Creek	Suce Creek
		Coke Creek
		Armstrong Spring Creek
		Nelson Spring Creek
		McDonald Spring Creek
		Emigrant Spring Creek
		Cinnabar Creek
		Trail Creek
		Billman Creek
		Fleshman Creek
		Sage Creek

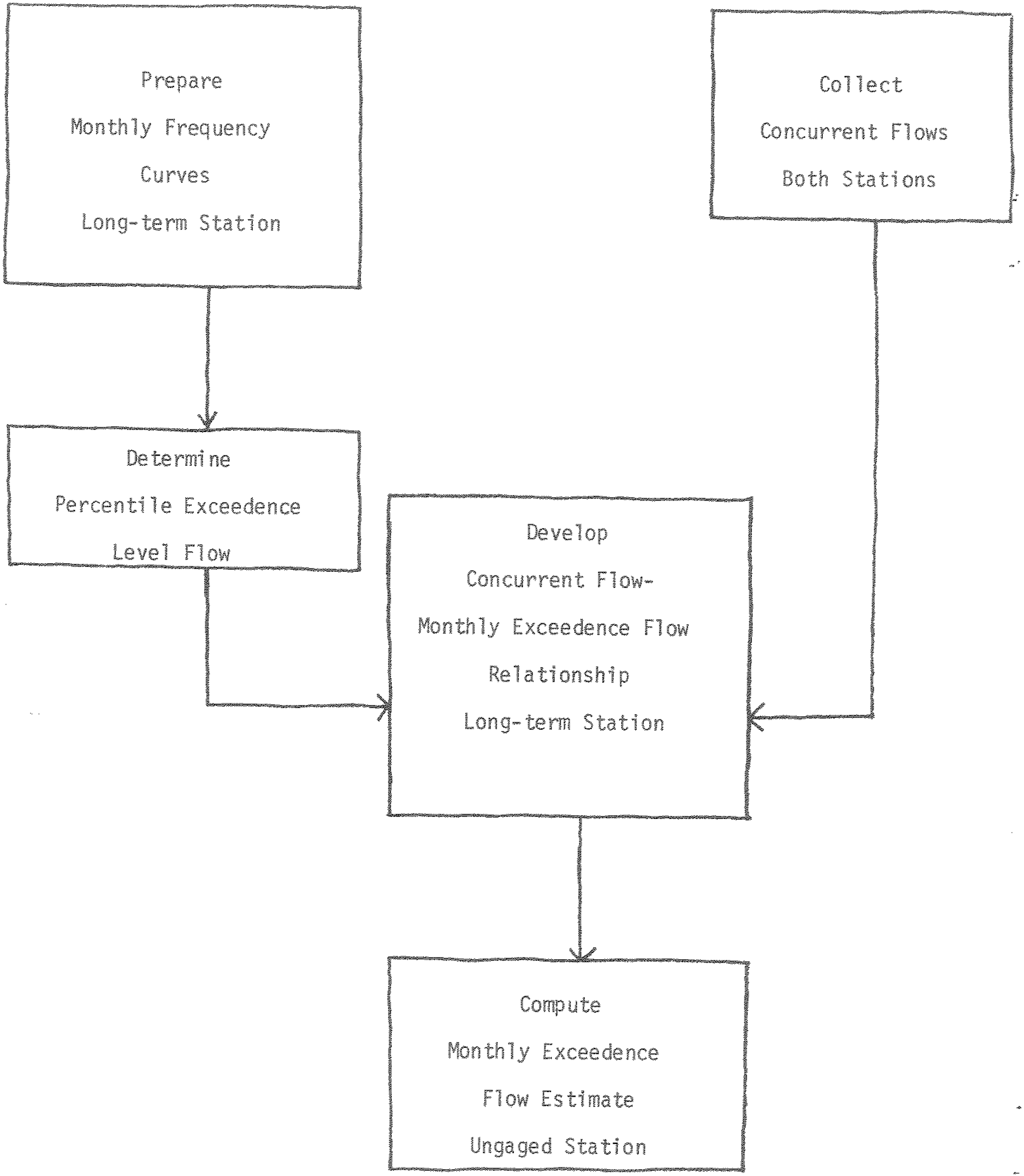

Figure 1. Schematic of the Riggs method.

Because of the close proximity, and general similarity of basin characteristics for the streams in the upper Yellowstone basin, few if any, should require any more of an intense data collection program than that prescribed by the Riggs method (Ref. 4). However, spring-fed streams such as Armstrong, Nelson, McDonald and Emigrant Spring Creek may not be amenable to the Riggs method. A more intensive data collection program may be required (e.g. operating a gaging station for a year or two or making frequent measurements for several years). The data collection program will be directed toward the use of one of the other hydrologic modeling techniques. If no acceptable technique can be found, then establishment of a USGS type stream gaging station is warranted.

References

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Riggs, H. C. 1968. Mean Streamflow From Discharge Measurement, U.S. Geological Survey, Washington D.C.

STATE OF MONTANA

DEPARTMENT OF

FISH AND GAME

1420 East Sixth Ave.
Helena, MT 59620
December 22, 1980

Rich Moy
Dept. of Natural Resources
& Conservation
Helena, Montana 59620

Dear Rich:

Enclosed is a copy of a proposed methodology for converting instream percentile flows granted on certain Yellowstone tributaries to cubic feet per second and acre-feet per month as required by condition 116B of the Board's Order Establishing Water Reservations for the Yellowstone Basin. This methodology was prepared by Systems Technology Inc. of Helena in consultation with DNRC and USGS.

At this time we are requesting that you review the final plan and indicate your approval with a letter of concurrence. If you have any problems or questions with the proposed methodology, please contact myself or Dick Karp. We would appreciate a response by January 12, if possible. Thank you.

Sincerely,

Larry G. Peterman
Water Resources Supervisor
Ecological Services Division

LGP/mac

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

THOMAS L. JUDGE, GOVERNOR 32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872 HELENA, MONTANA 59601

January 12, 1981

Larry G. Peterman
Water Resource Supervisor
Department of Fish, Wildlife
and Parks
1420 E. Sixth Ave.
Helena, Montana 59621

Dear Larry:

I have read and reviewed the plan to convert the minimum-flow instream reservations on the Yellowstone River into cubic feet of water per second and acre-feet of water per month using hydrologic modeling techniques, as per, the Board's Order, specifically condition 116(b). My only suggestion is that there should be a provision for evaluating the Riggs method using existing long-term stations in the area. Aside from this provision, the department concurs with the plan as presented.

Sincerely,

Rich

Richard Moy, Chief
Water Sciences Bureau

RM/DK/mb

UPDATE OF LEGAL PROCEEDINGS RELATED TO YELLOWSTONE RIVER WATER RESERVATION

This section provides further information on legal and administrative occurrences since December 15, 1979. In the December 1979 report, the conclusion noted that petitions for review of two District Court cases were continuing. These court cases were City of Billings v. Department of Fish and Game, et al. and Utah International v. Department of Fish and Game, et al. It was reported that settlement of the city of Billings case was close. Settlement of this case has occurred and subsequent Board action taken thereon.

On August 12, 1980, the State District Court in Billings took final action on the settlement. In the interest of avoiding litigation on the dispute with the city of Billings with the resultant cost and expenditures and time and money, all parties to the petition for review agreed that evidence presented may support some upward adjustments in the amount of reservation of water for the city of Billings, which can be effected without undue sacrifice to the interests and needs served by the parties defended. It was further agreed and understood that the upward adjustment in the amount of reservation of water for the city of Billings would be met and offset by a consequent downward adjustment in the amounts of water allocated for instream purposes and without detriment or prejudice to the availability of water for noninstream purposes. All is set forth and provided in the Board of Natural Resources and Conservation's order of December 15, 1978. The resultant adjustment in waters was an increase in the reservation to the city of Billings of 12,321 AF/year and a decrease to the Department of Fish, Wildlife and Parks and Department of Health and Environmental Sciences of 12,321 AF/year. The board took cognizance of this order and made adjustments accordingly in November 1980.

The Utah International case is pending. This matter will be stayed until a determination of a separate district case between Utah International and Intake Water Company. That separate case revolves on the issue of whose filing for a water right permit in the Powder River has first priority.

In the Utah International case, hearing on the separation of issues question noted in 1979 was held on January 17, 1980. On January 24, 1980, the court stayed further proceedings in the Utah International case until the Utah-Intake issue was determined.

During this reporting period, the board, of its own motion, reviewed reservations of the DFWP and DHES in the mid-Yellowstone area. The proposal of the board was to increase the availability of water in the mid-Yellowstone reach by reducing the reservations to DFWP and DHES to approximately the 80% exceedence level - water is available 8 years out of 10.

The DFWP responded pointing out that an apparent dilemma exists in the reservation granted for the Yellowstone at Billings with respect to availability of water allocated to the conservation districts. It is generally understood that water must be available eight years out of ten in order to provide an economically feasible irrigation operation for any agricultural operation. Based on this understanding and the recognition that the normal irrigation demands on the Yellowstone during high flow months should not significantly affect waters passing through the system during the spring, together with the second priority for the instream flow for fish, wildlife and recreational purposes, the department determined it would be possible to modify downward the instream reservations to the extent the BNRC has proposed, and at the same time maintain substantial protection for the aquatic resources against the increasingly severe low flow events in the Yellowstone River in that reach. The DHES also responded with a statement of position and objection to the Board's proposed order.

On November 17, 1980, the Board took action as it had proposed and did modify the reservation to the DHES and DFWP in the mid-reach of the Yellowstone River. No other legal or administrative activities took place during this report period. This section was prepared by F. Woodside Wright, legal counsel for the Department of Fish, Wildlife and Parks.

WATER AVAILABILITY - YELLOWSTONE RIVER AT BILLINGS

The Montana Department of Fish, Wildlife and Park's first annual Yellowstone Instream Reservation report contained a section concerned with the question of water availability for the reservations of the conservation districts at and above Billings. The problem as described in the first annual report and contained in the legal section of this report is briefly summarized below:

The Department of Fish, Wildlife and Parks was granted an instream flow reservation for August and September of 4,090 and 3,415 cfs respectively. This corresponds roughly to the 65th percentile flow and means that water in excess of our reservation occurs approximately 65 years out of 100. Flows granted for May, June, and July represent approximately the given second priority in this reach.

The conservation districts at Billings and upstream were granted reservations totaling 207,764 af/yr and were given third priority. To economically develop efficient, full-service irrigation systems, a good water supply is usually considered to be necessary about 8 years out of 10, on the average (Draft EIS Vol. I 1976).

Since these conservation district reservations are junior to the instream reservation, they are subject to a certain water availability constraint. For the months of August and September, the constraint imposed by the 65th percentile instream flow level does not allow for the economic development of the water reserved for the conservation districts in this reach of river.

As set forth in the first annual Yellowstone River report (December 15, 1979), the department favored a downward adjustment of the instream reservation at Billings during the irrigation season to allow for the economic development of the water reservations granted to the conservation districts at and upstream from Billings. An adjustment of the instream reservation at Billings during the irrigation season was suggested which would increase water availability from the 82nd to 91st percentile level while, at the same time, not cause serious degradation of the aquatic and recreational resources in that reach of river (DFWP 1979). At the same time, it was suggested that those lands which are developed for irrigation with waters granted to the conservation district and subject to water availability constraints from July 11 through September 30, would not be subject to water availability constraints from May 1 through July 10. It is recognized that the only real possibility for altering the spring hydrograph and materially affecting channel configuration on the Yellowstone is a mainstem impoundment. Normal irrigation demands on the Yellowstone during the high flow months should not significantly affect the spring hydrograph.

On November 21, 1980, the Board of Natural Resources and Conservation adopted an Order modifying the instream reservations downward at Billings in order to increase water availability for the Conservation District reservations. The instream flow numbers adopted by the Board are in reasonably close agreement with those offered by the department and should accomplish the goal of increasing water availability while, at the same time, not causing serious degradation of the aquatic and recreational resources in that reach of river.

A critical factor in the determination of minimal impact of the proposed instream flow adjustment is the second priority held by the instream flow reservants in that reach of river. With second priority it is possible to modify downward the instream reservation to the extent proposed and still maintain substantial protection for the naturally occurring low flow events. Those low flow events occurring below the minimum established instream flow level should not become more frequent or severe with the development of the conservation district's reservation at and above Billings.

THE TONGUE RIVER

The atypical flow regime that occurred in the lower Tongue River during spring, 1980 provided an opportunity to evaluate the probable impacts of the granted instream flow reservation on populations of sauger and shovelnose sturgeon, sport species which utilize the Tongue River for spawning and rearing. For the Tongue River at its mouth, the DFWP was granted an instream reservation of a minimum flow of 75 cfs. The fish survey and flow data for 1980 strongly suggested that the 75 cfs minimum is totally inadequate for maintaining the sauger and sturgeon spawning runs at existing levels.

Based on past fish sampling efforts during typical flow years, sauger residing in the Yellowstone River begin entering the Tongue River in late March or early April and remain in the river until late May when high runoff flows occur. The erratic and unseasonably low flow regime that occured in spring, 1980 appears to have disrupted the sauger spawning migration and, consequently, eliminated or substantially reduced reproduction for 1980. A report summarizing this data is presently being prepared by the DFWP.

The spawning run of shovelnose sturgeon begins entering the Tongue River in early May in typical flow years. In 1980, sturgeon were not collected until June 9 when the flow was 629 cfs. Flows did not exceed 300 cfs until June 2. Sturgeon remained in the river throughout the June high flow period. In late June, flows decreased to 500 cfs and the sturgeon catch rate declined.

The 1980 flow and fish survey data demonstrated the inadequacy of the instream reservation of 75 cfs for maintaining existing spawning migrations of both sauger and shovelnose sturgeon. In the event the Tongue River Reservoir is expanded, serious consideration should be given to allocating a portion of the additional storage to supplement flows during the spring period.

STATUS OF YELLOWSTONE STUDIES

During the course of the water reservation process on the Yellowstone and the various impact assessments associated with coal development in eastern Montana, a large number of articles, reports and publications were generated. A partial compilation of reports pertinent to the biology of the Yellowstone and its tributaries or to the department's effort to reserve instream flows in the Yellowstone basin was presented in Appendix A.

A portion of the water law pertaining to Reservations of Water states that "The board shall, periodically but at least once every 10 years, review existing reservations to ensure that the objectives of the reservation are being met. Where the objectives of the reservation are not being met, the board may extend, revoke, or modify the reservation." In addition, recent legislation (HB 842 - 1979) confirmed the ability of the Board to reallocate water originally reserved for instream purposes to other qualified reservants. To reallocate reserved water, the Board must determine that "all or part of the reservation is not required for its purpose and that the need for the reallocation has been shown by the applicant to outweigh the need shown by the original reservant."

To meet the instream responsibility during the reservation review period and possible reallocation, several studies are either ongoing or have been initiated to provide necessary data. In addition to the studies referred to above, several recently completed or ongoing projects provide additional sources of data for various parts of the Yellowstone basin. A summary of these projects and reports is provided below.

Upper Yellowstone Instream Flow Study

During the fall of 1980 personnel of the Montana Department of Fish, Wildlife and Parks (DFWP) completed a field investigation that was designed to better define the flow regimes needed to maintain game fish populations of the upper Yellowstone River at acceptable recreational levels. The methodology chosen to derive these flow regimes involves the use of the wetted perimeter-discharge relationship for a composite of channel cross-sections. Wetted perimeter is the distance along the bottom and sides of a channel cross-section in contact with water. As the discharge in a stream channel decreases, the wetted perimeter also decreases, but the rate of loss of wetted perimeter is not constant throughout the entire range of discharges. Starting at zero discharge, wetted perimeter increases rapidly for small increases in discharge up to the point where the stream channel nears its maximum width. Beyond this inflection point, the increase of wetted perimeter is less rapid as discharge increases. The flow recommendation is selected at this inflection point.

This methodology was applied to sites on the upper Yellowstone River near Columbus, Greycliff, Livingston, and Corwin Springs. Five channel cross-sections encompassing various habitat types were established at each of these four sites. Field data were collected at these sites during July through October, 1980. These data are presently being prepared for computer analyses.

Personnel of the DFWP continued in 1980 to monitor fish populations in the upper Yellowstone River. River fish populations between Springdale and Laurel were censused during the summer and fall with a boat-mounted electrofishing unit to determine species composition, distribution, relative abundance and size composition. In addition, the numbers and biomass of trout in river sections near Columbus, Big Timber, Livingston and Corwin Springs were estimated using the mark-recapture method. This population data provides information needed for management purposes and also documents the existing sport fishery resource of the upper river.

Lower Yellowstone River Fishery Study

This work is a compilation and extension of previous studies to quantify flow requirements and assess the impacts of energy development on the aquatic resource of the lower Yellowstone River and its tributaries. A summary of the study is presented.

Chronology of abundance of sauger, tag returns, and distribution of eggs and larvae show that the Tongue and Powder Rivers are two major spawning areas for this species in the lower Yellowstone River system. Sauger larvae were captured in drift nets in the Tongue and Powder Rivers near their mouth, however, no larval sauger were caught in the Yellowstone River upstream from the Tongue. Mature sauger were not abundant in the mainstem between Forsyth (river km 381) and the North Dakota border (river km 26) at a time when spawning concentrations were evident in the Tongue and Powder Rivers. Only one area of sauger reproduction was documented in the mainstem of the Yellowstone River, located downstream from Intake Dam (river km 114). However, this was also a major walleye spawning area; sauger eggs comprised only 2 to 12 percent, depending on year, of the combined walleye-sauger eggs collected from this area. It is evident that recruitment from the Tongue and Powder Rivers are necessary for an abundant sauger population in the lower Yellowstone River.

Walleye are not numerous in the Yellowstone except during April when large numbers migrate out of Garrison Reservoir and move upstream into the Yellowstone River. A spawning area, which supported large numbers of mature walleye and lesser numbers of mature sauger, was documented in 1976 just downstream from Intake Dam (river km 114). In April of 1978, the number of mature walleye on the Intake gravel bar was estimated to be 991 fish per kilometer. In 1980 numbers were suspected to be even higher. Of the 2488 mature walleye and sauger collected from the Intake gravel bar from 1976 to 1980, 24 percent were sauger. Migrant walleye are apparently becoming more numerous in the Yellowstone River and are expanding their spawning range. Intake was the only area where significant walleye reproduction could be documented in 1977 while 14 other spawning sites were located in 1980 including 2 upstream near Glendive (river km 163). Successful walleye reproduction in the Yellowstone River is probably very important to walleye recruitment in the upper reaches of Garrison Reservoir where suitable spawning areas are limited.

Sauger and walleye larvae hatch during the end of April or beginning of May when water levels are beginning to increase from mountain runoff. For this reason, larvae drift downstream for many kilometers. The distribution of larvae and young of year sauger indicate that virtually all sauger hatched in the Tongue and Powder Rivers drift to areas downstream in the Yellowstone. No young of year walleye were collected in the Yellowstone River suggesting that virtually all walleye larvae drift into Garrison Reservoir.

The fact that larval sauger drift downstream indicates they must migrate back upstream to repopulate these areas. Tag returns and age structure of electrofishing samples revealed that this upstream migration does not occur for most sauger until after age I or older. Large concentrations of juvenile sauger were noted from Glendive (river km 145) downstream.

Flows in Tongue River during the time of sauger migration and spawning ranged from 370 to 720 cfs during 1976 through 1979 and were generally above 440. From the ratio of the total number of sauger captured to the number recaptured the same spring, it was determined that numbers of sauger entering the Tongue River each of these four years were very similar. Flows during 1980 were much lower, ranging from 94 to 404 cfs during the spawning run. Numbers of sauger entering the Tongue River in 1980 weresignificantly smaller than each of the previous four years. Maximum numbers of larval sauger drifting in the Tongue River in 1980 were estimated to be one third of that the previous year. A critical low flow of 300 cfs, appeared to cause sauger to migrate out of the Tongue during the middle of the spawning period. This critical low flow was four times the instantaneous discharge allocated for instream purposes (75 cfs).

Optimum flows were predicted for the Intake spawning area for walleye and sauger using observed depth, velocity, and substrate criteria at egg sampling sites. Predicted spawning flows ranged from 6000 to 11,000 cfs. In 1977 and 1978 discharge during time of spawning was usually within these two figures. Numbers of *Stizostedion* sp. eggs were similar these two years. In 1979 flows were as high as 16,800 cfs during the spawning period; maximum egg abundance and number of mature walleye were sharply lower this year. Water temperatures were also 3.5 to 4.0 C lower during the spawning period in 1979 and may have been a contributing factor to the poor reproduction. Allocated instream flows during April for the mainstem at Sidney (river km 56) are 6,808 cfs and should be adequate for mainstem sauger and walleye reproduction.

Fourteen walleye spawning sites in addition to the one at Intake were located during 1980 from near Glendive to the Montana-North Dakota border. Few spawning sites were found downstream from Sidney. None of the sites were as extensive as the Intake spawning area. Spawning flows determined adequate for the Intake spawning area would also probably be sufficient for these other areas.

Both mature and immature sauger tagged downstream from Intake Dam generally migrated upstream from spring to fall. In addition, sauger which spawned in the Tongue or Powder Rivers rear in the Yellowstone either near or upstream from the mouth of these tributaries. A diversion dam at Forsyth (river km 381) appears to partially block this fall migration. Tag returns indicated that only 10 percent of the sauger which migrated as far upstream as Forsyth Dam moved over the dam. Sauger were significantly longer and older upstream from Forsyth Dam than in all sections downstream indicating mostly larger individuals were negotiating the dam. Sauger were 3 to 8 times more abundant in fall electrofishing collections downstream from the dam than upstream.

Estimates of the sauger populations for an 8 km reach of the Yellowstone River at Miles City (river km 298) during fall of 1978 and 1979 were 1981 and 1416 fish, respectively. These estimates as well as other related population statistics will be used to monitor abundance and well being of the sauger population.

Issues of special concern for the sauger population include: (1) low flows, especially in the Tongue and Powder River during the spawning and incubation period, (2) removal of larval sauger as they drift downstream in the Yellowstone River by large scale water diversion projects, (3) the predatory effects of expanding populations of rainbow smelt (which were introduced into Garrison Reservoir in 1972 and captured for the first time in the Yellowstone River in 1980) on larval and young of year sauger.

Tongue River Fishery Study

In April, 1980, a study was completed entitled Vital Statistics and Instream Flow Requirements of Fish in the MONTCO Mine Area of the Tongue River, Montana (Appendix A). This study further investigates the fish populations and instream flow needs of the Ashland-Birney section of the Tongue River. The abstract is presented below.

Abstract

A survey of the fish populations in the Ashland-Birney area of the Tongue River was undertaken during 1978 and 1979 in light of proposed surface coal mining adjacent to the river.

Four study sections were chosen on the river to assess vital statistics of the fish populations. Habitat in the four sections was similar with section three containing higher amounts of instream brush than the other sections. Shorthead redhorse were the most common species in the study area. Downstream drift of larval fish probably accounts for the fact that larger individuals of most species occur in the upstream sections. Smallmouth bass are the prevalent gamefish in the study area. Population estimates indicate a healthy population exists in the study area. Older bass (3+) exhibited an upstream migration during April and May followed by a downstream migration during September and October. Growth was comparable to smallmouth bass in the Tongue River Reservoir and was best in the farthest upstream section (1). Growth of rock bass was similar to other northern latitude waters. The 1975 year class of smallmouth bass was severely depressed by a flood coupled with cool spring and summer temperatures. Condition and survival are similar to the Tongue River Reservoir fish. Tag loss was higher for spring tagged fish than for fall tagged fish. Growth of young of the year was better than other northern latitude waters. Minimum instream flow requirements of the bass were measured for all times of year. Movement of fish into the two primary tributaries was assessed. A discussion of possible impacts of coal mining is included.

LITERATURE CITED

Montana Department of Fish, Wildlife and Parks. 1979. The Yellowstone River Instream Reservation, Dec. 15, 1978 - Dec. 15, 1979. 24 pp.

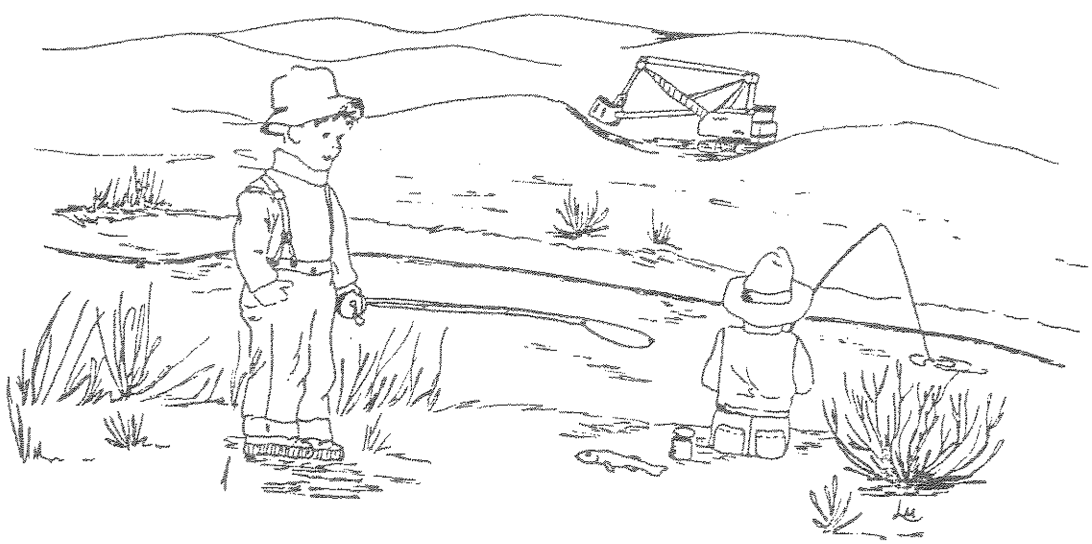
Montana Department of Natural Resources and Conservation. 1976. Yellowstone River basin, draft environmental impact statement for water reservation applications, Volume I. Montana Dept. of Nat. Res. and Conser., Helena. 217 pp.

APPENDIX A

Vital Statistics and Instream Flow Requirements of Fish in the MONTCO Mine Area of the Tongue River, Montana

By

Christopher G. Clancey
Fisheries Biologist
Montana Department of Fish, Wildlife and Parks



Submitted to MONTCO

April, 1980

This report is available upon request.