United States Department of the Interior
OFFICE OF THE SOLICITOR

MAILING ADDRESS:
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DENVER FEDERAL CENTER
DENVER, CO 80225

July 22, 1981

Mr. Robert L. McCarty
490 L'Enfant Plaza East
Suite 3306
Washington, D.C. 20024

Dear Bob:

Pursuant to your telephone request, I am sending the following documents to you and Mr. Roland Fischer.

1. Memorandum of Understanding between Bureau of Reclamation and FWS for Acquiring Biological Data on Colorado River Endangered Fishes.

2. Cooperative Agreement between FWS and National Park Service to Study Endangered Colorado River Fishes in the Yampa River.

3. Geological Survey's Study entitled "Impact of Reservoir Development Alternatives on Streamflow Quantity in the Yampa River Basin, Colorado and Wyoming."

4. Cooperative Agreement between the U.S. Fish and Wildlife Service and the Geological Survey for the above study.

I am expecting the copy of the archeological study by LOPA that was not included in the documents enclosed with your July 9, 1981 letter that I had requested of you by phone.

Thank you for your cooperation in this matter.

Sincerely,

Margot Zallen

Margot Zallen
For the Regional Solicitor
Rocky Mountain Region

Enclosure

✓cc: Roland Fischer (w/encl.)

Contract No. 9-07-40-L-1016

Memorandum of Understanding between U.S. Bureau of Reclamation, Upper Colorado Region, and U.S. Fish and Wildlife Service, Region 6, For Acquiring Biological Data on Colorado River Endangered Fishes

1. This Memorandum of Understanding between the Bureau of Reclamation Upper Colorado Region, hereinafter called the Bureau, and the U.S. Fish and Wildlife Service Region 6, hereinafter called the Service, both being agencies of the United States Department of the Interior, is entered into on this 16th day of April 1979, under Authority of the Economy Act, Section 601 (47 Stat. 417) as amended of the Act of July 20, 1942 (56 Stat 661) 31 U.S.C. 686.

2. The Bureau is developing water resource projects in the Upper Colorado River Basin which will affect and alter the physical and aquatic environment of the Colorado River. The Endangered Species Act of 1973, including the Amendments of 1978, requires the Bureau to consult with the Service where proposed development may result in an impact to an endangered or threatened species or their habitat. If the Service finds that a proposed Bureau action is in or affects an area occupied by an endangered or threatened species, it is the Bureau's responsibility to provide the Service with a biological assessment of the impacts of the proposed action on such species. It is the Service's responsibility, after receiving the assessment data, to provide a biological opinion on the impact of the proposed project on endangered or threatened species. The Bureau and Service are presently in consultation concerning the impacts of various water development projects on the endangered Colorado River fishes, the Colorado squawfish (*Ptychocheilus lucius*) and humpback chub (*Gila cypha*). The Service has conducted preliminary examinations of several Bureau projects under the formal Section 7 consultation procedures, as provided for by the Endangered Species Act of 1973. Conclusions from these initial examinations and other documentation indicate that the proposed actions may jeopardize the continued existence of both fish species. The Service has stressed the need for the Bureau to develop additional data on the habitat requirements of these species; therefore, in order for the Bureau to meet its responsibilities under the Endangered Species Act of 1973 and the Amendments of 1978, additional data are needed. The Service requires this data to prepare biological opinions on those projects where consultation has been initiated and for which biological opinions have not been prepared. Also, data are needed to prepare biological assessments for those projects where consultation has not been initiated.

3. This Memorandum of Understanding will provide for a major funding source and study effort to determine habitat requirements, monitor existing habitats, expand life history information, and facilitate the gathering of biological data on the endangered Colorado squawfish and humpback chub. This information will also be used by the Service to formulate recommendations for the restoration

of the Colorado squawfish and humpback chub in the Colorado River. The studies to be implemented under this Memorandum of Understanding are outlined in the attached work plan. The work plan was formulated in accordance with the Final Colorado River Squawfish Recovery Plan dated March 16, 1978, and the draft Humpback Chub Recovery Plan as submitted in February 1979.

4. The Bureau and Service have determined that the most efficient and cost-effective method for obtaining the needed biological and physical assessment data is for both agencies to work together at their respective Regional Office levels. Specifically, the responsibility of the Service will be to directly acquire data, to technically administer biological contracts for acquiring data, and to coordinate the data-gathering efforts. The Bureau's responsibility will be to provide funding, to provide the contracting capabilities, to actively participate in physical data analysis related to streamflow and Bureau projects, and to insure that data being collected are adequate to fulfill the Bureau's requirements.

5. The purpose of this Memorandum of Understanding is to establish the mechanisum for the Service to organize a team of professional biologists to carry out and oversee the biological and physical data collection on the Colorado River endangered fishes. Specifically, the Service will establish a Colorado River Fishery Project with appropriate personnel. Data gathered by this Colorado River Fishery Project will be used by the Bureau to prepare biological assessments for those Bureau projects where Section 7 consultation on the Colorado squawfish and humpback chub is necessary and not completed. The biological assessments, along with other ancillary information, will provide the Service data from which to make cumulative biological opinions, as required by Section 7. The data from this Colorado River Fishery Project will be used by the Service to prepare biological opinions for individual Bureau project consultations and for cumulative impact biological opinions.

6. The Bureau Agrees:

6.1. To transfer funds to the Service on a reimbursable basis for cost assumed or expenditures made by the Service for carrying out the purposes of this Memorandum of Understanding. Such billings shall not be more often than once a month or less often than quarterly.

6.2. To provide for contracting and transfer to the Service the amount of $500,000 apportioned over fiscal years 1979, 1980, and 1981.

6.3. To apply the funds herein provided to the following activities for Colorado squawfish and humpback chub as described on the attached Table 1 and for other information that may be required as mutually agreed by the Service and Bureau:

(A) Spawning Requirements - Items 1, 2, 3, and parts of 5.
(B) Young and Adult Requirements - Items 1, 2, and 5
(C) Migration and Movement - Items 1 and 2
(D) Interspecific competition - Item 1
(E) Bioassay Studies - Items 1, 2, and 3

6.4. To solicit and execute contracts as deemed necessary with commercial firms or institutions to provide data requirements, major equipment, or project requirements.

X 6.5 To provide physical - chemical data on the waters of the Upper Colorado River and the analytical capabilities to interpret this data as needed by the Service to assess present and future conditions and future conditions with and without water development project(s).

7. <u>The Service Agrees</u>:

7.1 To perform the work as stated in section 6.3. by entering into cooperative agreements, administering contracts, and conducting the data gathering efforts.

7.2. To structure the project organization as shown in the attached Table II, with the Project Office and Project Leader located in Salt Lake City, Utah.

7.3. To delegate to the Project Leader the authority to make decisions regarding the day-to-day administration of this project. The Project Leader will coordinate work with the Upper Colorado Region of the Bureau.

7.4. To establish an Overview Committee that will assist the project leader in setting priorities, and will review and make recommendations to the Service and the Bureau regarding any significant changes in design, scope, timing, and geographical area of the Colorado River Fishery project. The Overview Committee will be limited to five members as agreed to by the Regional Director's of the Service and Bureau, Committee members may be representatives from the Bureau, the Service, Bureau of Land Management, State of Colorado, State of Utah or other agencies or institutions as agreed to by the directors.

7.5. To provide to the Bureau a Project Evaluation and Review Technique (PERT) Chart that will be followed in the implementation of the study. The PERT Chart will be provided to the Bureau as part of this agreement. Any significant changes in scheduled work as defined in 6.3 shown on the PERT Chart would require Bureau approval prior to implementation.

7.6. To provide the Bureau with written quarterly progress reports and hold quarterly meetings or as needed or requested by the Bureau to review progress of those project activities which the Bureau is funding.

7.7. To continue to provide guidance and available information on an informal basis as needed by the Bureau for preparation of biological assessments.

7.8. To provide the Bureau with (a) the data collected under this contract, (b) biological opinions and (c) other available information as needed by the Bureau for each project where Section 7 consultation has been requested. The biological opinions involving the Colorado squawfish and humpback chub will address the particular Bureau project where Section 7 consultation has been requested, and will also provide a biological opinion based on cumulative affects of those projects in the Colorado River Basin that may affect the subject endangered species.

7.9. To consult with the Bureau prior to any key personnel changes and receive the Bureau's concurrence in the selection of, or changes in, the Project Leader.

7.10. To provide the Bureau with a draft report covering those items as outlined in Section 6.3. above by January 1, 1981. The Service shall provide a final report by March 1, 1981.

8. The Service and Bureau Mutually Agree:

8.1. That this Colorado River Fishery Project will be initiated immediately upon execution of this Memorandum of Understanding and shall remain in effect until March 31, 1981.

8.2. That the project study period and dates scheduled for the draft and final reports may be extended upon agreement of both parties.

8.3. That there will be an annual project and financial review in September of each year that this agreement is in effect.

8.4. That the following procedure will be followed in the event of any major disagreement between the Service, the Bureau, the Overview Committee, or the Project Leader: (a) The subject of the Disagreement shall be documented in writing in the form of a memorandum, (b) the memorandum shall be transmitted to the Regional Directors of the Bureau and the Service, and (c) the disagreement shall be resolved by negotiation between those officials.

8.5. That this Memorandum of Understanding may be terminated upon 90 days' notice from either party.

Nelson W. Plummer
Regional Director, UCR
Bureau of Reclamation
Department of the Interior

Nelson W. Plummer
April 16, 1979
Date

Harvey Willoughby
Regional Director, Region 6
Fish and Wildlife Service
Department of the Interior

Harvey Willoughby
April 12, 1979
Date

Table 4 (Continued)

BIOLOGICAL INFORMATION	Fish Species	Field (F) Hatchery (H) Lab (L)	Size of Fish (mm)	Geographic Area	Months to Work	Time To Complete	Special Considerations
2. Use stomach analysis to determine food requirements. Use preserved fish in various collections. Also use fish captured in this study by taking stomach contents, without sacrificing fish.	All four species	F&L	All sizes	All areas fish taken and wherever preserved specimens are curated.		1-2 years	Relate food taken to various times of the year.
3. Using fish from hatchery operation determine stamina and peak swimming speeds for various sizes of fish. Need to accelerate and expand hatchery operation to raise test fish.	All four Species	H&L	Need to concentrate effort on smaller size fish	Any hatchery or lab which has facilities to test fish	NA	1 year	Bonytail chub needs to be taken to hatchery immediately for propagation work
4. Do feeding tests on various size fish at hatchery to determine what natural foods are taken most readily. Relate this information to the insitu situation.	All four Species	H	All sizes	Hatchery where fish being held or propagated	NA	2 years	
5. Use SCUBA or snorkelling gear to visually record where fish found. Measure major habitat parameters.	Colo squawfish Humpback Chub Bonytail chub Razorback sucker	F F No known viable field population of riverfish available for study. F	All sizes All sizes All sizes	Green R, UT; Colo R. CO; B.R. Colo R. CO; Little Colo R.AZ Green R. UT; Colo R.,CO.	low flow low flow low flow	1-2 years 1-2 years 1-2 years	
C. Migration and Movement							
1. From Section A. record movement of adult spawning fish. Tag all fish large enough to tag, which are captured under A. & B. with numerical type spagetti tags.	All four species	F	>150	Green R, UT; Colo R., CO; Little Colo R, AZ	concentrate on spring movements Mar-Jul	2-4 years	
3. Sample in Yampa, White, Upper Green and Upper Colorado Rivers specifically to capture fish large enough to tag. Employ a spaghetti type tag or similar tag with individual numbers.	All four species	F	>150	Yampa-below Maybell; White-lower 40 mi.; Upper Colo-below DeBeque	All four seasons	2-4 years	
D. Interspecific competition							
1. Under objective A,B,&C record all species of fish found together. Analyze data statistically to determine if correlations exist between occurance of endangered species and the occurance or non-occurance of other species.	All four species	F	All sizes	All areas sampled under A, B, C	NA	2-4 years	

Table 1 - Biological Information Needs of Four Endemic Colorado River Fishes

BIOLOGICAL INFORMATION	Fish Species	Field (F) Hatchery (H) Lab (L)	Size of Fish (mm)	Geographic Area	Months to Work	Time To Complete	Special Considerations
A. Spawning requirements							
1. Tag adult fish Use radio tags as will be prescribed from VELVI contract study or individual numbered spagetti tags. After tagging follow tagged fish by radio, seining, trapping, and underwater observation.	Colo squawfish	F	>450	Green R., UT	May-Aug	2 summers	Use radio tags
	Humpback Chub	F	>250	Little Colo R., AZ; Black Rocks (B.R.) on Colo R., Colo	May-Aug	2 summers	Use spagetti type tags
	Bonytail Chub		(No known viable field population of river fish available for study)				
	Razorback Sucker	F	>300	Green R. UT, Colo R. Colo	Apr-Aug	2 summers	Use spagetti type tags
2. Take habitat measurements where spawning size fish move, rest, and spawn. Parameters to record would be flow, substrate, temperature, turbidity, T.D.S, area of stream.	Colo squawfish	F	>450	Green R. UT	May-Aug	2 summers	
	Humpback Chub	F	>250	Little Colo R. AZ, B.R. on Colo R, CO	May-Aug	2 summers	Procedures should conform to I.F.G. guidelines for electivity curves
	Bonytail Chub		(No known field population of river fish available for study)				
	Razorback Sucker	F	>300	Green R., UT; Colo R, CO	Apr-Aug	2 summers	
3. Measure habitat parameters where young-of-the-year (yoy) are found. Use seining to sample backwater areas. Also electrofish downstream into a blocking seine where possible. Record same habitat parameters as given in # 2.	Colo Squawfish	F	<60	Green R., UT	Aug-Nov	2 falls	
	Humpback Chub	F	<60	Little Colo, AZ, B.R.on Colo R, CO	Aug-Nov	2 falls	
	Bonytail Chub		(No known viable field population of river fish available for study)				
	Razorback Sucker	F	<60	Green R. Ut; Colo R. CO	Aug-Nov	2 falls	
4. Use adult fish now in a hatchery or get fish into hatchery to record spawning data. Using recirculating water with temperature control and selective bottom types in 1 or 2 raceways, document spawning behavior, temperature when spawning occurs, and what type of bottom is selected.	Colo Squawfish	H	>450	Appropriate Hatchery	NA	2-3 years	Could use Columbia R. squawfish for basic data
	Humpback Chub	H	>250		NA	2-3 years	
	Bonytail Chub	H	>250		NA	2-3 years	
	Razorback Sucker	H	>300		NA	2-3 years	
5. Determine egg survival under various conditions, ie. temperature, substrate etc. Use endangered or threatened species if eggs available, if not use similar species. Can be correlated with No. 4 above.	All four species	H&L	NA	Appropriate Hatchery	NA	1-2 years	Could use Columbia R. squawfish or roundtail chub for some basic data
B. Young and adult requirements							
1. Sample by all possible means; seines electrofishing, trammel nets, trap nets, etc., for various sizes of fish. Record all pertinent habitat parameter measurements where fish taken as in (A-2).	Colo Squawfish	F	60-450	Green R, UT; Colo R., CO	Sample all four seasons	2 years	Area should include tributaries such as White and Yampa Rivers for all species
	Humpback Chub	F	60-250	Little Colo, R.,AZ; B.R.-Colo R., Colo, Green R., UT	"	2 years	
	Bonytail Chub	F	60-250	Green R., UT	"	?	
	Razorback Sucker	F	60-300	Green R, UT; Colo R., CO	"	2 years	

BIOLOGICAL INFORMATION	Fish Species	Field(F) Hatchery(F) Lab (L)	Size of Fish (mm)	Geographic Area	Months to Work	Time To Complete	Special Considerations
2. Do controlled competition tests with endangered-threatened species of different sizes and the various exotic species. Particular emphasis should be placed upon the more numerous exotics and on the introduced game fish species. Work will require accelerated hatchery program to raise test specimens.	All four species	H&L	Do various Sizes	Hatchery or lab equipped to do this type of work	NA	2-4 years	Colorado squawfish and humpback chubs should be done first.
3. Do feeding tests on the effect of endangered or threatened species feeding on the various exotics. Particular emphasis should be placed upon the potential adverse effects of feeding on spiny rayed fishes such as channel catfish, bullheads, walleye, and other exotic species, which now reside in the Upper Colorado River system.	Colo squawfish Humpback Chub Bonytail chub	H&L H&L H&L	>150 >150 >150	Could do in hatchery where fish being reared or in appropriate lab	NA	2-4 years	
C. <u>Bioassay Studies</u>							
1. Do LD-50 tests on fry and young-of-year for temperature, T.D.S., and trace elements.	All four species	L	<60	At appropriate lab	Jul-Dec	2-4 years	Availability of test fish could cause problems. Use related species if necessary
2. Do LD-50 tests on eggs also. If no threatened or endangered species eggs available use closely related species.	All four Species	L	NA	At appropriate lab	May-Aug when eggs available	2-4 years	Could use Columbia River squawfish and roundtail chub if necessary for basic data on these generic type of fish
3. Do bioassy tests on subadults and adults (fish over 1 year old) for temperature, T.D. S., and selected trace elements.	All four Species	L	>60	At appropriate lab	NA	2-4 years	Use as starting point for squawfish research. The bioassay work at Univ. of Idaho on the development of fish toxin "squaxin"

BIOLOGICAL INFORMATION	Fish Species	Field(F) Hatchery (H) Lab (L)	Size of Fish (mm)	Geographic Area	Months to Work	Time To Complete	Special Considerations
F. Propagation and Rearing Techniques							
1. Experiment in hatchery on best way to propagate endangered and threatened fish.	All four species	H	NA	Appropriate hatchery	NA	2-4 years	
a. Develop egg taking techniques							
b. Test various flow, temperature, substrate, etc. on egg & fry survival							
c. Use similar species if adult endangered species are not available.							
2. Develop disease treatment technique for the various life stages.	All four species	H	All sizes	Appropriate Hatchery	NA	2-4 years	
G. Disease and Parasites							
1. All fish collected in field will be inspected and parasites taken for analysis. Also, analyze fish specimens which exhibit definite symptoms of being diseased.	All four species	F&L	All sizes	Compare geographic areas as stated in sections A, B, and C	NA	1-2 years	
2. From preserved specimens in collection record incidence of parasitism and correlate with types of parasites now found.	All four species	L	All sizes	Compare by geographic area of collections	NA	1-2 years	
3. Correlate from F(above) parasites and diseases which occur in hatchery to that found in wild.	All four species	H&L	All sizes	All areas where samples available	NA	NA	

14-16-0006-81-931(IA) J-X

ITEM 2 M. Zallen letter of July 22, 81 → RLM

COOPERATIVE AGREEMENT

Between

U. S. FISH and WILDLIFE SERVICE

and

NATIONAL PARK SERVICE

To Study Endangered Colorado River Fishes in the Yampa River

1. INTRODUCTION and BACKGROUND

The Yampa River is the largest free-flowing tributary of the Green and Colorado Rivers in remaining without major modifications. Extending from the headwaters near Steamboat Springs, Colorado to its confluence with the Green River, the Yampa flows from Deerlodge Park to the confluence within the confines of Dinosaur National Monument (see attached map).

Previous workers have reported that Colorado River endangered fishes use the Yampa River during certain times of the year. Colorado squawfish have been documented upstream as far as Milk Creek, a distance of approximately 125 river miles. Humpback chub have been found upstream in the Yampa River as far as Cross Mountain Canyon, about 60 river miles upstream from its mouth. Bonytail chub have not been found in the Yampa River in recent years, however, they were reported to be common in the lower river during the 1960s.

The Yampa River cannot be separated from the Green River when discussing Colorado River endangered fishes. The Green River downstream of the Yampa is of extreme importance to the Colorado River fishes and has continually been shown to be an area where all life stages of the fish occur. Also, a Colorado squawfish tagged in the Green River was recaptured 52 miles up the Yampa. The Green River downstream of the Yampa exists in a semi-natural state today because of the contribution of water from the Yampa.

There is presently a rush for water development in the Yampa River drainage. The proposed Juniper Cross Mountain Project consists of two reservoirs with a combined storage capacity of 1,291,000 acre feet. The project would cause a minimum depletion of 60,000 acre-feet annually of reservoir evaporation, and could set the stage for ultimate depletion of approximately 400,000 acre-feet annually by making additional diversions possible. The Cheyenne Water Project is proposing to divert 24,000 acre-feet from the headwaters of the Little Snake River, a major tributary of the Yampa River. Power production, some under construction, near Craig, Colorado will use approximately 20,000 acre-feet per year and may request additional water in the future. Because of increased energy development in the basin, we expect additional water demands besides those mentioned.

With the present rush for development on the Yampa and upper Green Rivers, it is imperative that biologists and hydrologists determine water flow requirements for these endangered Colorado River fishes. Of critical importance is the need for the National Park Service to define specific flow requirements for Dinosaur National Monument. An important consideration [illegible] needs of the endangered Colorado River fishes.

Because of the mutual needs of the National Park Service and the FWS, these two agencies are cooperating in this study of the Yampa River. The FWS will conduct the field work and data analysis and NPS will provide assistance in the form of personnel, funding, and other logistical support.

The Colorado Division of Wildlife (DOW) is presently monitoring the Yampa River relative to Colordo squawfish habitat changes as required in the Colorado Squawfish Recovery Plan. The FWS plans to coordinate efforts with the Colorado DOW in conducting this Yampa River study.

2. AREA OF STUDY

The area of study will include the Yampa River from Craig, Colorado downstream to the confluence with the Green River, the Little Snake River from its confluence with the Yampa River upstream to a distance of 30 miles, and the Green River from the mouth of the Yampa River downstream to Split Mountain.

3. TIME OF STUDY

A literature review will be done in March - April 1981, and all previous data summarized. Field work will begin in April and continue through October 1981. Data summarization and analysis will be done in November - December and a final report will be completed by January 15, 1982.

4. OBJECTIVES

The overall objective is to determine the importance of the Yampa River for maintenance of the endangered Colorado River fishes and to delineate stream flows needed to sustain these fishes. Specific objectives are as follows:

a. Determine distribution and relative abundance of Colorado squawfish and humpback chub in the Yampa River and in the Green River within Dinosaur National Monument.

b. Obtain information on possible reproduction of Colorado squawfish and humpback chub in the Yampa River.

c. Determine habitat requirements of Colorado squawfish and humpback chub in the Yampa River and Green River within Dinosaur National Monument.

d. Determine extent and significance of movement of Colorado squawfish and humpback chub in the Yampa River - Green River study area.

e. Determine the effect of various flows in the Little Snake and Yampa Rivers on important habitats of the Colorado squawfish and humpback chub in the Yampa and Green Rivers.

5. METHODOLOGY

a. Biological Data:

To evaluate reproduction of endangered fish in the Yampa River, intensive sampling for young fishes will be conducted throughout the study area during the 1981 field season. The primary sampling gear for this effort will be seines. Spawning sites and movement will be investigated by radio telemetry of 10-20 adult Colorado squawfish and humpback chubs. Fish would be implanted in April. Monitoring would be intensified during spawning periods: May for humpback chubs and July - August for Colorado squawfish. Electrofishing will be employed to catch adult fish in the Green and Yampa Rivers within the study area. These fish will be implanted with an appropriate radio tag, held for a week, then released near the point of capture. Efforts will be made to track fish on an intensive basis during the spawning period. Also, attempts will be made to recapture tagged fish during spawning. Habitat used for spawning would be described in detail and reproductive success would be monitored by making collections of young and larval fishes as described above.

Movement and potential migration of fishes within the study area will be investigated using radio telemetry. In addition, all endangered fish larger than 150 mm will be tagged with a Carlin dangler tag having a specific number code. Recapture of these fish throughout the study area will assist in determining extent of fish movement and habitat preferences.

To determine the type of habitat utilized by the endangered Colorado River fishes, extensive fish sampling will be done throughout the study area. This sampling will be done using seining, electrofishing, trapping, netting, and any additional means possible. Sampling will be done systematically using a stratified sampling design. The mix of the various species will be recorded and documented in line with the ongoing Colorado River Fishery Project in the Green and Colorado Rivers. Habitat preference data will be gathered on all endangered fishes encountered in this study. This will include preferences for water depth, water velocity, water temperature, substrate and presence or absence of other fish species.

Special investigations will be made of the humpback chub population known to exist in the Cross Mountain area. This effort may be done by Colorado DOW or a combined effort by Colorado DOW and FWS.

b. Hydraulic Data:

Relationship of flow to endangered species habitat will be examined using the FWS Instream Flow Group (IFG) Methodology. Two IFG stations will be set up in the Green River study area and at least one additional station in the Yampa River.

Integration of habitat data and biological data to determine flow needs will be done by FWS personnel involved in the study. This work will be done from June through September.

6. EXPECTED RESULTS

Results will describe the magnitude and significance of endangered fish use of the Yampa River. Important habitat areas will be identified and described. Changes in habitat with flow will be described. Use of the Yampa River by endangered fish will be related to the overall Green River population and use.

Flow and habitat needs of the endangered fish will be keyed to 1) the Lily Park area immediately upstream of Dinosaur National Monument, 2) the Juniper Cross Mountain area, and 3) the Echo Park area of the Green River.

7. U.S. FISH AND WILDLIFE SERVICE RESPONSIBILITY

The U.S. Fish and Wildlife Service will conduct the above study providing manpower, equipment, and support in the amount of approximately $137,500.

8. NATIONAL PARK SERVICE RESPONSIBILITY

In order for this study effort to succeed, the full cooperation of the NPS is needed. NPS will need to provide or permit the following:

a. Funding in the amount of $12,500 for support of fishery biologist to function as assistant field team leader from March 1, 1981 to January 15, 1982.

b. Two boatmen to work with the project from April 1981 to October 1981.

c. Some office, storage, and living space for FWS workers. Living accomodations for a YACC helper, and a team of 2-3 bio aids on a part-time basis if such accomodations are not required by other regular park operations.

d. Permit the low-level flying over the river of a radio receiving search plane, up to one or more flights per week.

e. Permit the temporary stopping of river floating for up to 1/2 day while stream flow measurements are made. This will be during the July - September period.

f. Transportation assistance in moving personnel and equipment within the monument.

g. Establish and run a water discharge staff gauge and thermograph at both Deerlodge Park on the Yampa River and Echo Park on the Green River.

h. Purchasing of equipment will be done by FWS with the cooperation and input from NPS personnel. Technical representative contact for the NPS will be Steve Petersburg at Dinosaur National Monument, and Jim Reid of the NPS Regional Office in Denver. Equipment purchased by the NPS will remain the property of NPS following completion of the study.

i. The FWS Project Leader (CRFI) will work directly with the Park Superintendent concerning details of the above.

9. COORDINATION WITH COLORADO DIVISON OF WILDLIFE

Our efforts will benefit greatly from assistance by Colorado DOW. FWS project personnel will coordinate study efforts with Tom Lytle, Colorado DOW in Grand Junction and Charles Haynes, Colorado DOW in Fort Collins. The following will be attempted:

a. Use of Colorado field teams in April - May to assist in capturing adult fish for radio tagging.

b. Employment of one Colorado DOW field team from March to June to conduct fish sampling above Lily Park on Yampa.

c. Coordinate with Colorado DOW crew from July to October in sampling for larval and young of endangered fish.

d. Coordinate with Colorado DOW to have the State people take lead in efforts to work with humpback chub in Cross Mountain area of Yampa. FWS would supply some of equipment and one man as necessary to assist DOW efforts in Cross Mountain.

10. REPORTS

Reports will be provided to FWS, NPS, and Colorado DOW on a regular schedule. The first quarterly report will be completed June 1, 1981 and include accomplishments to date and any problem areas that may be evident. A second quarterly report will be due September 15 and will briefly outline accomplishments to date. A draft final report will be due December 15, 1981 and a final report will be due January 15, 1982.

James B Thompson
Regional Director, NPS

Don W. Minnich
Regional Director, FWS

4/3/81
Date

4/3/81

Date

Contracting Officer, U.S.F.W.S

Attachment

Equipment [illegible]:

1 - Aluminum electrofishing frame for [illegible] raft.
1 - Chatooga raft and frame
1 - Mewalk raft and frame
2 - 16' flat bottom boats and trailers
2 - 25 hp outboards
2 - 16-20' plastic whitewater canoes with floatation
1 - 15 hp long shank outboard
3 - 4x4 pickup trucks
1 - Flatbed trailer
2 - 16' fiberglass p[illegible]
[illegible] - Cameras
[illegible] - Velocity [illegible]
[illegible]
1 - Hach turbid[illegible]
1 - Hach DO kit
1 - VVP 15 and a[illegible] switches, [illegible]
1 - Generator
6 - Sterns type V life jackets
6 - Waders/hip boots
12 - River bags; 6 large and 6 small
2 - 2-way radios
3 - Radiotracking receivers (2 pinpoint and 1 search, or 3 combination)
3 - Antennae and connections
10 - Fish modules (implantable radiotransmitter/battery combination)
1 - Surgical kit (MS222, surgical instruments, etc.)
- Minor equipment (boat tools, etc.)
- Nets; seines, trammel and gill, dipnets, etc.

Some additional equipment may be required later as conditions and study details require.

Lee - Mike

ITEM 3
M. Zallen letter of
July 22 1981 → RLM

IMPACT OF RESERVOIR-DEVELOPMENT ALTERNATIVES ON STREAMFLOW QUANTITY IN THE YAMPA RIVER BASIN, COLORADO AND WYOMING

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 80-113

Prepared in cooperation with the

U.S. Fish and Wildlife Service

Dept.
Seal

IMPACT OF RESERVOIR-DEVELOPMENT ALTERNATIVES ON STREAMFLOW

QUANTITY IN THE YAMPA RIVER BASIN, COLORADO AND WYOMING

By Jack E. Veenhuis and Donald E. Hillier

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PRELIMINARY REPORT SUBJECT TO REVISION

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Lakewood, Colorado

1980

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, Secretary

GEOLOGICAL SURVEY

Doyle G. Frederick, Acting Director

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METRIC CONVERSIONS

Multiply inch-pound unit	By	To obtain metric unit
inch (in.)	25.40	millimeter
mile (mi)	1.609	kilometer
acre-foot (acre-ft)	0.001233	cubic hectometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second

IMPACT OF RESERVOIR-DEVELOPMENT ALTERNATIVES ON STREAMFLOW QUANTITY IN THE YAMPA RIVER BASIN, COLORADO AND WYOMING

By Jack E. Veenhuis and Donald E. Hillier

ABSTRACT

A total of 35 major reservoirs has been proposed for construction in the Yampa River basin to provide additional water for increasing industrial, irrigation, and municipal uses. Also, one new transmountain diversion and an addition to a second ~~transmountain~~ diversion have been proposed. A multireservoir-flow computer model was used to simulate the effects on streamflow of five potential options, including one representing historic conditions and four representing various degrees of reservoir and transmountain-diversion development. Various combinations of 17 proposed reservoirs and the 2 transmountain diversions were used in the analysis. By varying the percentages (25, 50, 75, and 100 percent) of hypothetical agricultural and transmountain diversions within each proposed reservoir-development option studied, different degrees of water-use allocation were simulated, thus providing results for a greater range of alternatives. The results of these simulations provide water managers and planners with some insight into how proposed surface-water developments will affect streamflow.

The proposed Vidler transmountain diversion would affect streamflow only in the Yampa River subbasin while the proposed addition to the Hog Park transmountain diversion would affect streamflow primarily in the Little Snake River subbasin. Streamflow in tributaries to the Yampa River would be relatively unaffected by the Vidler transmountain diversion although streamflow in all reaches of the Yampa River downstream from the proposed diversion site would be affected to some degree.

More uniform flow regimes throughout the year would result from some of the proposed reservoir-development options. However, existing (1979) minimum streamflows would not be maintained in many instances and for many months there would be no streamflow with the larger percentage water-use allocations.

INTRODUCTION

Historically, the principal use of surface water in the Yampa River basin (fig. 1) has been for irrigation of hay meadows and wheat fields. However, increased energy and economic development in the basin will result in increased use of surface-water supplies for industrial, municipal, and recreational purposes. Because only 57,000 acre-ft of reservoir storage (Steele and others, 1979) is currently (1979) available in the basin, the construction of numerous reservoirs in the basin has been proposed as a means of providing additional surface-water supplies. Proposals include the construction of 35 major reservoirs with a total capacity of 2.18 million acre-ft, which is 41 percent greater than the mean-annual outflow from the basin (Steele and others, 1979). The effects of reservoir development on streamflow and the effects on fish and wildlife habitat need to be determined. Accordingly, the U.S. Fish and Wildlife Service requested that the U.S. Geological Survey determine the effects of potential reservoir configurations and various allocations for irrigation and transmountain diversions on the quantity of streamflow throughout the Yampa River basin.

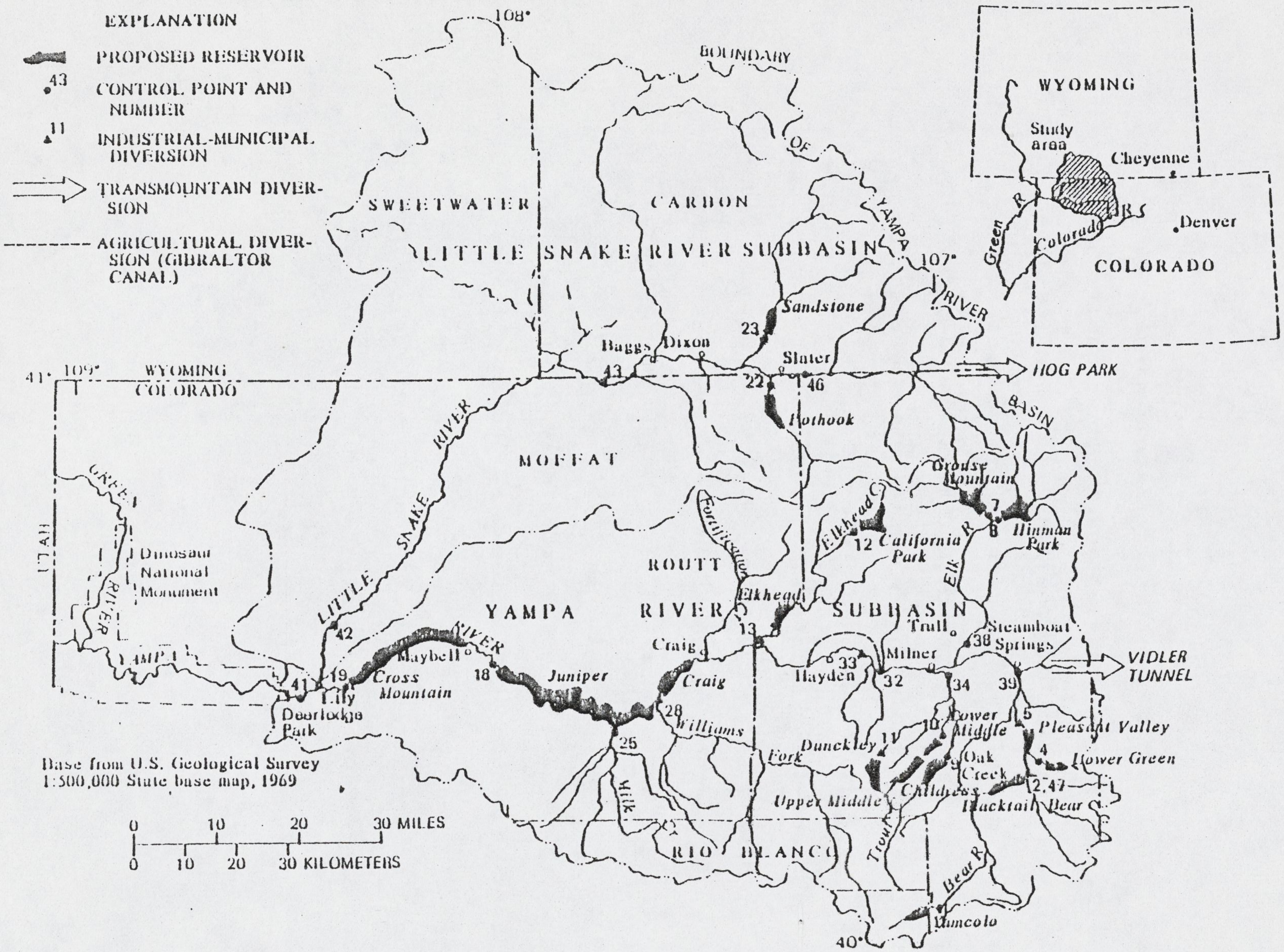

Figure 1.--Location of some representative proposed reservoirs and control points used in multireservoir-modeling analysis.

In this study, a multireservoir-flow model was used to simulate the effects of various configurations of 17 proposed reservoirs, and 1 proposed transmountain diversion and an addition to a second transmountain diversion, on streamflow in the Yampa River basin. The 17 proposed reservoirs are the larger of the total 35 reservoirs being considered for construction in the basin. Whereas the geohydrologic characteristics of the Yampa River basin are well known, the physical characteristics and operating schedules of the reservoirs and transmountain diversions are speculative, as are the flows resulting from the model simulations. To obtain some knowledge of the possible effects on streamflow, five potential options including one representing historic conditions (no additional reservoir development) and four representing various degrees of reservoir and transmountain-diversion development were studied. This study is an extension of earlier reservoir modeling completed for the Yampa River basin (G. B. Adams, D. P. Bauer, R. H. Dale, and T. D. Steele, U.S. Geological Survey, written commun., 1980).

By varying the percentages of agricultural and transmountain diversions within each proposed reservoir-development option studied, different degrees of development were simulated, thus providing results for a greater range of alternatives. The results of these simulations will provide water managers and planners with some insight into how proposed surface-water developments will affect minimum streamflows.

Results for nine representative control points are presented in this report. Results for the remaining 38 control points may be obtained from the U.S. Geological Survey for the cost of computer and reproduction time.

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MODEL DESCRIPTION

The multireservoir-simulation model used in this study was the HEC-3 multireservoir-flow model developed by the U.S. Army Corps of Engineers (1968) to do multipurpose, multireservoir routing of streamflow within a river basin. For this study, the Yampa River basin was simulated by a series of 47 control points, arranged in downstream order, representing either a reservoir, a diversion or return-flow point, a confluence of streams, or a stream reach where fish and wildlife habitat is of interest. At all reservoir control points, monthly values of net evaporation (evaporation minus precipitation), downstream discharge-channel capacities, and reservoir geometry, including elevation-area and elevation-volume tables, were specified. Storage in each reservoir was divided into six storage and surface-area increments to facilitate approximate simultaneous adjustment of all reservoir levels throughout the basin. Monthly diversions, return flows to the next downstream control point, and estimates of consumptive use were specified at all diversion control points. Between all control points, incremental inflow was computed on the basis of available streamflow records.

DATA AVAILABILITY

Streamflow Records

Daily streamflow records, unadjusted for changes in water use, from 36 streamflow-gaging stations for water years 1910-76 (figs. 2 and 3) were used to compute mean monthly and mean annual streamflow at the stations. Data for periods of no record were synthesized using a least-error, linear-regression technique (A. W. Burns, U.S. Geological Survey, written commun., 1976). The resulting streamflow data were used to: (1) Determine incremental inflows to proposed reservoirs, and (2) determine incremental inflows between all other control points for the 1927-76 model-analysis period.

Either measured streamflow data or a combination of measured and synthesized streamflow data were used to determine what is termed in this report as "historic conditions" for the model-analysis period (water years 1927-76).

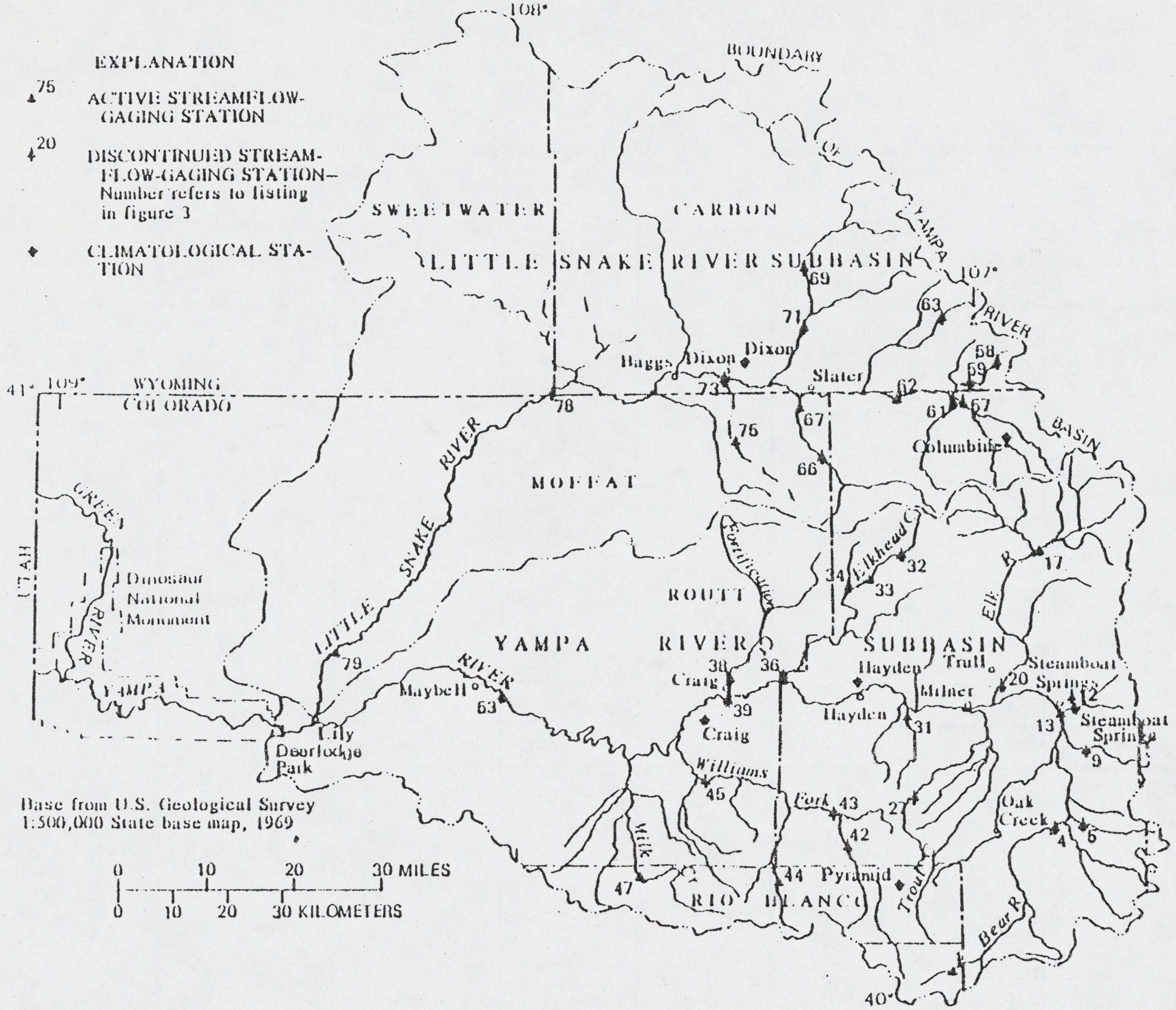

Figure 2.--Location of streamflow-gaging and climatological stations having records used in multireservoir-modeling analysis.

CONTROL POINT (THIS REPORT)	CONTROL POINT (STEELE AND OTHERS, 1979)	U.S. GEOLOGICAL SURVEY STATION NUMBER
--	1	09236000
—	4	09237600
—	6	09237800
—	9	09238600
—	12	09239400
39	13	09239500
—	17	09241000
38	20	09242500
11	27	09244100
33	31	09244410
--	32	09244600
12	33	09245000
--	34	09245600
13	36	09246600
--	38	09247000
28	39	09247600
--	42	09248600
--	43	09249000

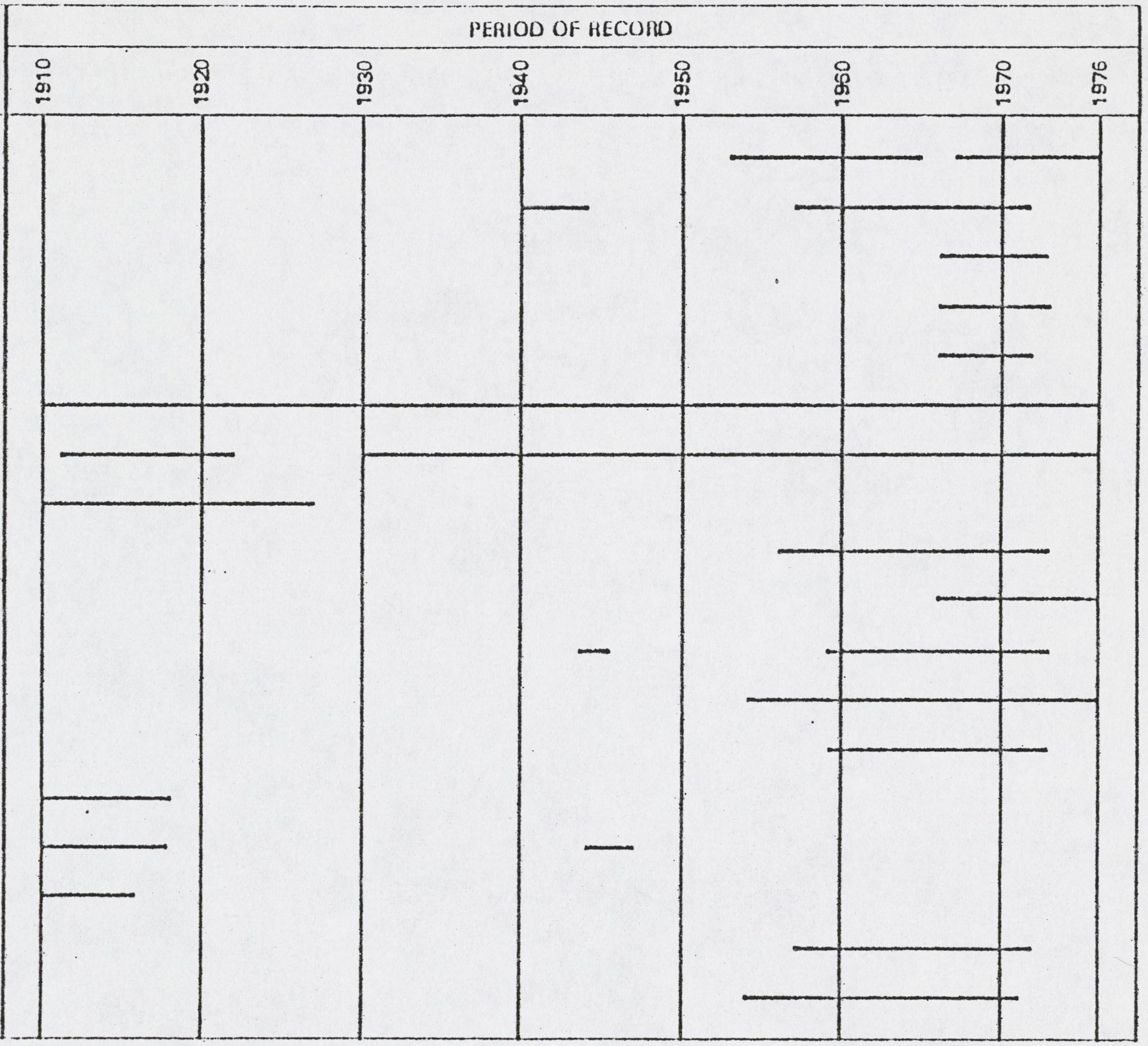

Figure 3.--Periods of record for streamflow data used in the multireservoir-modeling analysis.

CONTROL POINT (THIS REPORT)	CONTROL POINT (STEELE AND OTHERS, 1979)	U.S. GEOLOGICAL SURVEY STATION NUMBER
--	44	09249200
--	45	09249500
--	47	09250000
18	53	09251000
--	57	09251500
--	58	09251800
--	59	09251900
--	61	09252500
46	62	09253000
--	63	09253400
--	66	09254500
22	67	09255000
--	69	09255500
23	71	09256000
--	73	09257000
--	75	09258000
43	78	09259700
42	79	09260000

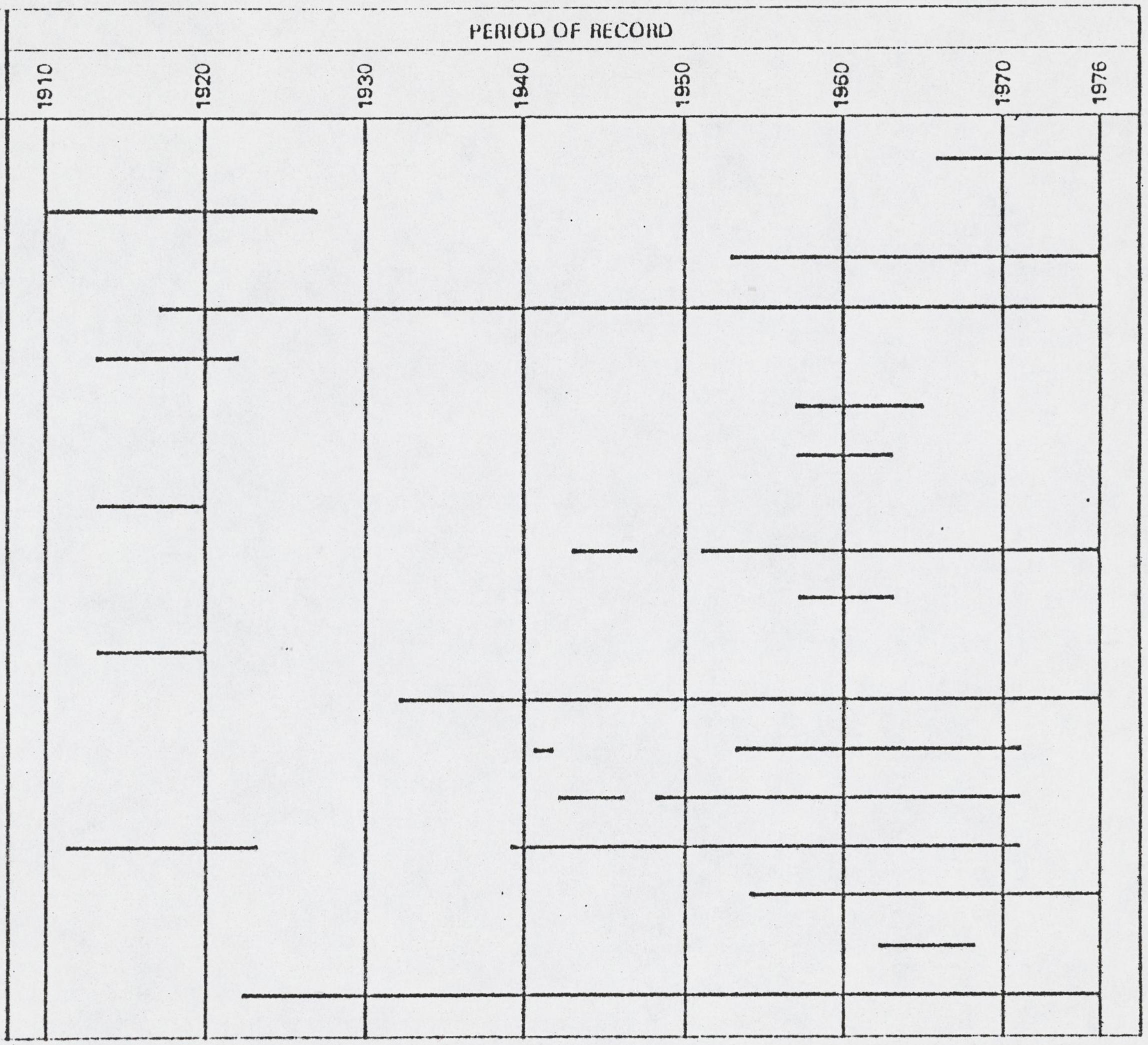

Figure 3.--Periods of record for streamflow data used in the multireservoir-modeling analysis--Continued.

Precipitation Records

Monthly precipitation records for water years 1910-76 from climatological stations operated by the National Weather Service at Columbine, Craig, Hayden, Pyramid, and Steamboat Springs, Colo., and Dixon, Wyo. (fig. 2), were used in the reservoir analysis. Data for periods of no record were synthesized using a least-error, linear-regression technique (A. W. Burns, U.S. Geological Survey, written commun., 1976).

Evaporation Records

Limited evaporation data are available for the Yampa River basin. For this reason, monthly evaporation rates determined for reservoirs in the vicinity of Denver, Colo. (Ficke and others, 1976), were used in the reservoir analysis. Monthly evaporation rates for a reservoir in the Yampa River basin were selected from the data in table 1, based on a comparison of geometric characteristics between one of the Denver-vicinity reservoirs and the reservoir of interest in the Yampa River basin. In many instances, the evaporation rates had to be estimated for November through March as data were not collected for these months because of ice#cover ~~effects~~ (N. E. Spahr, U.S. Geological Survey, written commun., 1977).

Table 1.-- Monthly evaporation rates used for reservoirs in the Yampa River basin [modified from Ficke and others (1976); values for November through March are estimated]

Reservoir near Denver, Colo.	Elevation, in feet above sea level	Monthly evaporation rate, in inches											
		October	November	December	January	February	March	April	May	June	July	August	September
Antero	8,778	3.30	3.30	1.60	0	0	0	0	4.30	4.40	3.80	3.50	3.50
Dillon	9,017	4.50	3.50	1.70	0	0	0	0	3.20	4.00	5.20	5.50	5.90
Elevenmile Canyon	8,597	4.60	4.00	2.00	0	0	0	0	4.00	5.30	5.70	5.90	6.30
Gross	7,282	3.70	3.30	1.60	0	0	0	4.13	4.30	4.70	4.90	5.60	3.80
Ralston	6,046	4.65	4.31	3.44	0	0	0	0	2.97	2.88	2.74	3.07	3.41

Consumptive Use and Existing Surface-Water Diversions

Analyses of existing surface-water rights and diversions indicate that more than 90 percent of the water withdrawals and 96 percent of the consumptive use of water in northwestern Colorado during 1976 was attributed to agricultural irrigation (Knudsen and Danielson, 1977; Gray and others, 1977). Most records of diversions to the hay and wheat fields and pasturelands in the basin are incomplete. However, the effects of most of these diversions on streamflow were accounted for by incremental inflows between control points. Diversions through the Gibraltar Canal from the Yampa River near Hayden, Colo., are documented and were included in the reservoir analysis (table 2).

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Table 2.-- Assumed monthly schedules for Agricultural diversions.

[illegible]ervoir or diversion	Control point in figure 1	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
		Monthly diversions, in thousands of acre-feet											
[illegible]mesta Reservoir	1	0.12	0	0	0	0	0	0.12	0.36	0.40	0.84	0.40	0.[illegible]
[illegible]ear Reservoir	2	.30	0	0	0	0	0	.30	1.16	2.04	2.77	2.04	1.[illegible]
[illegible]ascent Valley Reservoir	5	.36	0	0	0	0	0	.36	1.33	2.36	3.25	2.36	1.[illegible]
[illegible]ckley Reservoir	11	1.30	0	0	0	0	0	1.30	5.40	9.10	12.3	9.10	5.[illegible]
[illegible]lifornia Park Reservoir	12	1.02	0	0	0	0	0	1.02	4.22	7.36	9.80	7.36	4.[illegible]
[illegible]uniper Reservoir	18	33.0	0	0	0	0	0	33.0	150.	230.	310.	230.	[illegible]
[illegible]ross Mountain Reservoir	19	3.70	0	0	0	0	0	3.70	15.0	26.0	35.0	26.0	15.
[illegible] Reservoir	22	.78	0	0	0	0	0	.78	3.08	5.54	7.47	5.54	3.[illegible]
[illegible] Reservoir	23	.45	0	0	0	0	0	.45	1.70	2.90	3.90	2.90	1.7
Craig Reservoir	28	1.60	0	0	0	0	0	1.60	6.60	11.4	15.0	11.4	6.[illegible]
[illegible] Canal 1/	32	1.80	0	0	0	0	0	1.80	7.30	12.7	16.6	12.7	7.[illegible]

1/ Existing diversion schedules.

Reservoir Geometry

Data regarding the geometry of the proposed reservoirs were obtained from Herbert Dishlip, U.S. Water and Power Resources Service (formerly U.S. Bureau of Reclamation, written commun., 1977). Reservoir data obtained included water-surface elevation versus surface area and volume and some preliminary estimates of active storage volumes (conservation pool minus dead storage) for each reservoir. Outflow elevations were generally not available, so estimates were made for dead-storage or conservation-pool elevations. The amount of active storage available for downstream needs was not specified; therefore, for the 100-percent allocation, all available reservoir storage was distributed through the water year. Thus, the 100-percent allocation for each reservoir option represented use of the reservoirs' total storage for diversion purposes.

ALTERNATIVE RESERVOIR CONFIGURATIONS STUDIED

Because it was not economically feasible to model all possible configurations of the 35 proposed reservoirs, 4 representative reservoir-development options for 17 larger proposed reservoirs were chosen as summarized in table 3; the locations of the reservoirs and control points are shown in figure 1. These options are the same as those used in the U.S. Geological Survey's Yampa River basin assessment and include the largest proportion of the total reservoir storage proposed for the basin (D. B. Adams, C. P. Bauer, R. H. Dale, and T. D. Steele, U.S. Geological Survey, written commun., 1980). Using these options, a representative expected range in flow may be simulated for various degrees of reservoir development.

Table 3.--Proposed reservoirs used in model analysis

Option 1	Option 2	Option 3	Option 4	Proposed reservoir	Stream	Proposed storage capacity (acre-feet)
X				Bear[1]	Yampa River	11,610
X	X	X		Cross Mountain[1]	Yampa River	142,000
X	X	X		Juniper[1]	Yampa River	1,079,990
X	X	X	X	Yamcolo[1]	Bear River	9,000
	X	X	X	Blacktail	Yampa River	229,250
	X	X	X	Childress	Trout Creek	24,160
	X	X	X	Lower Green	Green Creek	99,600
	X	X	X	Lower Middle	Middle Creek	25,150
	X	X	X	Pothook[1]	Slater Fork	60,000
	X	X	X	Sandstone[1]	Savery Creek	15,500
	X	X	X	Upper Middle	Middle Creek	102,200
		X	X	California Park[1]	Elkhead Creek	36,540
		X	X	Craig[1]	Yampa River	44,490
		X	X	Dunckley[1]	Fish Creek	57,090
		X	X	Grouse Mountain	Willow Creek	79,260
		X	X	Hinman Park	Elk River	44,040
		X	X	Pleasant Valley[1]	Yampa River	43,220

[1]Proposed diversions for agricultural uses.

Some of the proposed larger reservoir complexes considered for this study include: (1) Juniper and Cross Mountain project (Colorado River Water Conservation District, 1975); (2) Oak Creek Water and Power Project (Oak Creek Power Company, 1976), which includes the following proposed reservoirs: Blacktail, Lower Green, Upper and Lower Middle, and Childress; (3) Savery-Pothook project (U.S. Department of the Interior, 1976); and (4) Yamcolo project (Western Engineers, Inc., ________ 1975). The proposed Pleasant Valley reservoir is an expansion of the existing Lake Catamount Reservoir (Woodward-Clyde Consultants, 1977).

PROPOSED DIVERSIONS USED IN THE MODEL

Proposed diversions associated with reservoir development in the Yampa River basin will be made for agricultural, industrial, and municipal use within the basin, and municipal use outside the basin (transmountain diversions). In the model simulations, the proposed diversions for agricultural use within the basin were varied by using a percentage water-use allocation (25, 50, 75, and 100 percent) of the total or part of active reservoir storage used in each option. The proposed diversions for industrial and municipal use within the basin were assumed to be 100-percent usage throughout the analysis; the proposed transmountain diversions also were varied by the same percentages as the proposed diversions for agricultural use.

Agricultural Diversions

Agricultural diversion for irrigation is one of the largest proposed uses of reservoir storage. An approximate monthly distribution of diversions, most occurring during the growing season, was assumed for all model simulations (table 2). The values shown in table 2 represent 100 percent of the agricultural irrigation water-use allocations from the noted reservoir. For the analysis, it was assumed that the total active reservoir storage was available each year. In the model, it also was assumed that, of the monthly agricultural diversions, two-thirds would be returned to the streams and that one-third would be lost--either by plant evapotranspiration or recharge to the ground-water system. Some agricultural diversion control-point locations are shown in figure 1, but because of the numerous return-flow sites, control points for return flows are not shown in figure 1.

Industrial and Municipal Diversions

Proposed industrial and municipal diversions used in the model are listed in table 4 and the corresponding control points are shown in figure 1; the values in table 4 were not varied during the model simulations. It was assumed that industrial diversions would be completely used in the cooling processes associated with electricity generation at fossil-fueled powerplants. Values for the amount of water needed for cooling per megawatt of electricity produced were adapted from computations by Palmer and others (1977). For example, in a wet-cooling tower, 27,000 acre-ft of water is required for every 2,000 megawatts of electricity generated. For municipal uses, it was assumed that one-third of the diversions would be consumed and that two-thirds would be returned to the streams.

Table 4.--Proposed monthly diversions for industrial and municipal use

Reservoir or diversion	Control point in figure 1	Type of diversion	Monthly diversion (thousands of acre-feet)	Consumptive use (percent)	Remarks
Pleasant Valley Reservoir	5	Municipal	0.91	33	Steamboat Springs, Colo., area.
Dunckley Reservoir	11	Municipal	.60	33	Downstream area.
Elkhead Reservoir	13	Industrial and municipal	.66	100	Cooling water for electric-power generation plant and municipal use in Craig, Colo., area.
Yampa River downstream from Fortification Creek	28	Industrial	.24	100	Cooling water for electric-power generation plant in Craig, Colo., area.
Hayden powerplant	33	Industrial	.60	100	Cooling water for electric-power generation plant.
Blacktail Reservoir	47	Industrial	7.85	100	Cooling water for Oak Creek Water and Power Project.

Transmountain Diversions

Two transmountain diversions from the Yampa River basin have been proposed: The Vidler diversion (Sheephorn project) that would divert about 132,000 acre-ft per year from the eastern part of the Yampa River subbasin to the Denver, Colo., metropolitan area (Robert Moreland, Vidler Tunnel Corp., written commun., 1977), and an addition to the existing Hog Park diversion that would divert about 31,000 acre-feet per year from the eastern part of the Little Snake River subbasin to Cheyenne, Wyo. (Banner and Associates, Inc., 1976). In the model, control point 39 (Yampa River at Steamboat Springs, Colo.) represents the withdrawal point for the Vidler diversion, which will divert water from the Yampa River and six tributaries upstream from Steamboat Springs, and control point 46 (Little Snake River near Slater, Wyo.) represents the withdrawal point for the Hog Park diversion (fig. 1). The monthly schedules assumed for the diversions, which were based on the availability of water during peak-flow months, are listed in table 5.

Table 5.-- Assumed monthly schedules Sor trans-mountain diversions.

Diversions	Control Point	Monthly diversions, in thousands of acre-feet												[illegible]
		Oct.	Nov.	Dec.	Jan.	Febr.	Mar.	Apr.	May	June	July	Aug.	Sept.	[illegible]
Viddler 1/	39	4.70	4.70	4.70	4.70	4.70	4.70	23.6	23.6	23.6	23.6	4.70	4.70	1[illegible]
Hog Park	46	0	0	0	0	0	0	7.75	7.75	7.75	7.75	0	0	3.[illegible]

1/ Also referenced as Sheephorn project.

MODEL VERIFICATION

Because the HEC-3 simulation model has no parameters to calibrate, only verification to gaged streamflow was used to determine the accuracy of its predictive capability for the Yampa River basin. Therefore, a model simulation representing historic conditions with negligible reservoir operations was compared to streamflow records at three streamflow-gaging stations for 50 water years (1927-76). The comparisons between simulated and measured mean annual discharges at the three streamflow-gaging stations are shown in figures 4-6. Simulated discharges were within 5 percent of measured discharges at control point 39 (Yampa River near Steamboat Springs, Colo.) and control point 42 (Little Snake River near Lily, Colo.), and within 20 percent at control point 18 (Yampa River near Maybell, Colo.). The decrease in accuracy for certain locations is partly due to the uncertainty in accurately representing historic irrigation diversions in the model. On the basis of these simulations, it is ~~concluded~~ that the model has been partly verified for the study area.

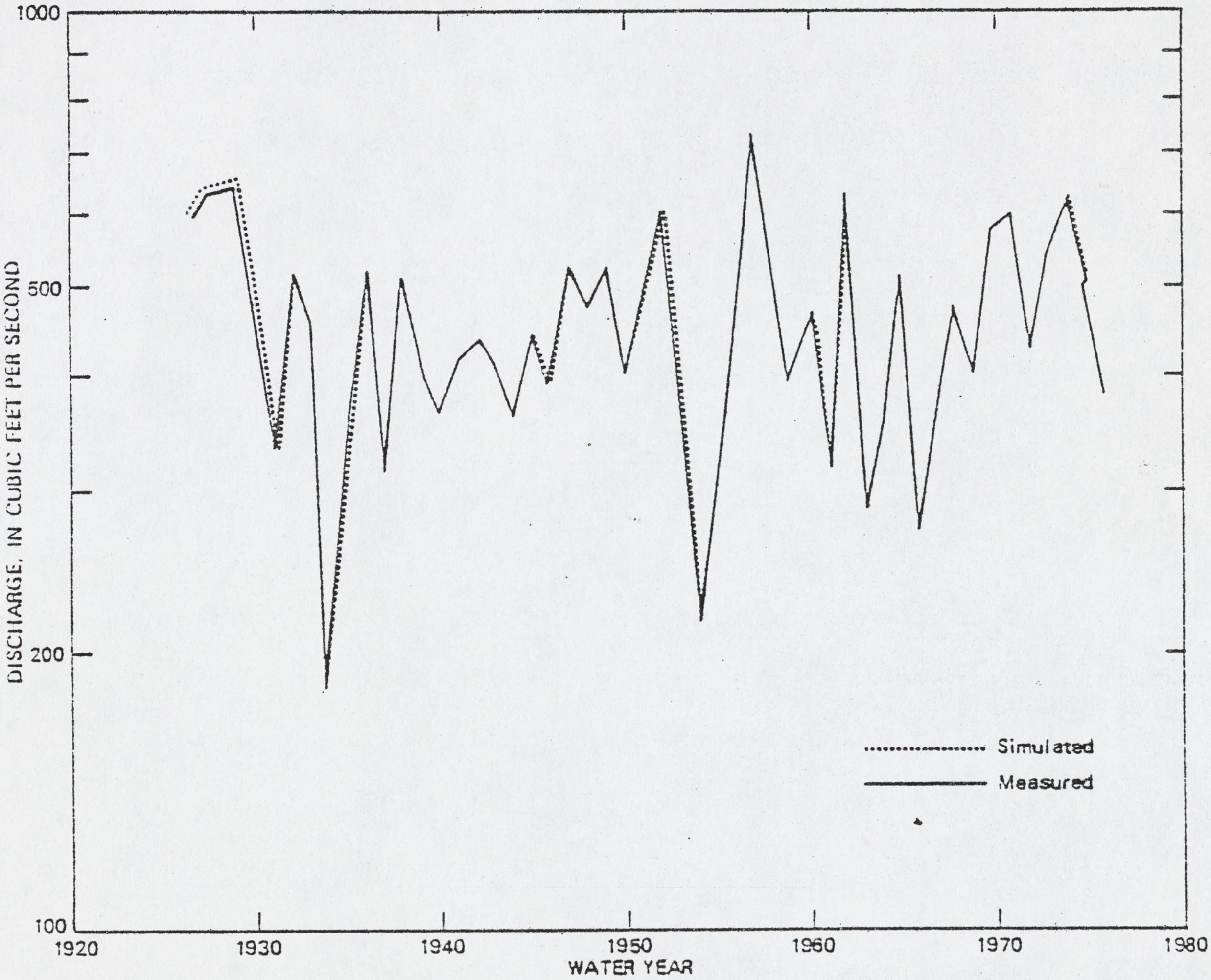

Figure 4. --Simulated and measured mean-annual streamflow at control point 39, Yampa River at Steamboat Springs, Colo., 1927-76 water years.

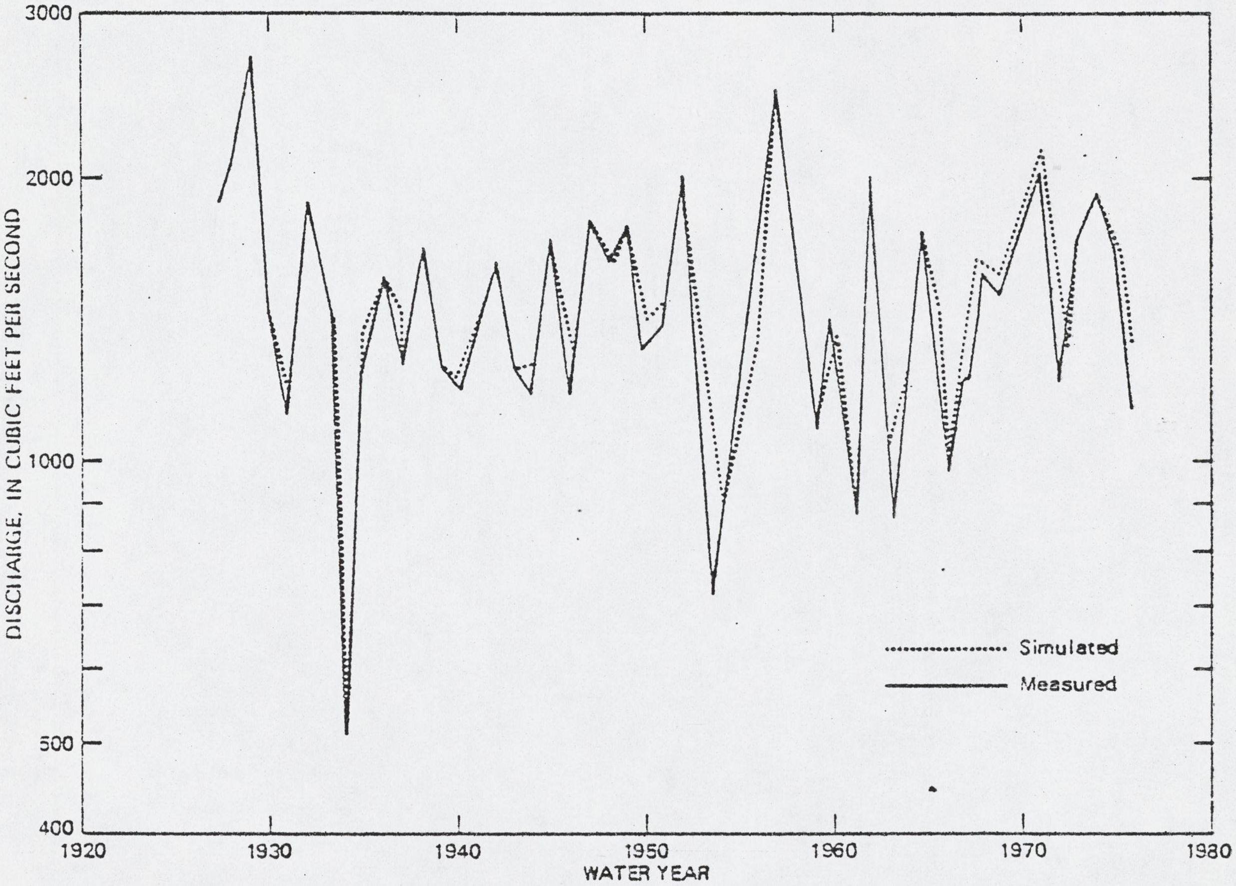

Figure 5.--Simulated and measured mean-annual streamflow at control point 18, Yampa River near Maybell, Colo., 1927-76 water years.

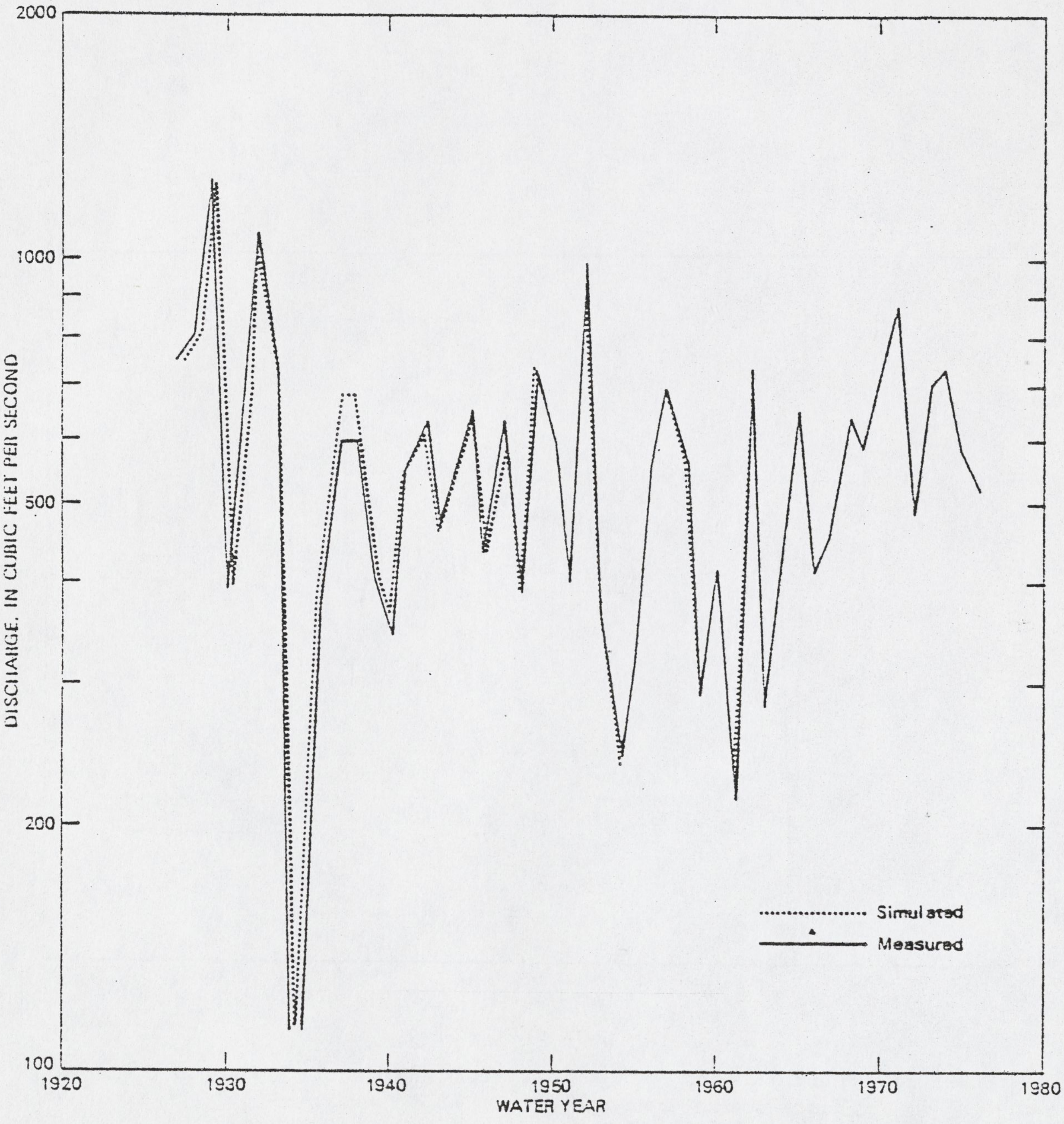

Figure 6. --Simulated and measured mean-annual streamflow at control point 42, Little Snake River near Lily, Colo., 1927-76 water years.

MODEL SIMULATIONS

Model simulations were made for a 50-year period of water years 1927 through 1976. This period was chosen because the period included a wide range of climatic conditions, including the droughts of the 1930's and the 1950's, and because the HEC-3 model is limited to a 50-year interval.

Thirty-four simulations were made to determine streamflow at the 47 control points in the model. The first simulation determined historic conditions without any proposed transmountain diversions or reservoir development. For the second simulation, the assumption was made that only the two transmountain diversions would be in operation. In each simulation, mean, median, and 80-percent exceedence flows, in cubic feet per second, were determined for each month at each control point. The 80-percent exceedence flows are average flows that would be exceeded 80 percent of the months. Statistically, median flows for a given month can be expected to be exceeded once every 2 years, on the average, and the 80-percent exceedence flows can be expected to be exceeded 4 out of every 5 years, on the average.

Simulated monthly streamflows at the 47 control points throughout the Yampa River basin were determined as follows:

A. Historic conditions:

1. Historic conditions without any proposed diversions.
2. Historic conditions with 100 percent of proposed transmountain diversions.

B. Reservoir-development options 1-4:

1. Allocation of 25 percent of total active reservoir storage for agricultural use without any transmountain diversions, and including 100 percent of industrial and municipal diversions.
2. Allocation of 25 percent of total active reservoir storage for agricultural use with 25 percent of proposed transmountain diversions, and including 100 percent of industrial and municipal diversions.
3. Allocation of 50 percent of total active reservoir storage for agricultural use without any transmountain diversions, and including 100 percent of industrial and municipal diversions.
4. Allocation of 50 percent of total active reservoir storage for agricultural use with 50 percent of proposed transmountain diversions, and including 100 percent of industrial and municipal diversions.

5. Allocation of 75 percent of total active reservoir storage for agricultural use without any transmountain diversions, and including 100 percent of industrial and municipal diversions.

6. Allocation of 75 percent of total active reservoir storage for agricultural use with 75 percent of proposed transmountain diversions, and including 100 percent of industrial and municipal diversions.

7. Allocation of 100 percent of total active reservoir storage for agricultural use without any transmountain diversions, and including 100 percent of industrial and municipal diversions.

8. Allocation of 100 percent of total active reservoir storage for agricultural use with 100 percent of proposed transmountain diversions, and including 100 percent of industrial and municipal diversions.

MODEL RESULTS

Results of the model simulations for nine representative control points (table 6) are presented in this section. Four of the control points are at or near streamflow-gaging stations, which permits a comparison with actual conditions in the basin. The model results showing monthly values of mean, median, and 80-percent exceedence flows for each control point are presented in a series of five tables. The first table presents the results of historic conditions without and with transmountain diversions and, where applicable, a summary of the streamflow records for water years 1927-76 from the streamflow-gaging station at or near the control point. The remaining four tables present the results of the 25-, 50-, 75-, and 100-percent water-use allocations of the agricultural diversions with and without the transmountain diversions. For all tables, monthly streamflow statistics less than the corresponding values for historic conditions are underscored to indicate reductions in flow.

Table 6.--Control points for which results of model simulations are presented

Control point	Location	Significance
39	Yampa River at Steamboat Springs, Colo. (at gaging station 09239500)	Gaging-station control; transmountain diversion.
38	Elk River near Trull, Colo. (at gaging station 09242500)	Gaging-station control; fish habitat.
34	Trout Creek at mouth	Fish habitat.
28	Yampa River at Craig, Colo. (downstream from proposed Craig Reservoir)	Industrial and municipal supplies; fish habitat.
25	Confluence of Yampa River and Milk Creek	Fish habitat.
18	Yampa River near Maybell, Colo. (at gaging station 09251000; downstream from proposed Juniper Reservoir)	Gaging-station control; fish habitat.
19	Yampa River near Lily, Colo. (downstream from proposed Cross Mountain Reservoir)	Fish habitat.
43	Little Snake River near Baggs, Wyo. (near gaging station 09254700)	Gaging-station control; transmountain diversion.
41	Yampa River near Deerlodge Park, Colo.	Commitments for Upper Colorado River Compact.

Model-simulated monthly streamflows for control point 39 (Yampa River at Steamboat Springs, Colo.) are presented in tables 7-11. Simulated monthly mean streamflows for historic conditions without proposed transmountain diversions vary from +1 to -8 percent and average absolute variation of 3 percent of the monthly streamflows calculated from streamflow gaging-station records; this indicates that the model can reasonably predict conditions at this control point. The average absolute variation is computed by summing the individual absolute values of percentage variations for a given location and model conditions and then dividing by the number of data points.

The underscored values in tables 8-11 indicate a reduction in the historical flow for any development condition. Only the nonirrigation months of December or January occasionally showed no decrease in flow statistics. Generally, as the reservoir-development options and percentage of water use allocation increased, the flow volume lessened. Reservoir-development option 4 indicated the most significant reduction in flow as a result of the absence of demand from Juniper and Cross Mountain Reservoirs downstream on the Yampa River. Without the demand from these two reservoirs, the flow at this site was reduced and more water remained in the upstream reservoirs.

Simulated streamflow at this control point also showed the potential effects of proposed withdrawals for the Vidler transmountain diversion at the 100-percent water-use allocation level in table 7 and the four options cited in tables 8-11. Reduced streamflow would occur more frequently as the water-use allocation percentages increase. Zero-flow conditions were found to occur most frequently for reservoir-development option 4 for all levels of water-use allocation. Even the historic conditions with 100 percent of the transmountain diversions indicated only zero flow commonly occurring during July.

Table 7.--*Summary of simulated monthly streamflows, control point 39 (Yampa River at Steamboat Springs, Colo.), for historic conditions and with 100 percent of transmountain diversions*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than historic conditions without transmountain diversions]

	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
FLOW VALUES	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
SIMULATED HISTORIC CONDITIONS												
A	130	122	104	100	101	158	669	1716	1760	348	145	101
B	120	119	102	97	98	144	615	1565	1724	276	134	88
C	83	97	87	82	83	111	419	1270	1128	197	92	69
SIMULATED HISTORIC CONDITIONS WITH 100 PERCENT OF TRANSMOUNTAIN DIVERSIONS												
A	53	44	27	23	23	80	286	1325	1373	69	69	28
B	42	41	24	18	19	66	224	1174	1332	0	56	10
C	5	19	9	4	5	-33	28	879	737	0	14	0
CALCULATED STREAMFLOW FROM GAGING-STATION RECORDS												
A	136	126	104	101	104	172	681	1771	1821	345	150	106
B	132	121	100	100	100	159	630	1755	1720	260	136	90
C	87	97	87	82	85	115	428	1288	1074	163	90	66

Table 8.--*Summary of simulated monthly streamflows, control point 39 (Yampa River at Steamboat Springs, Colo.), with 25 percent of agricultural and no transmountain diversions, and with 25 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 7 historic conditions]

OPTION	FLOW VALUES	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	127	110	101	108	99	154	658	1707	1750	353	149	105
	B	105	112	101	102	98	138	607	1554	1717	282	136	100
	C	94	72	79	88	81	111	411	1262	1121	208	108	77
2	A	74	68	62	100	65	100	551	1534	1663	265	79	53
	B	61	57	58	54	52	87	497	1486	1642	181	54	48
	C	39	47	42	39	43	60	307	1197	1029	103	42	24
3	A	65	61	61	59	60	90	551	1609	1655	257	66	52
	B	51	51	56	53	52	75	471	1407	1612	179	52	33
	C	35	37	40	39	38	54	288	1180	1010	111	39	28
4	A	39	37	36	33	35	63	380	1321	1614	201	31	21
	B	33	30	35	31	30	53	349	1282	1585	130	22	15
	C	16	18	17	17	18	34	215	804	938	38	13	3
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	111	84	77	91	76	131	560	1609	1657	263	133	99
	B	96	78	78	87	77	117	508	1451	1619	135	117	92
	C	31	40	52	68	54	90	310	1164	1024	114	92	58
2	A	54	48	42	80	45	80	453	1496	1565	175	59	36
	B	42	38	38	34	33	68	399	1388	1544	83	44	25
	C	20	27	23	20	24	44	210	1099	931	5	22	9
3	A	45	40	40	40	40	69	450	1510	1557	167	46	33
	B	31	30	33	33	32	55	352	1365	1514	83	32	23
	C	16	16	19	19	19	34	180	1082	913	25	19	14
4	A	20	18	16	14	15	44	282	1223	1517	103	12	2
	B	13	11	16	11	11	34	251	1134	1487	32	3	0
	C	0	0	0	0	0	15	117	706	885	0	0	0

MONTHLY FLOWS, IN CUBIC FEET PER SECOND

Table 9.--*Summary of simulated monthly streamflows, control point 39 (Yampa River at Steamboat Springs, Colo.), with 50 percent of agricultural and no transmountain diversions, and with 50 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 7 historic conditions]

OPTION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	123	107	106	110	101	154	656	1693	1742	357	158	108
	B	108	102	105	106	99	138	602	1542	1713	285	144	104
	C	92	73	85	89	82	108	382	1260	1110	210	114	77
2	A	74	68	62	100	64	100-	551	1595	1664	266	79	56
	B	62	57	58	54	52	87	497	1486	1643	182	65	45
	C	40	47	42	39	43	60	308	1198	1030	106	43	30
3	A	61	53	56	57	58	86	526	1580	1637	254	77	55
	B	50	43	52	51	52	73	441	1439	1596	175	64	42
	C	32	33	36	36	38	50	260	1146	987	109	53	33
4	A	39	37	36	33	35	63	375	1270	1597	191	28	21
	B	33	30	35	31	30	53	349	1206	1570	120	22	15
	C	16	18	17	17	18	34	215	756	968	35	13	7
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	93	56	55	73	59	108	449	1498	1545	134	122	73
	B	90	46	59	75	58	95	393	1348	1510	98	116	75
	C	74	14	18	45	33	68	197	1069	919	59	87	34
2	A	36	29	23	21	64	64	357	1399	1469	112	42	21
	B	23	18	19	14	13	48	301	1291	1447	0	25	6
	C	1	8	3	0	4	21	112	1002	835	0	4	0
3	A	25	17	16	19	18	38	314	1369	1436	104	33	21
	B	10	6	8	11	10	25	184	1217	1396	23	21	3
	C	1	0	0	1	2	9	46	913	794	0	0	0
4	A	0	0	0	0	0	24	180	1074	1401	0	0	0
	B	0	0	0	0	0	14	153	1011	1375	0	0	0
	C	0	0	0	0	0	0	20	560	773	0	0	0

Table 10.--*Summary of simulated monthly streamflows, control point 39 (Yampa River at Steamboat Springs, Colo.), with 75 percent of agricultural and no transmountain diversions, and with 75 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 7 historic conditions]

OP-TION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	109	96	95	112	114	147	666	1684	1735	367	163	103
	B	106	91	100	106	100	135	601	1549	1708	293	156	104
	C	63	53	56	85	66	103	422	1257	1125	226	119	61
2	A	66	62	57	95	58	93	530	1577	1668	270	82	55
	B	57	57	52	47	49	85	495	1465	1643	134	67	45
	C	34	32	38	32	29	50	292	1146	1032	108	45	31
3	A	55	45	43	46	44	147	456	1493	1634	276	88	50
	B	44	34	42	45	43	64	387	1373	1592	208	77	42
	C	27	25	27	26	28	44	231	1065	1013	122	61	27
4	A	39	37	36	33	35	63	371	1221	1581	184	27	21
	B	33	30	35	31	30	53	349	1145	1552	109	22	15
	C	16	18	17	17	18	34	215	712	954	35	13	7
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	46	29	24	34	48	107	406	1394	1445	120	94	39
	B	39	10	11	28	32	82	381	1257	1404	32	93	23
	C	0	0	0	0	0	36	172	963	828	0	21	0
2	A	16	13	9	8	51	37	236	1270	1380	74	28	6
	B	0	0	0	0	0	15	118	1145	1354	0	8	0
	C	0	0	0	0	0	0	0	847	752	0	0	0
3	A	16	11	6	7	8	19	188	1163	1349	82	32	15
	B	0	0	0	0	0	2	64	1038	1309	0	0	0
	C	0	0	0	0	0	0	0	722	719	0	0	0
4	A	0	0	0	0	0	5	78	928	1288	0	0	0
	B	0	0	0	0	0	0	55	852	1259	0	0	0
	C	0	0	0	0	0	0	0	419	661	0	0	0

Table 11.--*Summary of simulated monthly streamflows, control point 39 (Yampa River at Steamboat Springs, Colo.), with 100 percent of agricultural and no transmountain diversions, and with 100 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 7 historic conditions]

OPTION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
						WITHOUT TRANSMOUNTAIN DIVERSIONS							
1	A	90	90	84	121	136	146	682	1689	1739	370	145	88
	B	83	69	70	108	98	137	639	1552	1707	306	148	66
	C	45	48	46	49	49	67	423	1265	1133	225	73	45
2	A	54	49	47	83	48	78	469	1542	1670	277	80	46
	B	42	40	41	37	41	67	399	1414	1643	193	69	23
	C	18	20	22	20	24	35	236	1131	1034	110	30	7
3	A	52	46	38	37	37	107	414	1442	1670	294	86	45
	B	39	33	37	35	34	59	371	1371	1614	212	74	22
	C	18	19	20	20	21	34	218	1033	1105	133	20	9
4	A	39	37	36	33	35	63	370	1175	1565	178	25	21
	B	33	30	35	31	30	53	349	1083	1530	109	22	15
	C	16	18	17	17	18	34	215	654	940	35	13	7
						WITH TRANSMOUNTAIN DIVERSIONS							
1	A	7	0	2	23	34	85	349	1304	1356	76	59	5
	B	0	0	0	0	7	62	252	1182	1312	0	21	0
	C	0	0	0	0	0	9	124	879	740	0	0	0
2	A	2	2	3	1	35	22	133	1142	1283	48	18	2
	B	0	0	0	0	0	0	0	1043	1252	0	0	0
	C	0	0	0	0	0	0	0	679	643	0	0	0
3	A	9	6	3	0	0	10	65	1053	1307	76	37	17
	B	0	0	0	0	0	0	0	949	1275	0	0	0
	C	0	0	0	0	0	0	0	618	708	0	0	0
4	A	0	0	0	0	0	0	0	784	1174	0	0	0
	B	0	0	0	0	0	0	0	691	1139	0	0	0
	C	0	0	0	0	0	0	0	263	549	0	0	0

Model-simulated monthly streamflows for control point 33 (Elk River near Trull, Colo.) are presented in tables 12-16. Simulated monthly streamflows for historic conditions without proposed transmountain diversions vary from +1 to -25 percent and an average absolute variation of 11 percent of the monthly streamflows calculated from streamflow-gaging-station records.

Table 12.--*Summary of simulated monthly streamflows, control point 38 (Elk River near Trull, Colo.), for historic conditions and with 100 percent of transmountain diversions*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than historic conditions without transmountain diversions]

FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
	SIMULATED HISTORIC CONDITIONS											
A	84	76	79	76	90	146	580	1911	2082	498	85	57
B	83	79	80	75	89	143	561	1873	2129	443	82	54
C	46	47	62	56	79	118	420	1476	1646	137	55	29
	SIMULATED HISTORIC CONDITIONS WITH 100 PERCENT OF TRANSMOUNTAIN DIVERSIONS											
A	84	76	79	76	90	146	580	1911	2082	498	85	57
B	83	79	80	75	89	143	561	1873	2129	443	82	54
C	46	47	62	56	79	118	420	1476	1646	137	55	29
	CALCULATED STREAMFLOW FROM GAGING-STATION RECORDS											
A	109	91	85	79	89	156	633	1995	2149	552	113	74
B	110	91	86	78	86	146	580	1955	2170	482	100	74
C	57	60	69	55	76	116	434	1488	1574	206	62	37

Table 13.--*Summary of simulated monthly streamflows, control point 38 (Elk River near Trull, Colo.), with 25 percent of agricultural and no transmountain diversions, and with 25 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 12 historic conditions]

OP-TION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
							WITHOUT TRANSMOUNTAIN DIVERSIONS						
1	A	98	88	88	85	94	147	546	1850	2078	510	105	75
	B	95	90	89	81	93	144	529	1800	2123	448	103	75
	C	61	62	75	65	83	121	397	1393	1646	159	77	50
2	A	110	88	87	87	93	146	547	1823	2068	513	118	87
	B	112	91	89	87	93	143	529	1742	2098	447	116	86
	C	84	59	69	64	82	120	397	1376	1646	172	99	67
3	A	173	164	163	158	165	200	490	1423	1854	555	212	172
	B	180	167	165	160	167	200	461	1326	1831	469	215	176
	C	146	147	155	148	160	183	372	1032	1498	285	182	146
4	A	76	68	77	80	97	153	580	1905	2069	485	75	50
	B	73	71	79	80	97	152	561	1866	2117	430	72	48
	C	41	43	57	51	88	125	425	1464	1637	121	47	24
							WITH TRANSMOUNTAIN DIVERSIONS						
1	A	100	88	88	85	94	146	547	1842	2075	515	108	76
	B	95	90	89	81	93	144	529	1781	2105	451	105	76
	C	69	62	75	65	83	121	397	1394	1646	178	79	51
2	A	112	86	85	86	91	145	547	1814	2064	521	124	90
	B	119	90	89	87	91	143	529	1740	2092	450	126	93
	C	90	58	69	56	79	120	397	1376	1646	202	109	59
3	A	248	230	227	221	229	308	491	1419	1852	561	214	171
	B	237	217	224	214	221	292	461	1320	1828	478	218	170
	C	183	188	195	193	206	249	372	1032	1498	292	182	140
4	A	76	68	77	80	97	153	580	1905	2069	485	75	50
	B	73	71	79	80	97	152	561	1866	2117	430	72	48
	C	41	43	57	51	88	125	425	1464	1637	121	47	24

Table 14.--*Summary of simulated monthly streamflows, control point 38 (Elk River near Trull, Colo.), with 50 percent of agricultural and no transmountain diversions, and with 50 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 12 historic conditions]

OPTION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
						WITHOUT TRANSMOUNTAIN DIVERSIONS							
1	A	98	88	88	85	94	147	547	1838	2074	517	113	77
	B	95	90	89	82	93	143	529	1777	2110	457	109	76
	C	68	62	74	65	83	121	397	1398	1646	164	83	51
2	A	106	86	86	85	92	146	547	1818	2066	520	127	87
	B	115	90	89	87	92	143	529	1748	2092	458	126	89
	C	83	58	69	57	79	120	397	1377	1646	181	108	66
3	A	171	163	163	157	163	198	491	1396	1819	587	249	174
	B	175	166	165	160	167	199	461	1308	1842	525	255	169
	C	147	147	155	148	160	180	372	1034	1472	310	205	142
4	A	76	68	77	80	97	153	580	1905	2069	485	75	50
	B	73	71	79	80	97	152	561	1866	2117	430	72	48
	C	41	43	57	51	88	125	425	1464	1637	121	47	24
						WITH TRANSMOUNTAIN DIVERSIONS							
1	A	99	85	86	80	95	145	547	1832	2068	535	115	81
	B	100	90	89	81	93	143	529	1765	2108	461	111	81
	C	71	58	69	59	82	120	397	1384	1646	232	93	50
2	A	106	84	83	80	93	145	547	1808	2062	537	139	85
	B	112	91	82	80	90	143	529	1750	2095	469	146	85
	C	57	50	67	55	79	116	397	1376	1646	231	119	51
3	A	175	162	161	154	160	194	493	1390	1813	603	248	176
	B	181	166	166	159	167	199	461	1308	1834	557	260	170
	C	150	147	155	145	156	170	372	1038	1472	317	196	142
4	A	76	68	77	80	97	153	580	1905	2069	485	75	50
	B	73	71	79	80	97	152	561	1866	2117	430	72	48
	C	41	43	57	51	88	125	425	1464	1637	121	47	24

Table 15.--*Summary of simulated monthly streamflows, control point 38 (Elk River near Trull, Colo.), with 75 percent of agricultural and no transmountain diversions, and with 75 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 12 historic conditions]

OP-TION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	93	82	82	81	90	143	552	1853	2073	532	115	75
	B	94	86	84	80	91	138	538	1843	2121	473	118	80
	C	53	55	64	58	77	117	397	1402	1656	184	84	43
2	A	96	83	83	81	90	146	548	1842	2067	534	123	74
	B	108	86	83	82	90	143	530	1842	2104	476	139	79
	C	52	55	67	55	77	117	397	1396	1643	198	83	37
3	A	143	126	117	110	115	185	452	1491	1841	682	299	180
	B	175	150	149	121	102	169	451	1527	1865	648	308	182
	C	53	51	48	41	53	88	332	1066	1488	408	244	105
4	A	76	68	77	80	97	153	580	1905	2069	485	75	50
	B	73	71	79	80	97	152	561	1866	2117	430	72	48
	C	41	43	57	51	88	125	425	1464	1637	121	47	24
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	90	79	80	74	91	143	557	1865	2074	549	108	69
	B	90	81	78	72	88	137	550	1855	2119	485	109	69
	C	46	48	63	50	73	116	399	1421	1659	225	59	33
2	A	93	79	80	76	89	142	553	1853	2070	544	123	71
	B	97	81	81	74	86	140	536	1839	2118	485	123	69
	C	46	50	64	55	74	115	398	1404	1656	210	81	33
3	A	129	110	101	91	100	143	483	1548	1884	714	290	158
	B	136	105	85	73	88	135	446	1596	1914	685	319	189
	C	50	43	47	40	50	84	329	1095	1522	451	207	34
4	A	76	68	77	80	97	153	580	1905	2069	485	75	50
	B	73	71	79	80	97	152	561	1866	2117	430	72	48
	C	41	43	57	51	88	125	425	1464	1637	121	47	24

Table 16.--*Summary of simulated monthly streamflows, control point 38 (Elk River near Trull, Colo.), with 100 percent of agricultural and no transmountain diversions, and with 100 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 12 historic conditions]

OP-TION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	86	77	78	79	90	141	558	1878	2081	538	106	65
	B	81	79	75	74	90	139	539	1858	2125	481	109	67
	C	46	54	62	50	76	111	402	1416	1667	185	59	31
2	A	87	77	79	77	89	143	554	1873	2075	540	114	67
	B	84	76	81	74	91	140	540	1862	2120	482	113	68
	C	46	54	62	50	76	112	397	1416	1662	186	66	32
3	A	92	80	73	71	77	138	451	1650	1956	772	284	115
	B	68	58	53	52	54	96	405	1614	1973	735	337	54
	C	31	37	43	33	49	75	306	1253	1573	518	130	22
4	A	76	68	77	80	97	153	580	1905	2069	485	75	50
	B	73	71	79	80	97	152	561	1866	2117	430	72	48
	C	41	43	57	51	88	125	425	1464	1637	121	47	24
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	84	75	77	73	90	140	566	1892	2085	538	99	59
	B	81	75	75	71	81	131	559	1867	2132	480	84	56
	C	46	47	62	50	69	106	409	1459	1670	188	56	29
2	A	85	77	77	73	91	144	557	1884	2079	543	104	63
	B	89	76	75	71	85	142	553	1864	2124	491	95	66
	C	46	47	62	50	72	116	397	1424	1668	195	56	29
3	A	77	70	66	58	70	115	423	1769	2003	789	222	100
	B	64	53	51	47	53	91	385	1755	2010	793	156	49
	C	35	37	43	33	48	72	291	1403	1605	515	40	23
4	A	76	68	77	80	97	153	580	1905	2069	485	75	50
	B	73	71	79	80	97	152	561	1866	2117	430	72	48
	C	41	43	57	51	88	125	425	1464	1637	121	47	24

The effects of agricultural and transmountain diversions were reduced at this site because no additional proposed diversions were considered for the proposed Hinman Park or Grouse Mountain Reservoirs. In reservoir-development options 1 and 2, the 50-year flow statistics (tables 12-16) have responded to an increased demand from the downstream Yampa main-stem reservoirs, principally Juniper and Cross Mountain Reservoirs, by a slight reduction in the monthly peak flow. Reservoir-development options 3 and 4 included the proposed Hinman Park and Grouse Mountain Reservoirs upstream, and tended to even out the monthly flow cycle. In reservoir-development option 3, more water has been released from Hinman Park and Grouse Mountain to meet the demand from the Juniper and Cross Mountain Reservoirs during the irrigation season. Reservoir-development option 4 includes the Hinman Park and Grouse Mountain Reservoirs, but the downstream demand from Juniper and Cross Mountain Reservoirs use is not included; consequently the flow did not vary with increased water-use allocations. Increasing the water-use allocation percentages generally increased the number of months that the flow statistics are less than the historic conditions (underscored statistics, tables 12-16), especially during irrigation season (April to October). The upstream reservoir caused a reduction in peak flows and a flow increase during the low-flow, high water-use irrigation months.

[illegible]

The transmountain diversions have little or no effect in reservoir-development options 1, 2, and 4. Only in reservoir-development option 3, where the large downstream reservoirs were requiring water to replace the Vidler Tunnel transmountain diversion water taken from the Steamboat Springs location, can any real effect on the flow statistics be noticed for the Elk River near Trull, Colo. location.

Model-simulated monthly streamflows for control point 34 (Trout Creek at mouth) are presented in tables 17-21 and the general location of this site is shown on figure 1. The effects of agricultural and transmountain diversions would be negligible in many instances at this control point. The effects of the proposed diversions for the Oak Creek Water and power Project are indicated by the data for reservoir-development options 2, 3, and 4. The Oak Creek power complex includes only industrial diversions and, therefore, very little change in monthly flow statistics with change in water-use allocation can be noticed (see tables 18-21). The reservoir-development option 4 monthly streamflows were slightly reduced because the Juniper and Cross Mountain Reservoirs were not in operation and did not require upstream flow to fulfill diversion requirements.

Table 17.--*Summary of simulated monthly streamflows, control point 34 (Trout Creek at mouth), for historic conditions and with 100 percent of transmountain diversions*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than historic conditions without transmountain diversions]

FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
	WITHOUT TRANSMOUNTAIN DIVERSIONS											
A	21	25	24	23	27	41	158	297	103	22	14	14
B	17	23	23	23	29	40	128	243	88	17	11	11
C	11	17	17	17	23	29	91	166	40	11	6	11
	WITH TRANSMOUNTAIN DIVERSIONS											
A	21	25	24	23	27	41	158	297	103	22	14	14
B	17	23	23	23	29	40	128	243	88	17	11	11
C	11	17	17	17	23	29	91	166	40	11	6	11

Table 18.--*Summary of simulated monthly streamflows, control point 34 (Trout Creek at mouth), with 25 percent of agricultural and no transmountain diversions, and with 25 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 17 historic conditions]

OPTION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	21	25	24	23	27	41	158	297	103	22	14	14
	B	17	23	23	23	29	40	128	243	88	17	11	11
	C	11	17	17	17	23	29	91	166	40	11	6	11
2	A	24	25	23	42	27	39	131	224	94	34	23	20
	B	19	20	20	21	26	36	114	191	84	41	15	10
	C	10	15	15	15	21	26	81	140	52	15	9	9
3	A	23	24	22	21	24	36	116	194	99	44	25	19
	B	17	19	19	20	25	32	102	170	94	41	13	9
	C	8	14	14	15	20	25	75	132	65	13	8	8
4	A	16	18	19	20	23	34	121	239	99	32	16	12
	B	13	17	18	19	23	30	98	204	85	31	7	7
	C	7	13	13	14	19	24	72	137	49	11	3	3
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	21	25	24	23	27	41	158	297	103	22	14	14
	B	17	23	23	23	29	40	128	243	88	17	11	11
	C	11	17	17	17	23	29	91	166	40	11	6	11
2	A	24	25	23	42	27	39	131	224	94	34	23	20
	B	19	20	20	21	26	36	114	191	84	41	15	10
	C	10	15	15	15	21	26	81	140	52	15	9	9
3	A	23	24	22	21	24	36	116	194	99	44	25	19
	B	17	19	19	20	25	32	102	170	94	41	13	9
	C	8	14	14	15	20	25	75	132	65	13	8	8
4	A	16	18	19	20	23	34	121	239	99	32	16	12
	B	13	17	18	19	23	30	98	204	85	31	7	7
	C	7	13	13	14	19	24	72	137	49	11	3	3

Table 19.--*Summary of simulated monthly streamflows, control point 34 (Trout Creek at mouth), with 50 percent of agricultural and no transmountain diversions, and with 50 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 17 historic conditions]

OPTION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	21	25	24	23	27	41	158	297	103	22	14	14
	B	17	23	23	23	29	40	128	243	88	17	11	11
	C	11	17	17	17	23	29	91	166	40	11	6	11
2	A	24	25	23	42	27	39	131	224	94	34	23	2
	B	19	20	20	21	26	36	114	191	84	41	15	10
	C	10	15	15	15	21	26	81	140	52	15	9	9
3	A	23	23	22	21	24	36	120	203	98	34	21	18
	B	18	19	19	19	24	32	107	176	88	39	13	9
	C	8	14	14	14	19	24	75	131	55	13	8	8
4	A	15	19	20	21	24	35	126	251	98	20	9	9
	B	13	18	18	20	24	32	104	218	84	14	6	7
	C	7	13	13	15	20	26	78	145	35	6	3	5
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	21	25	24	23	27	41	158	297	103	22	14	14
	B	17	23	23	23	29	40	128	243	88	17	11	11
	C	11	17	17	17	23	29	91	166	40	11	6	11
2	A	24	25	23	22	47	39	131	224	94	34	23	20
	B	19	20	20	21	26	36	114	191	84	41	15	10
	C	10	15	15	15	21	26	81	140	52	15	9	9
3	A	23	23	22	21	24	36	120	202	98	34	21	19
	B	18	19	19	19	24	32	107	176	88	39	13	9
	C	8	14	14	14	19	24	75	131	55	13	8	8
4	A	15	19	20	21	24	35	126	251	98	20	9	9
	B	13	18	18	20	24	32	104	218	84	14	6	7
	C	7	13	13	15	20	26	78	145	35	6	3	5

Table 20.--*Summary of simulated monthly streamflows, control point 34 (Trout Creek at mouth), with 75 percent of agricultural and no transmountain diversions, and with 75 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 17 historic conditions]

OPTION	FLOW VALUES	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	21	25	24	23	27	41	158	297	103	22	14	14
	B	17	23	23	23	29	40	128	243	88	17	11	11
	C	11	17	17	17	23	29	91	166	40	11	6	11
2	A	23	25	23	41	28	41	130	226	94	34	24	20
	B	15	20	20	21	26	36	115	196	84	41	15	10
	C	10	15	15	15	20	26	76	140	52	15	9	7
3	A	22	23	20	19	22	41	114	211	92	35	25	21
	B	16	19	19	19	21	28	99	186	86	39	13	11
	C	8	13	10	14	14	21	71	130	53	13	8	7
4	A	15	19	20	21	24	36	129	256	92	16	9	9
	B	13	18	18	20	25	33	107	215	78	12	6	7
	C	7	13	13	15	20	26	78	140	29	6	3	5
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	21	25	24	23	27	41	158	297	103	22	14	14
	B	17	23	23	23	29	40	128	243	88	17	11	11
	C	11	17	17	17	23	29	91	166	40	11	6	11
2	A	22	24	22	22	46	40	133	227	95	38	26	22
	B	15	20	20	21	24	30	117	201	84	41	15	10
	C	7	15	15	15	15	22	86	143	52	15	7	7
3	A	21	23	20	18	22	33	120	214	93	37	26	20
	B	14	19	19	19	19	28	101	196	86	40	15	9
	C	6	13	10	14	14	20	71	136	54	13	6	6
4	A	15	19	20	21	24	36	129	256	92	16	9	9
	B	13	18	18	20	25	33	107	215	78	12	6	7
	C	7	13	13	15	20	26	78	140	29	6	3	5

Table 21.--*Summary of simulated monthly streamflows, control point 34 (Trout Creek at mouth), with 100 percent of agricultural and no transmountain diversions, and with 100 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 17 historic conditions]

OP-TION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
						WITHOUT TRANSMOUNTAIN DIVERSIONS							
1	A	21	25	24	23	27	41	158	297	103	22	14	14
	B	17	23	23	23	29	40	128	243	88	17	11	11
	C	11	17	17	17	23	29	91	166	40	11	6	11
2	A	20	22	21	43	30	40	132	230	95	38	32	24
	B	15	15	15	21	26	39	113	203	88	42	13	7
	C	7	11	11	11	15	22	76	143	54	15	7	7
3	A	18	20	18	18	20	35	112	220	93	47	35	21
	B	13	15	14	14	18	24	100	200	89	43	18	6
	C	6	10	10	10	14	20	61	133	54	17	6	5
4	A	16	19	20	21	25	37	131	258	88	16	9	9
	B	13	18	18	30	25	33	107	215	78	12	6	7
	C	7	13	13	15	20	26	77	140	29	6	3	5
						WITH TRANSMOUNTAIN DIVERSIONS							
1	A	21	25	24	23	27	41	158	297	103	22	14	14
	B	17	23	23	23	29	40	127	243	89	17	11	11
	C	11	17	17	17	23	29	91	166	40	11	6	11
2	A	18	21	19	21	47	46	135	234	98	40	41	23
	B	12	15	15	15	21	43	114	209	90	41	9	7
	C	7	11	11	11	15	22	86	150	56	15	5	7
3	A	16	19	17	16	20	29	106	235	99	54	38	18
	B	12	14	14	14	18	24	95	207	95	47	10	8
	C	6	10	10	10	14	18	58	146	67	19	4	6
4	A	16	19	20	21	25	37	131	258	88	16	9	9
	B	13	18	18	20	25	33	107	215	78	12	6	7
	C	7	13	13	15	20	26	77	140	29	6	3	5

Model-simulated monthly streamflows for control point 28 (Yampa River at Craig, Colo.) are presented in tables 22-26. This control point is located downstream from the proposed Craig Reservoir and also downstream from the confluence of the Williams Fork (fig. 1). The simulated results for reservoir-development option 1 represent both limited upstream diversion demands (table 3) and major downstream diversions from Juniper and Cross Mountain Reservoirs. The option-2 simulations included a larger number of upstream reservoirs (table 3) and consequently further reduced the flow at this site. Monthly streamflow simulations for reservoir-development options 3 and 4 included the immediate upstream effects of the Craig Reservoir and tended to even out the monthly flow distribution (tables 22-26). The monthly streamflow for reservoir-development option 4 is less than option 3 because of the absence of the downstream demand from Juniper and Cross Mountain Reservoirs. The simulated mean monthly streamflows for the 50-year period and the 100-percent water-use allocation (table 26) would be reduced to zero for at least 4 months each year under options 3 and 4.

The upstream Vidler transmountain diversion had varying effects (tables 22-26) on the flow at the Craig site. For the historic condition with 100 percent of transmountain diversion (table 22), the 5-year low flow (80-percent exceedence probability) was decreased to zero for 3 months. Simulated monthly streamflows including the Vidler transmountain diversion and the 100-percent water-use allocation (table 26) were also significantly reduced when the transmountain diversion was included.

Table 22.--*Summary of simulated monthly streamflows, control point 15 (Yampa River at Craig, Colo.), for historic conditions and with 100 percent of transmountain diversions*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than historic conditions without transmountain diversions]

FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
	SIMULATED HISTORIC CONDITIONS											
A	138	266	273	211	260	531	2179	5052	4904	767	117	126
B	114	269	278	251	260	530	2193	5293	4924	477	89	129
C	72	210	244	98	245	505	1676	4036	3155	124	42	24
	SIMULATED HISTORIC CONDITIONS WITH 100 PERCENT OF TRANSMOUNTAIN DIVERSIONS											
A	59	161	187	132	182	453	1795	4661	4517	512	53	53
B	13	179	200	173	181	452	1803	4902	4533	203	0	1
C	0	30	162	22	170	427	1387	3645	2764	0	0	0

Table 23.--*Summary of simulated monthly streamflows, control point 15 (Yampa River at Craig, Colo.), with 25 percent of agricultural and no transmountain diversions, and with 25 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 22 historic conditions]

OP-TION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
						WITHOUT TRANSMOUNTAIN DIVERSIONS							
1	A	144	224	239	194	216	461	2010	4231	4333	752	168	157
	B	114	218	249	211	217	460	2066	4354	4296	472	142	123
	C	101	172	214	115	201	437	1589	3344	2864	227	115	104
2	A	125	223	235	234	218	414	1915	4782	4822	778	154	156
	B	96	227	237	202	208	410	1977	4922	4857	475	142	131
	C	96	165	209	96	191	383	1440	3900	3094	152	97	96
3	A	158	271	308	254	290	453	1807	4214	4542	833	225	211
	B	128	272	309	289	291	460	1884	4315	4517	532	210	169
	C	115	216	291	151	262	422	1408	3469	2783	274	155	129
4	A	32	122	174	137	192	379	1733	4534	4732	651	35	51
	B	0	128	186	170	194	377	1815	4627	4740	343	3	13
	C	0	33	149	31	177	354	1378	3606	2996	0	0	0
						WITH TRANSMOUNTAIN DIVERSIONS							
1	A	130	199	214	176	193	437	1913	4124	4232	667	154	142
	B	108	195	223	191	196	439	1970	4225	4194	380	124	111
	C	100	139	185	108	173	414	1489	3244	2766	131	110	100
2	A	109	201	213	212	197	394	1815	4675	4720	702	145	142
	B	96	206	213	180	186	389	1869	4812	4745	380	139	121
	C	48	140	180	60	170	364	1344	3802	2964	100	96	96
3	A	144	242	287	236	268	432	1701	4110	4441	754	210	196
	B	116	241	288	270	269	439	1766	4194	4400	443	198	155
	C	105	174	262	145	240	402	1277	3378	2720	216	148	120
4	A	24	81	131	115	169	360	1635	4437	4634	577	26	38
	B	0	58	164	148	175	358	1718	4530	4642	245	0	0
	C	0	0	43	6	156	335	1281	3508	2898	0	0	0

Table 24.--*Summary of simulated monthly streamflows, control point 15 (Yampa River at Craig, Colo.), with 50 percent of agricultural and no transmountain diversions, and with 50 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 22 historic conditions]

OPTION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	138	222	243	196	218	461	1998	4194	4303	740	166	150
	B	115	217	250	216	219	461	2064	4257	4248	461	144	124
	C	100	174	227	116	202	436	1580	3314	2828	212	118	100
2	A	117	221	234	231	217	414	1924	4759	4800	768	150	148
	B	96	225	234	199	206	408	1986	4900	4818	467	139	125
	C	63	164	206	90	190	383	1460	3875	3056	140	96	96
3	A	139	238	314	262	295	440	1703	4105	4435	827	262	202
	B	120	231	317	294	301	444	1754	4217	4321	537	260	173
	C	99	188	298	176	267	402	1292	3426	2717	279	203	132
4	A	26	95	152	139	196	383	1703	4403	4668	595	12	32
	B	0	67	183	174	198	381	1817	4498	4637	291	0	0
	C	0	0	80	33	181	358	1377	3505	2936	0	0	0
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	108	168	189	154	177	413	1799	3992	4100	585	134	122
	B	100	156	194	169	175	417	1877	4093	4045	272	120	108
	C	90	107	150	101	141	393	1402	3113	2641	100	100	100
2	A	81	179	191	126	238	377	1731	4552	4600	641	134	116
	B	84	172	190	156	166	372	1786	4692	4613	314	132	115
	C	1	121	164	7	150	342	1290	3678	2834	96	96	43
3	A	119	193	271	221	248	386	1499	3882	4215	706	222	175
	B	103	196	277	244	256	402	1427	4004	4101	416	216	155
	C	85	110	251	140	214	340	1090	3186	2539	214	150	108
4	A	12	46	73	86	111	302	1534	4208	4473	474	5	14
	B	0	0	60	117	146	328	1622	4303	4441	95	0	0
	C	0	0	0	0	0	221	1132	3309	2740	0	0	0

Table 25.--*Summary of simulated monthly streamflows, control point 15 (Yampa River at Craig, Colo.), with 75 percent of agricultural and no transmountain diversions, and with 75 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 22 historic conditions]

OP-TION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	116	205	226	194	228	450	2018	4190	4277	743	159	136
	B	111	198	229	210	216	447	2064	4304	4232	468	146	122
	C	50	139	189	110	177	395	1658	3283	2835	208	106	53
2	A	91	208	224	219	209	413	1923	4763	4783	772	140	124
	B	86	213	227	189	200	412	2002	4966	4802	473	143	108
	C	8	149	187	50	179	376	1410	3846	3047	147	67	26
3	A	108	164	198	167	189	454	1599	4217	4382	924	301	208
	B	121	171	253	193	226	404	1646	4505	4381	726	305	216
	C	0	0	0	0	0	132	1262	3322	2898	378	237	92
4	A	16	62	115	127	177	385	1726	4340	4610	540	2	11
	B	0	0	134	172	196	384	1816	4438	4579	220	0	0
	C	0	0	0	0	149	358	1373	3405	2885	0	0	0
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	58	123	147	111	159	409	1763	3911	3989	514	96	76
	B	40	120	136	113	139	389	1304	4033	3943	191	92	52
	C	0	60	109	70	103	353	1411	3028	2541	54	24	0
2	A	51	147	170	110	217	351	1656	4464	4499	597	101	85
	B	6	142	167	144	149	341	1713	4620	4549	301	97	72
	C	0	89	142	1	125	315	1169	3561	2756	96	10	0
3	A	75	114	136	106	126	243	1433	3972	4146	771	245	154
	B	72	81	138	32	130	311	1367	4312	4167	510	245	144
	C	0	0	0	0	0	0	962	3026	2734	291	115	0
4	A	7	13	30	39	63	213	1404	4047	4317	385	0	0
	B	0	0	0	0	14	286	1507	4145	4285	0	0	0
	C	0	0	0	0	0	0	1080	3112	2592	0	0	0

Table 26.--*Summary of simulated monthly streamflows, control point 15 (Yampa River at Craig, Colo.), with 100 percent of agricultural and no transmountain diversions, and with 100 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 22 historic conditions]

OPTION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	87	194	211	201	249	447	2038	4209	4271	732	124	104
	B	61	197	193	185	218	424	2093	4340	4232	459	113	79
	C	25	132	176	115	158	381	1680	3330	2843	203	34	19
2	A	62	181	207	204	200	395	1884	4765	4780	772	128	107
	B	14	176	200	173	189	400	2014	4963	4809	465	127	66
	C	0	119	176	39	162	334	1408	3884	3067	154	6	0
3	A	56	65	76	89	94	304	1658	4464	4516	997	272	133
	B	0	0	0	0	0	189	1690	4624	4521	753	304	0
	C	0	0	0	0	0	16	1180	3624	3145	438	33	0
4	A	11	36	83	116	151	370	1724	4276	4548	483	0	0
	B	0	0	25	166	195	375	1813	4374	4519	113	0	0
	C	0	0	0	0	0	335	1370	3329	2828	0	0	0
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	24	74	111	101	139	385	1713	3839	3894	451	59	40
	B	0	63	112	87	112	367	1755	3969	3852	148	11	0
	C	0	0	64	0	79	310	1271	2958	2448	0	0	0
2	A	31	116	157	99	202	349	1552	4386	4403	558	91	74
	B	0	110	149	128	147	325	1645	4599	4443	300	48	26
	C	0	47	130	0	120	294	1179	3559	2686	30	0	0
3	A	34	39	46	34	42	117	1175	4362	4215	811	194	93
	B	0	0	0	0	0	1	1170	4467	4209	566	91	0
	C	0	0	0	0	0	0	721	3533	2764	287	0	0
4	A	0	6	9	14	26	131	1274	3885	4160	301	0	0
	B	0	0	0	0	0	91	1408	3983	4128	0	0	0
	C	0	0	0	0	0	0	931	2938	2437	0	0	0

Model-simulated monthly streamflows for control point 25 (confluence of Yampa River and Milk Creek) are presented in tables 27-31. This site is located approximately 10 river miles upstream from damsite of the proposed Juniper Reservoir (fig. 1).

At the confluence of the Yampa River and Milk Creek, the flow statistics are similar to the upstream Yampa River at Craig, Colo., (control point 28) with only the addition of the flow from Milk Creek and return flow from Craig Reservoir diversions. Reservoir-development options 1 and 2 were similar in effect, with less mean annual flow for option 2 due to additional demands for water upstream. For reservoir development option 3, the larger flow statistics reflect the Juniper and Cross Mountain Reservoir downstream demands. In reservoir-development option 4, the downstream demands were non-existent, and the flow statistics decreased at this site. There also was a decrease in flow statistics as the allocation percentages increased (tables 28-31), but to a much smaller degree. The absence of a downstream demand allowed more water to be retained in Craig Reservoir and other upstream reservoirs, and less water to be released.

Table 27.--*Summary of simulated monthly streamflows, control point 25 (confluence of Yampa River and Milk Creek), for historic conditions and with 100 percent of transmountain diversions*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than historic conditions without transmountain diversions]

FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
						SIMULATED HISTORIC CONDITIONS						
A	150	278	286	223	275	564	2349	5571	5088	794	125	133
B	122	279	289	267	273	565	2373	5696	4996	498	99	133
C	76	218	259	109	261	528	1763	4409	3240	147	43	32
	SIMULATED HISTORIC CONDITIONS WITH 100 PERCENT OF TRANSMOUNTAIN DIVERSIONS											
A	71	174	200	144	197	486	1965	5180	4701	539	62	65
B	26	195	211	189	194	487	1982	5305	4605	235	23	18
C	4	38	170	33	183	450	1451	4018	2849	11	4	4

Table 28.--*Summary of simulated monthly streamflows, control point 25 (confluence of Yampa River and Milk Creek), with 25 percent of agricultural and no transmountain diversions, and with 25 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 27 historic conditions]

OP-TION	FLOW VALUES	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	156	237	251	206	231	494	2180	4749	4517	779	176	164
	B	125	228	258	226	230	491	2235	4753	4416	493	150	132
	C	106	180	222	125	218	464	1634	3694	2936	250	121	108
2	A	137	236	247	246	232	447	2085	5301	5007	305	162	162
	B	104	237	248	212	222	440	2125	5451	4957	496	147	137
	C	100	173	217	104	204	418	1519	4219	3166	171	104	104
3	A	175	283	321	266	304	486	1982	4751	4758	900	265	236
	B	141	285	320	300	302	485	2027	4791	4664	594	248	193
	C	127	224	300	161	275	456	1473	3773	2924	333	191	158
4	A	48	136	187	149	207	413	1908	5071	4947	718	75	76
	B	15	138	200	189	206	410	1945	5015	4859	404	46	44
	C	8	41	162	41	188	382	1457	3917	3113	63	35	22
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	142	212	226	189	207	471	2083	4643	4417	693	162	149
	B	116	205	234	205	208	469	2137	4621	4307	401	135	122
	C	104	147	195	117	188	438	1534	3599	2838	154	116	104
2	A	121	214	226	224	211	427	1985	5194	4904	728	154	149
	B	104	217	228	191	200	420	2020	5352	4845	401	144	128
	C	56	148	195	71	183	397	1417	4121	3036	113	104	100
3	A	161	255	299	248	283	465	1875	4646	4656	831	250	220
	B	130	251	300	279	283	464	1909	4654	4545	505	235	180
	C	117	182	273	153	255	436	1364	3680	2850	266	184	145
4	A	41	95	143	127	184	393	1810	4973	4850	644	66	63
	B	12	71	173	167	186	390	1847	4917	4761	307	41	29
	C	8	48	51	16	169	363	1359	3820	3015	51	35	38

Table 29.--*Summary of simulated monthly streamflows, control point 25 (confluence of Yampa River and Milk Creek), with 50 percent of agricultural and no transmountain diversions, and with 50 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 27 historic conditions]

OP-TION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
						WITHOUT TRANSMOUNTAIN DIVERSIONS							
1	A	150	235	256	208	232	494	2166	4713	4488	767	175	157
	B	124	228	261	231	232	490	2232	4691	4379	482	149	132
	C	105	182	238	126	217	465	1625	3691	2900	235	122	106
2	A	128	233	246	243	231	447	2094	5278	4985	795	159	155
	B	104	236	247	210	220	439	2116	5439	4921	488	144	131
	C	74	172	215	100	202	417	1534	4214	3142	159	104	100
3	A	159	250	327	274	310	473	1882	4659	4682	934	333	244
	B	139	247	328	311	312	474	1944	4662	4521	640	330	217
	C	116	196	312	186	282	433	1346	3714	2851	374	270	172
4	A	47	110	164	151	210	417	1909	4957	4915	702	83	74
	B	17	85	195	190	210	414	1949	4932	4785	392	70	44
	C	13	8	90	41	192	386	1464	3846	3077	92	66	40
						WITH TRANSMOUNTAIN DIVERSIONS							
1	A	120	181	201	166	192	446	1969	4511	4284	612	142	128
	B	111	169	206	135	188	446	2034	4488	4172	293	130	115
	C	98	115	161	111	152	412	1447	3489	2713	119	104	104
2	A	93	192	204	138	252	410	1901	5071	4785	668	143	123
	B	101	184	204	171	180	400	1906	5253	4722	335	134	122
	C	10	129	175	16	165	378	1356	4018	2955	112	100	47
3	A	140	205	283	233	263	419	1678	4436	4462	813	293	217
	B	121	210	287	255	267	428	1656	4418	4289	518	285	200
	C	102	122	262	150	232	372	1258	3500	2789	306	213	158
4	A	33	61	86	98	125	335	1713	4762	4720	582	76	56
	B	17	11	75	134	160	365	1753	4736	4589	197	70	41
	C	13	8	11	11	11	251	1268	3650	2882	92	66	40

Table 30.--*Summary of simulated monthly streamflows, control point 25 (confluence of Yampa River and Milk Creek), with 75 percent of agricultural and no transmountain diversions, and with 75 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 27 historic conditions]

OP-TION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
						WITHOUT TRANSMOUNTAIN DIVERSIONS							
1	A	128	217	239	206	242	483	2188	4709	4462	770	167	143
	B	120	209	240	221	231	487	2230	4749	4371	489	153	127
	C	58	147	200	117	188	423	1724	3687	2907	230	110	53
2	A	103	221	237	231	223	447	2093	5281	4967	798	148	131
	B	102	225	238	204	216	441	2127	5512	4929	494	149	112
	C	12	158	199	61	193	416	1544	4194	3151	166	69	41
3	A	132	177	210	179	203	488	1782	4789	4660	1071	402	263
	B	143	181	266	203	239	432	1802	5042	4606	869	413	273
	C	21	11	11	11	11	158	1341	3661	3090	518	339	150
4	A	41	76	128	139	191	419	1910	4912	4888	687	104	71
	B	21	13	151	192	211	414	1952	4890	4751	362	102	57
	C	17	8	11	11	157	388	1468	3779	3058	132	98	57
						WITH TRANSMOUNTAIN DIVERSIONS							
1	A	58	123	147	111	159	409	1763	3911	3989	514	96	76
	B	40	120	136	113	139	389	1804	4033	3943	191	92	52
	C	0	60	109	70	103	353	1411	3028	2541	54	24	0
2	A	63	159	183	122	232	384	1826	4983	4684	624	110	92
	B	23	159	180	158	162	377	1823	5171	4672	333	106	76
	C	4	97	153	11	136	337	1256	3904	2861	108	20	4
3	A	97	126	148	118	141	276	1616	4544	4424	916	336	201
	B	94	93	151	91	140	346	1537	4850	4423	663	347	202
	C	9	11	11	11	11	30	1089	3334	2926	426	201	25
4	A	32	27	42	51	78	247	1587	4619	4595	532	102	61
	B	21	11	11	11	35	326	1649	4597	4457	144	102	57
	C	17	8	8	8	11	30	1175	3486	2765	132	98	57

Table 31.--*Summary of simulated monthly streamflows, control point 25 (confluence of Yampa River and Milk Creek), with 100 percent of agricultural and no transmountain diversions, and with 100 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 27 historic conditions]

OP-TION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
							WITHOUT TRANSMOUNTAIN DIVERSIONS						
1	A	99	207	223	213	263	480	2208	4728	4456	758	132	111
	B	75	213	203	201	233	450	2261	4745	4363	480	119	86
	C	32	140	185	126	171	409	1725	3727	2915	222	37	24
2	A	74	193	220	216	214	428	2054	5284	4964	799	137	114
	B	28	191	212	183	203	433	2134	5477	4936	486	131	74
	C	4	127	187	43	174	369	1524	4180	3152	173	17	8
3	A	83	78	88	101	109	337	1846	5054	4825	1177	376	181
	B	26	11	11	15	17	222	1858	5215	4785	937	437	60
	C	10	8	11	8	11	53	1277	3959	3390	607	65	8
4	A	40	51	96	128	166	403	1912	4866	4857	671	133	78
	B	26	11	38	183	209	412	1956	4868	4723	296	133	75
	C	22	8	11	11	11	368	1469	3772	3025	172	129	75
							WITH TRANSMOUNTAIN DIVERSIONS						
1	A	36	87	123	114	154	418	1883	4358	4078	477	67	47
	B	8	73	123	100	125	396	1921	4369	3978	170	16	14
	C	4	10	75	11	91	344	1342	3345	2520	11	4	4
2	A	43	129	169	112	217	382	1722	4905	4587	585	100	80
	B	8	118	162	140	158	361	1789	5067	4547	325	53	36
	C	4	55	142	11	135	328	1277	3813	2766	42	8	4
3	A	53	51	58	46	56	151	1362	4952	4524	987	269	137
	B	15	11	11	11	15	44	1339	5083	4409	749	141	42
	C	8	8	8	8	11	26	856	3989	3010	459	12	8
4	A	30	19	22	26	40	165	1462	4475	4469	489	133	78
	B	26	11	11	11	15	125	1546	4477	4332	134	133	75
	C	22	8	8	8	11	30	1042	3381	2634	172	129	75

[illegible]

Model-simulated monthly streamflows for control point 13 (Yampa River near Maybell, Colo.) are presented in tables 32-36. This site is located downstream from the proposed Juniper Reservoir and approximately 1 mile east of the town of Maybell (fig. 1). In comparison to the streamflow-gaging station record, simulated mean monthly streamflows for the historic (1927-76) conditions without transmountain diversions (table 32) vary from +6 to -23 percent and with an average absolute variation of 7 percent.

These simulated values tend to principally underpredict the flow statistics during the months of July, August, and September. All monthly flow statistics in tables 32-36 less than the corresponding historic monthly flow are underscored.

For the Yampa River at Maybell location, a large agricultural diversion, Juniper Reservoir, is located upstream. The assumed total agricultural diversion simulated for Juniper Reservoir would involve as much as eight times the amount of water to be diverted for the upstream Vidler tunnel transmountain diversion. The Yampa River near Maybell location (control point 18) is also the streamflow-gaging site and index station for streamflow from the Yampa River for the Colorado River Compact of 1948. This agreement requires that 5,000,000 acre-ft of water per 10-year period be delivered from the Yampa basin upstream, which represents an approximate continuous flow of 690 ft^3/s. For this reason, and also for the proposed Wild and Scenic River reach downstream (H. J. Belisle, U.S. Water and Power Resources Service, formerly U.S. Bureau of Reclamation, written commun., 1976), a 200-ft^3/s desired flow was set for this site. This flow also closely approximates the minimum mean monthly flow but is quite a bit less than the 1,550-ft^3/s mean annual flow for this location.

For the Yampa River near Maybell site, the Juniper Reservoir is included for reservoir-development options 1, 2, and 3 (table 2), and results in a more regulated flow condition than option 4 (tables 33-36). Reservoir-development option 4 without Juniper Reservoir tends to follow a reduced annual-flow pattern similar to the historic flows (tables 32 and 33).

For reservoir-development options 1, 2, and 3, the median monthly flows quickly drop to the desired flow of 200 ft^3/s and the 80-percent exceedence value dropped to zero for 3 or more months at the 75-percent allocation percentage (table 35). Realistically, if any substantial flow is to be maintained in the Yampa River at this location, reservoir-development options 1, 2, and 3 would be restricted to the 50-percent agricultural water-use allocation or less.

The Vidler transmountain diversion at the 100-percent allocation level alone causes an approximate 12-percent reduction in flow, as can be seen in table 32. When combined with the large irrigation diversion from this site (options 1, 2, and 3), the Vidler transmountain diversion increases the number of zero-flow occurrences as the percentage of water-use allocation increases and reduces the possibility of maintaining the desired flow of 200 ft^3/s (tables 33-36).

Table 32.--*Summary of simulated monthly streamflows, control point 13 (Yampa River near Maybell, Colo.), for historic conditions and with 100 percent of transmountain diversions*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than historic conditions without transmountain diversions]

FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
	SIMULATED HISTORIC CONDITIONS											
A	352	337	313	290	323	713	2794	6228	5277	1210	291	200
B	323	322	295	277	287	575	2616	5962	5331	1043	246	158
C	219	239	259	245	259	523	1840	4376	3644	459	110	81
	SIMULATED HISTORIC CONDITIONS WITH 100 PERCENT OF TRANSMOUNTAIN DIVERSIONS											
A	273	233	227	212	245	635	2410	5837	4891	955	228	132
B	236	230	216	199	209	497	2225	5571	4940	743	178	83
C	146	81	171	167	182	445	1449	3985	3253	331	72	22
	CALCULATED STREAMFLOW FROM GAGING-STATION RECORDS											
A	353	351	296	274	323	675	2647	6208	5472	1331	378	245
B	324	324	276	266	299	608	2755	6210	5315	1200	328	202
C	191	248	202	207	247	428	1544	4322	3546	545	197	137

Table 33.--*Summary of simulated monthly streamflows, control point 18 (Yampa River near Maybell, Colo.), with 25 percent of agricultural and no transmountain diversions, and with 25 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 32 historic conditions]

OPTION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	466	551	575	593	548	397	517	3034	3406	886	208	309
	B	505	578	596	606	575	418	200	2533	3165	805	200	326
	C	398	496	544	551	517	263	200	723	1586	696	200	262
2	A	485	573	594	586	556	397	525	3433	3891	902	204	306
	B	516	595	610	603	585	423	200	3151	3615	804	200	323
	C	414	523	566	547	503	266	200	753	1930	714	200	262
3	A	485	573	594	586	556	382	588	3191	3694	906	203	309
	B	516	595	610	603	585	418	200	2919	3350	813	200	327
	C	414	523	566	547	503	243	200	895	1753	721	200	260
4	A	250	196	213	217	255	562	2353	5728	5137	1132	241	143
	B	205	130	207	209	222	436	2217	5473	5204	753	200	102
	C	147	97	160	170	191	396	1539	3959	3547	379	105	44
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	455	546	576	590	544	384	458	2749	3260	872	208	306
	B	497	571	599	601	571	417	200	1872	3067	796	200	323
	C	360	495	558	551	500	265	200	717	1179	686	200	245
2	A	470	549	577	586	550	394	457	3153	3761	888	205	305
	B	510	579	595	592	566	424	200	2603	3511	803	200	322
	C	383	508	552	546	504	267	200	749	1733	691	200	257
3	A	481	565	586	582	557	382	508	2902	3565	888	204	308
	B	516	593	607	601	582	414	200	2214	3245	809	200	327
	C	388	516	554	546	516	246	200	727	1537	685	200	258
4	A	243	154	170	194	232	542	2255	5630	5039	1058	232	130
	B	200	130	188	190	196	416	2119	5375	5106	856	190	79
	C	145	31	49	139	171	376	1442	3861	3449	365	103	33

Table 34.--*Summary of simulated monthly streamflows, control point 18 (Yampa River near Maybell, Colo.), with 50 percent of agricultural and no transmountain diversions, and with 50 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 32 historic conditions]

OP-TION	FLOW VALUES	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	291	395	474	549	530	405	282	1518	1775	277	200	200
	B	304	431	527	573	556	426	200	591	1502	200	200	200
	C	200	240	395	469	449	322	200	271	200	200	200	200
2	A	304	409	479	537	534	410	283	1804	2416	281	200	200
	B	323	466	526	546	552	414	200	718	1919	200	200	200
	C	200	245	384	447	418	338	200	287	246	200	200	200
3	A	319	444	523	542	527	395	305	1550	2093	278	200	200
	B	350	511	565	547	554	430	200	542	1644	200	200	200
	C	200	254	467	477	446	294	200	200	232	200	200	200
4	A	249	169	191	218	258	566	2354	5615	5105	1116	249	141
	B	205	158	210	213	225	440	2224	5331	5182	925	210	93
	C	150	31	88	164	194	400	1546	3893	3511	406	134	42
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	261	343	448	528	553	383	243	1106	1299	266	200	200
	B	213	312	498	554	561	403	200	417	287	200	200	200
	C	200	200	295	439	495	286	200	200	200	200	200	200
2	A	280	362	462	520	543	400	240	1456	1911	272	200	200
	B	277	363	507	544	561	402	200	696	1634	200	200	200
	C	200	200	343	428	478	305	200	291	200	200	200	200
3	A	295	396	484	526	525	394	252	1179	1585	270	200	200
	B	322	448	535	558	559	427	200	424	668	200	200	200
	C	200	200	382	451	456	278	200	231	200	200	200	200
4	A	235	120	112	165	173	484	2159	5419	4909	996	242	123
	B	196	78	85	169	167	384	2028	5139	4986	760	208	73
	C	128	9	9	117	12	288	1351	3698	3315	370	134	39

Table 35.--*Summary of simulated monthly streamflows, control point 13 (Yampa River near Maybell, Colo.), with 75 percent of agricultural and no transmountain diversions, and with 75 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 32 historic conditions]

OP-TION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
						WITHOUT TRANSMOUNTAIN DIVERSIONS							
1	A	141	141	204	389	389	291	266	343	420	200	180	134
	B	200	200	200	381	471	329	200	200	200	200	200	200
	C	0	0	0	200	0	0	200	200	200	200	200	0
2	A	145	163	277	328	402	367	216	548	649	200	192	166
	B	200	200	214	310	478	416	200	200	200	200	200	200
	C	0	0	200	0	200	200	200	200	200	200	200	200
3	A	145	160	220	281	318	258	189	478	510	200	192	173
	B	200	200	200	200	325	280	200	200	200	200	200	200
	C	0	0	0	0	0	0	0	200	200	200	200	200
4	A	243	135	154	207	239	568	2355	5570	5077	1101	271	139
	B	204	78	152	205	219	444	2227	5272	5151	898	233	91
	C	130	9	9	162	185	400	1549	3837	3489	446	166	56
						WITH TRANSMOUNTAIN DIVERSIONS							
1	A	100	110	161	186	270	274	262	264	289	187	136	114
	B	100	0	200	100	220	297	200	200	200	200	200	200
	C	0	0	0	0	0	0	200	200	200	200	0	0
2	A	132	160	217	283	320	266	232	384	439	192	173	132
	B	200	200	200	200	307	271	200	200	200	200	200	200
	C	0	0	0	0	0	0	200	200	200	200	200	0
3	A	128	151	184	199	253	211	133	421	343	188	176	131
	B	200	200	200	200	216	200	200	229	200	200	200	200
	C	0	0	0	0	0	0	0	200	200	200	200	0
4	A	234	86	69	118	126	396	2032	5277	4784	946	268	128
	B	189	36	15	122	113	350	1885	4979	4858	690	213	81
	C	130	9	9	9	9	39	1239	3544	3195	410	166	58

Table 36.--*Summary of simulated monthly streamflows, control point 13 (Yampa River near Maybell, Colo.), with 100 percent of agricultural and no transmountain diversions, and with 100 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 32 historic conditions]

OPTION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	48	108	124	272	348	189	268	200	210	164	75	53
	B	0	0	0	200	440	0	200	200	200	200	0	0
	C	0	0	0	0	0	0	200	200	200	200	0	0
2	A	65	80	126	213	298	298	169	292	288	176	106	72
	B	0	0	0	200	241	249	200	200	200	200	200	0
	C	0	0	0	0	0	0	0	200	200	200	0	0
3	A	60	82	78	103	144	162	113	275	281	180	110	72
	B	0	0	0	0	0	0	200	200	200	200	200	0
	C	0	0	0	0	0	0	0	200	200	200	0	0
4	A	242	110	122	195	214	552	2357	5523	5047	1085	300	145
	B	202	59	65	202	217	440	2228	5220	5132	860	244	95
	C	135	9	9	118	67	369	1549	3817	3469	450	197	74
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	31	33	63	143	123	181	283	200	192	108	60	28
	B	0	0	0	0	0	0	200	200	200	200	0	0
	C	0	0	0	0	0	0	200	200	200	0	0	0
2	A	52	90	76	124	228	299	167	229	264	145	73	48
	B	0	0	0	0	0	250	200	200	200	200	0	0
	C	0	0	0	0	0	0	0	200	200	0	0	0
3	A	45	66	54	80	95	80	89	267	222	152	76	50
	B	0	0	0	0	0	0	0	200	200	200	0	0
	C	0	0	0	0	0	0	0	200	200	0	0	0
4	A	232	78	49	93	88	313	1907	5132	4659	905	300	145
	B	182	32	9	70	20	178	1740	4829	4740	669	244	95
	C	124	4	9	9	9	32	1046	3426	3078	450	197	74

Model-simulated monthly streamflows for control point 19 (Yampa River near Lily, Colo.) are presented in tables 37-41. This site is located downstream from the proposed Juniper and Cross Mountain Reservoirs (fig. 1) and approximately 2 mi upstream from the confluence of the Little Snake River. All monthly flow statistics less than the corresponding historic flow statistics given in tables 37-41 are again underscored.

At the Yampa River near Lily site, the proposed Cross Mountain Reservoir is considered for reservoir-development options 1, 2, and 3 (table 2). Principally because of the large return flow from the Juniper Reservoir agricultural diversions, the monthly flow statistics at this site reflect larger volumes than the upstream site at Maybell (control point 18) (tables 33-36, and 38-41). The flow statistics for this site also indicated a more highly regulated annual-flow hydrograph than the historic discharges for reservoir-development options 1, 2, and 3. Reservoir-development option 4 again followed a more closely historic annual-flow hydrograph because of the absence of the upstream Juniper and Cross Mountain Reservoirs. A hypothetical desired flow of 344 ft^3/s, which is approximately equal to the historic summer average monthly flow, was established for this location. In many instances, the 344-ft^3/s desired flow was not met, particularly for the 100-percent water-use allocation level (table 41). For example, in reservoir-development option 4 with the 25-, 50-, 75-, and 100-percent water-use allocations, both with and without the transmountain diversions, the desired flow was not met during at least 6 months of each year (tables 38-41).

Table 37.--*Summary of simulated monthly streamflows, control point 19 (Yampa River near Lily, Colo.), for historic conditions and with 100 percent of transmountain diversions*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than historic conditions without transmountain diversions]

FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
	SIMULATED HISTORIC CONDITIONS											
A	411	398	364	337	379	831	3260	7311	6220	1440	357	240
B	377	374	337	320	332	666	3033	7037	6305	1247	304	195
C	253	283	294	288	304	605	2060	5137	4315	556	142	104
	SIMULATED HISTORIC CONDITIONS WITH 100 PERCENT OF TRANSMOUNTAIN DIVERSIONS											
A	332	293	278	259	301	753	2876	6920	5833	1135	293	172
B	292	283	257	242	254	588	2642	6646	5914	951	235	132
C	177	117	211	204	226	527	1669	4746	3924	401	111	42

Table 38.--*Summary of simulated monthly streamflows, control point 19 (Yampa River near Lily, Colo.), with 25 percent of agricultural and no transmountain diversions, and with 25 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 37 historic conditions]

OPTION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	624	622	642	663	622	471	942	4394	4841	1861	712	664
	B	654	644	661	676	652	486	583	3826	4528	1720	689	673
	C	547	581	614	630	592	344	382	1720	2633	1720	670	630
2	A	632	630	643	659	629	481	950	4788	5331	1375	711	660
	B	660	655	662	674	650	492	619	4413	4978	1720	690	677
	C	562	593	617	620	593	351	390	1720	3186	1720	656	635
3	A	633	632	646	650	620	473	1053	4550	5132	1869	715	661
	B	661	657	663	674	653	490	659	3985	4712	1720	697	678
	C	563	594	618	620	593	356	450	1720	2985	1720	657	634
4	A	309	256	266	264	311	680	2819	6811	6079	1364	306	183
	B	253	228	248	248	265	529	2641	6548	6179	1157	257	126
	C	181	137	205	206	236	471	1759	4613	4218	463	142	75
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	624	622	642	663	622	463	859	4105	4693	1851	709	664
	B	654	644	661	676	652	477	530	3314	4430	1720	688	678
	C	547	581	614	630	592	344	367	1720	2522	1720	670	630
2	A	631	627	643	660	628	481	860	4506	5199	1862	708	660
	B	660	646	661	673	648	493	564	3875	4875	1720	689	677
	C	562	592	616	620	597	348	368	1720	2779	1720	656	632
3	A	633	630	644	649	620	473	953	4263	4999	1857	712	661
	B	661	652	663	674	651	490	627	3641	4608	1720	696	678
	C	563	594	618	620	593	351	443	1720	2643	1720	657	633
4	A	302	215	223	241	288	660	2721	6713	5982	1290	297	170
	B	247	184	229	228	243	510	2544	6450	6081	1059	250	107
	C	181	75	90	181	216	452	1662	4521	4120	442	142	57

Table 39.--*Summary of simulated monthly streamflows, control point 13 (Yampa River near Lily, Colo.), with 50 percent of agricultural and no transmountain diversions, and with 50 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 37 historic conditions]

OPTION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	615	622	642	663	522	468	565	3061	3721	1881	1252	834
	B	644	644	661	676	652	477	344	1720	3262	1754	1275	830
	C	537	581	614	630	592	344	344	1720	1798	1720	1230	809
2	A	622	622	631	650	624	475	589	3344	4374	1884	1256	834
	B	652	644	650	650	637	486	415	1737	3698	1754	1275	830
	C	561	596	606	607	586	344	344	1720	1993	1720	1235	809
3	A	623	626	638	645	617	470	643	3136	4049	1882	1259	834
	B	652	639	659	665	640	481	491	1819	3439	1753	1275	829
	C	563	598	609	624	591	344	344	1720	1832	1720	1235	808
4	A	308	229	244	265	314	684	2820	6698	6047	1348	314	182
	B	253	208	252	251	269	533	2646	6396	6156	1128	271	119
	C	186	75	123	204	239	475	1766	4547	4132	500	173	70
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	615	622	642	651	631	461	489	2654	3198	1868	1215	832
	B	644	644	661	676	653	469	344	1720	2394	1738	1273	830
	C	537	581	614	623	597	344	344	1720	1720	1720	1218	809
2	A	621	617	625	636	626	472	538	2972	3840	1875	1239	834
	B	644	627	644	652	643	483	430	1720	3407	1748	1275	830
	C	556	594	592	608	592	344	344	1720	1787	1720	1223	809
3	A	622	621	631	639	613	467	576	2731	3506	1873	1239	833
	B	644	628	651	662	637	481	444	1720	2769	1745	1274	829
	C	556	597	604	607	591	344	344	1720	1720	1720	1223	808
4	A	294	180	165	213	229	602	2625	6502	5852	1228	308	163
	B	243	132	124	208	215	474	2451	6200	5961	960	265	104
	C	177	54	46	145	59	374	1571	4351	3986	482	173	70

Table 40.--*Summary of simulated monthly streamflows, control point 19 (Yampa River near Lily, Colo.), with 75 percent of agricultural and no transmountain diversions, and with 75 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 37 historic conditions]

OP-TION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
						WITHOUT TRANSMOUNTAIN DIVERSIONS							
1	A	606	608	539	574	514	381	372	1986	2538	2398	1707	972
	B	634	613	638	655	617	385	344	1720	2270	2410	1792	1128
	C	527	580	501	568	188	206	344	1720	1720	2256	1760	613
2	A	613	595	579	568	522	433	381	2197	2820	2418	1773	1060
	B	631	605	595	596	596	460	344	1720	2434	2416	1792	1133
	C	560	563	536	522	522	344	344	1720	1720	2284	1761	1106
3	A	614	598	564	529	450	349	368	2070	2635	2396	1782	1084
	B	631	602	575	584	562	345	344	1720	2371	2416	1792	1132
	C	560	562	517	398	57	88	344	1720	1720	2230	1761	1105
4	A	302	196	208	254	295	686	2821	6653	6020	1333	336	179
	B	247	132	194	249	266	536	2650	6348	6125	1102	296	122
	C	170	57	48	197	229	476	1769	4519	4160	522	205	37
						WITH TRANSMOUNTAIN DIVERSIONS							
1	A	567	575	475	388	385	333	367	1858	2303	2362	1497	886
	B	623	613	617	570	546	344	344	1720	2146	2406	1785	1116
	C	514	567	57	41	46	96	344	1720	1720	2233	918	595
2	A	567	563	521	498	459	376	380	1960	2518	2384	1672	937
	B	592	582	567	589	560	359	344	1720	2150	2408	1791	1128
	C	521	538	412	274	125	204	344	1720	1720	2201	1756	561
3	A	563	561	510	448	403	322	363	1928	2341	2352	1660	933
	B	599	580	563	552	527	344	344	1720	2059	2400	1792	1121
	C	525	539	479	68	51	85	344	1720	1720	2090	1756	571
4	A	293	147	122	165	182	514	2498	6359	5727	1178	334	168
	B	241	96	61	162	169	427	2314	6055	5832	872	291	121
	C	170	54	44	52	53	136	1462	4226	3866	522	205	37

Table 41.--*Summary of simulated monthly streamflows, control point 19 (Yampa River near Lily, Colo.), with 100 percent of agricultural and no transmountain diversions, and with 100 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 37 historic conditions]

OP-TION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	496	476	356	405	446	305	349	1830	2765	2951	1343	775
	B	559	588	354	601	585	284	344	1720	2730	3130	1456	574
	C	394	54	36	41	163	133	344	1720	2212	3000	409	524
2	A	539	507	407	379	402	384	353	1909	2776	3000	1580	822
	B	571	558	498	523	519	352	344	1720	2581	3136	2277	523
	C	508	430	132	41	51	186	344	1720	2074	3035	439	461
3	A	532	507	389	299	254	240	318	1863	2669	3012	1655	838
	B	571	559	454	191	65	143	344	1720	2427	3135	2281	524
	C	505	430	129	39	45	82	221	1720	1362	3034	427	474
4	A	301	170	175	242	270	670	2823	6606	5989	1317	365	185
	B	250	114	110	240	263	534	2654	6296	6106	1066	322	139
	C	175	54	46	150	128	458	1769	4517	4140	562	236	105
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	452	357	266	234	202	235	356	1804	2705	2666	1091	633
	B	506	449	64	51	62	171	344	1720	2041	3045	463	563
	C	330	45	35	36	45	82	344	1720	2120	1885	398	409
2	A	490	441	320	299	333	353	354	1834	2637	2887	1230	687
	B	547	521	322	85	218	344	344	1720	2450	3118	931	490
	C	458	124	43	36	46	137	344	1720	1893	2404	344	405
3	A	504	448	325	267	201	180	309	1828	2462	2907	1269	736
	B	554	534	381	57	59	112	344	1720	2387	3133	1023	512
	C	466	158	55	36	45	80	221	1720	1220	2670	344	430
4	A	291	138	100	140	144	431	2374	6215	5601	1135	365	185
	B	242	83	56	123	74	286	2168	5905	5715	365	322	139
	C	173	54	44	52	51	116	1296	4126	3749	550	236	105

Model-simulated monthly streamflows for control point 43 (Little Snake River near Baggs, Wyo.) are presented in tables 42-46. In comparison to the streamflow-gaging station record, simulated monthly mean streamflows for historic conditions without proposed transmountain diversions vary from -8 to +3 percent and with an average absolute variation of 6 percent.

This indicates that the model can reasonably predict conditions at this control point (fig. 1), which is located downstream of the proposed Hog Park transmountain diversion and the proposed Sandstone and Pot Hook Reservoirs.

For reservoir development in option 1 without the Hog Park transmountain diversion, no change in flow was noticed from the historic conditions (tables 42-46) because neither Pot Hook nor Sandstone Reservoirs were considered for this option. Since there were no diversions for option 1, the increase in allocation percentage similarly had no effect on the flow statistics (tables 42-46). In reservoir-development options 2, 3, and 4, both upstream reservoirs were considered and the flow statistics were reduced principally during the spring-runoff months of March, April, May, and June. Reservoir-development option 4 flow statistics were the most regular with less flow during the spring runoff and more flow during the summer and winter months. By regulating the monthly flows at this location, additional flow was also being supplied for the low-flow months for the downstream Dinosaur National Monument.

Simulated streamflow statistics at control point 43 most significantly reflected the potential effects of proposed withdrawals by the Hog Park transmountain diversion during April through July. This diversion effect can most easily be seen in table 43 when 100-percent water-use allocation of the transmountain diversion was added, resulting in zero flow for the month of July during many years.

Table 42.--*Summary of simulated monthly streamflows, control point 43 (Little Snake River near Baggs, Wyo.), for historic conditions and with 100 percent of transmountain diversions*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than historic conditions without transmountain diversions]

FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
SIMULATED HISTORIC CONDITIONS												
A	64	93	83	77	96	285	1069	2296	1341	185	28	34
B	49	78	78	66	88	222	847	2268	1805	65	18	17
C	25	54	55	54	55	140	446	1369	889	21	8	10
SIMULATED HISTORIC CONDITIONS WITH 100 PERCENT OF TRANSMOUNTAIN DIVERSIONS												
A	64	93	83	77	96	285	949	2168	1715	87	28	34
B	49	78	78	66	88	222	730	2140	1672	0	18	17
C	25	54	55	54	55	140	328	1241	761	0	8	10
CALCULATED STREAMFLOW FROM GAGING-STATION RECORDS												
A	66	96	85	79	95	348	1017	2482	1890	196	26	37
B	50	86	78	74	88	260	920	2412	1806	80	14	6
C	17	54	55	55	56	159	576	1408	968	21	3	1

Table 43.--*Summary of simulated monthly streamflows, control point 43 (Little Snake River near Baggs, Wyo.), with 25 percent of agricultural and no transmountain diversions, and with 25 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 42 historic conditions]

OP-TION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	64	93	83	77	96	285	1069	2296	1841	185	28	34
	B	49	78	78	66	88	222	847	2268	1805	65	18	17
	C	25	54	55	54	55	140	446	1369	889	21	8	10
2	A	56	86	82	81	98	273	1030	2299	1825	179	36	36
	B	38	76	78	69	88	210	803	2223	1791	57	24	21
	C	22	47	53	58	62	127	390	1260	873	30	22	20
3	A	54	84	79	77	96	275	1038	2302	1825	179	35	36
	B	35	71	76	68	85	213	814	2250	1791	57	23	21
	C	20	45	52	54	60	131	403	1307	873	30	22	19
4	A	67	100	94	88	94	243	800	2007	1803	248	345	202
	B	41	79	75	70	87	187	526	1826	1715	205	367	191
	C	17	49	51	50	55	135	251	1018	809	45	162	12
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	64	93	83	77	96	285	1037	2264	1809	153	28	34
	B	49	78	78	66	88	222	815	2236	1773	33	18	17
	C	25	54	55	54	55	140	414	1337	857	0	8	10
2	A	57	88	82	80	99	272	994	2264	1793	152	36	37
	B	48	80	78	70	90	209	766	2177	1759	25	24	22
	C	23	47	53	58	64	128	356	1220	841	10	22	19
3	A	55	85	80	79	95	274	1001	2267	1793	152	36	36
	B	42	76	76	68	84	213	778	2211	1759	25	23	21
	C	22	46	52	54	62	128	366	1245	841	10	22	19
4	A	66	101	94	86	94	245	767	1973	1773	232	341	191
	B	41	79	75	70	87	194	494	1794	1679	190	357	171
	C	17	49	51	54	60	138	219	986	777	20	159	8

Table 44.--*Summary of simulated monthly streamflows, control point 43 (Little Snake River near Baggs, Wyo.), with 50 percent of agricultural and no transmountain diversions, and with 50 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 42 historic conditions]

OP-TION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	64	98	83	77	96	285	1069	2296	1841	185	28	34
	B	49	78	78	66	88	222	847	2268	1805	65	18	17
	C	25	54	55	54	55	140	446	1369	889	21	3	10
2	A	56	93	94	90	102	265	967	2256	1813	194	54	41
	B	40	89	85	92	89	205	751	2125	1779	78	45	26
	C	26	56	70	52	54	135	323	1206	860	59	45	26
3	A	54	90	87	83	97	267	980	2266	1813	194	54	41
	B	38	85	77	75	88	204	768	2142	1779	78	45	26
	C	21	49	58	58	57	136	364	1206	860	59	45	26
4	A	65	99	91	86	94	242	803	2004	1788	249	340	177
	B	40	80	75	70	87	187	528	1831	1695	217	355	141
	C	15	49	51	50	55	135	255	1022	821	65	146	12
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	64	93	83	77	96	285	1006	2232	1777	125	28	34
	B	49	78	78	66	88	222	783	2204	1741	2	18	17
	C	25	54	55	54	55	140	382	1305	325	0	3	10
2	A	56	98	100	92	101	266	896	2179	1750	142	54	41
	B	41	97	91	82	93	216	686	2033	1715	32	45	26
	C	22	59	68	56	60	134	276	1142	796	21	45	26
3	A	55	95	94	89	101	265	904	2186	1750	142	54	41
	B	39	94	84	78	92	203	687	2043	1715	32	45	26
	C	20	51	63	52	63	136	292	1142	796	21	45	26
4	A	64	101	91	83	94	247	738	1936	1726	213	330	164
	B	40	80	75	70	87	194	464	1767	1629	170	351	133
	C	15	49	51	55	56	138	191	958	757	21	146	3

Table 45.--*Summary of simulated monthly streamflows, control point 43 (Little Snake River near Baggs, Wyo.), with 75 percent of agricultural and no transmountain diversions, and with 75 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 42 historic conditions]

OPTION	FLOW VALUES	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	64	93	83	77	96	285	1069	2296	1841	185	28	34
	B	49	78	78	66	88	222	847	2268	1805	65	18	17
	C	25	54	55	54	55	140	446	1369	889	21	8	10
2	A	55	120	141	134	118	259	874	2131	1793	216	76	54
	B	39	125	134	134	101	217	647	1789	1737	106	67	40
	C	20	62	84	73	62	130	317	1158	848	89	67	40
3	A	54	118	153	137	123	266	876	2109	1789	216	76	54
	B	40	125	161	143	106	222	634	1752	1737	106	67	40
	C	20	58	108	85	67	131	381	1158	848	89	67	40
4	A	61	99	89	84	94	242	805	2001	1778	255	322	157
	B	38	78	75	70	87	187	529	1835	1673	228	358	102
	C	16	49	51	50	55	138	258	1026	324	89	140	9
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	64	93	83	77	96	285	975	2200	1746	104	28	34
	B	49	78	78	66	88	222	751	2172	1709	0	18	17
	C	25	54	55	54	55	140	350	1273	793	0	8	10
2	A	74	126	149	124	125	267	776	1986	1694	141	30	65
	B	57	124	140	138	115	223	523	1690	1631	46	67	40
	C	22	61	111	62	73	143	255	1040	752	31	67	40
3	A	70	127	153	136	130	271	780	1968	1688	141	86	58
	B	56	128	154	148	118	223	522	1656	1607	46	67	40
	C	22	61	114	63	67	143	313	1031	752	31	67	40
4	A	59	103	88	81	94	251	709	1899	1682	196	311	148
	B	38	78	75	70	87	200	433	1739	1577	160	354	37
	C	16	49	51	55	56	138	174	930	723	31	140	3

Table 46.--*Summary of simulated monthly streamflows, control point 43 (Little Snake River near Baggs, Wyo.), with 100 percent of agricultural and no transmountain diversions, and with 100 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 42 historic conditions]

OPTION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
						WITHOUT TRANSMOUNTAIN DIVERSIONS							
1	A	64	93	83	77	96	285	1069	2296	1841	185	28	34
	B	49	78	78	66	88	222	847	2268	1805	75	18	17
	C	25	54	55	54	55	140	446	1369	889	21	8	10
2	A	88	142	143	113	109	256	843	2039	1772	239	99	76
	B	82	139	136	104	99	220	563	1784	1691	132	89	59
	C	23	71	82	60	54	114	342	1078	835	119	89	53
3	A	89	140	151	120	112	264	847	2020	1767	238	99	74
	B	82	139	150	106	100	215	548	1758	1691	132	89	58
	C	24	66	92	62	55	140	386	1078	835	119	89	53
4	A	58	99	86	82	94	241	808	1999	1769	264	296	139
	B	36	76	75	70	87	187	531	1839	1652	191	328	83
	C	15	49	51	50	55	138	261	1030	830	119	148	8
						WITH TRANSMOUNTAIN DIVERSIONS							
1	A	64	93	83	77	96	285	949	2168	1715	87	28	34
	B	49	78	78	66	88	222	730	2140	1677	0	18	17
	C	25	54	55	54	55	140	328	1241	761	0	8	10
2	A	102	141	137	110	112	250	737	1878	1641	145	106	95
	B	92	142	123	90	90	207	449	1630	1554	66	89	63
	C	39	64	70	58	62	107	302	884	707	47	89	53
3	A	95	148	146	114	115	271	741	1855	1636	144	103	87
	B	87	153	136	94	97	220	479	1630	1556	66	89	61
	C	39	66	68	56	67	140	300	874	707	47	89	53
4	A	58	105	85	78	95	254	683	1864	1641	184	286	131
	B	36	76	75	68	88	201	403	1711	1524	140	323	53
	C	15	49	51	55	56	139	177	889	702	48	136	7

Model-simulated monthly streamflow statistics for control point 41 (Yampa River near Deerlodge Park, Colo.) are presented in tables 47-51. This site is located downstream from the confluence of the Yampa and the Little Snake Rivers and near the entrance to Dinosaur National Monument (fig. 1). All flow statistics given in tables 47-51 for less than the historic values are underscored. Although no streamflow record is available at this site, the historic simulated flow statistics should conform to the actual streamflows as there was close agreement for the nearest upstream streamflow-gaging stations, Yampa River at Maybell (control point 13) and the Little Snake River near Lily (control point 42).

The Yampa River at Deerlodge Park, is the last downstream control point in this river-basin simulation. As such, this location represents the total effect of all reservoir-development options, transmountain diversions, and water-use allocation on the outflow from the Yampa River basin. An average monthly desired streamflow of 750 ft^3/s was specified at this control point. This was computed from a combination of the 690-ft^3/s desired flow at the Maybell streamflow gage (control point 13) and the Little Snake River drainage input. This minimum desired flow was established on the basis of the 1948 Colorado River Compact and the proposed Wild and Scenic River designation within Dinosaur National Monument (H. J. Belisle, U.S. Water and Power Resources Service, formerly U.S. Bureau of Reclamation, written commun., 1976).

At this downstream point in the Yampa River basin, the streamflow statistics were similar for reservoir-development options 1, 2, and 3. Because of the size of the upstream Juniper and Cross Mountain Reservoirs and the other smaller proposed upstream reservoirs upstream (table 2) and also because of the desired flow requirement at this location, the flow statistics indicated large regulated impacts for the monthly flow values (tables 48-51). The desired flow of 750 ft^3/s is maintained throughout reservoir-development options 1, 2, and 3 for water-use allocations at the 25- and 50-percent levels (tables 48 and 49). Several values less than the 750-ft^3/s desired flow can be seen in tables 50 and 51 and at the 75- and 100-percent water-use allocation. A slight decline in flow was also noticed with progression from reservoir-development options 1, 2, and 3, due to increased proposed reservoir development upstream in the basin. Option 4 without Juniper and Cross Mountain Reservoirs reflected a fairly traditional annual hydrograph with a slightly reduced level of flow, and appears least affected by the water-use allocation percentage increases (tables 48-51). Because of the more traditional annual hydrograph (table 47), reservoir-development option 4, as well as the historic conditions, meets the hypothetical 750-ft^3/s desired flow target for 6 or more months each year (tables 48-51).

The flow statistics with both Vidler and Hog Park transmountain diversions at the 100-percent allocation are presented in table 48. The combined effect can be easily noticed when compared to the historic flow statistics, but when included with reservoir-development options (tables 49-51), it has the effect of reducing the number of months that the desired flow is met for both the median and 5-year low-flow (80 percent exceedence) statistics.

Table 47.--*Summary of simulated monthly streamflows, control point 41 (Yampa River near Deerlodge Park, Colo.), for historic conditions and with 100 percent of transmountain diversions*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than historic conditions without transmountain diversions]

FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
SIMULATED HISTORIC CONDITIONS												
A	517	513	461	424	499	1223	4359	9932	8143	1721	424	295
B	458	483	445	402	435	933	4030	9408	8181	1410	340	248
C	279	343	361	346	375	853	2527	6688	5611	646	181	114
SIMULATED HISTORIC CONDITIONS WITH 100 PERCENT OF TRANSMOUNTAIN DIVERSIONS												
A	438	408	374	346	421	1145	3856	9413	7631	1368	361	227
B	363	400	367	324	357	855	3511	8890	7662	1029	281	160
C	211	189	267	264	297	775	2105	6169	5092	382	131	72

Table 48.--*Summary of simulated monthly streamflows, control point 41 (Yampa River near Deerlodge Park, Colo.), with 25 percent of agricultural and no transmountain diversions, and with 25 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 47 historic conditions]

OP-TION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	740	738	738	750	742	863	2052	7056	6837	2235	850	761
	B	750	750	750	750	750	750	1690	6130	6470	2030	806	750
	C	750	750	750	750	750	750	961	3484	3725	1869	750	750
2	A	740	738	738	750	751	860	2021	7452	7312	2244	857	760
	B	750	750	750	750	750	750	1656	6722	7039	2013	822	750
	C	750	750	750	750	750	750	924	3747	4040	1875	750	750
3	A	740	738	738	738	739	854	2131	7217	7113	2238	860	760
	B	750	750	750	750	750	750	1749	6403	6702	2013	827	750
	C	750	750	750	750	750	750	946	3631	3878	1875	750	750
4	A	419	378	373	361	429	1029	3649	9143	7955	1708	691	407
	B	339	330	347	333	367	750	3320	8726	8023	1303	750	393
	C	207	202	267	273	317	705	2058	6232	5443	750	750	97
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	740	738	738	750	742	855	1937	6735	6657	2194	847	761
	B	750	750	750	750	750	750	1587	5720	6125	1998	805	750
	C	750	750	750	750	750	750	922	3452	3676	1837	750	750
2	A	740	738	738	750	751	859	1894	7135	7148	2204	854	760
	B	750	750	750	750	750	750	1496	6379	6825	1981	820	750
	C	750	750	750	750	750	750	856	3415	3727	1855	750	750
3	A	740	738	738	738	738	853	1994	6896	6948	2199	857	760
	B	750	750	750	750	750	750	1645	5911	6549	1981	825	750
	C	750	750	750	750	750	750	910	3446	3665	1855	750	750
4	A	411	338	330	337	406	1012	3518	9011	7828	1613	678	383
	B	324	283	320	314	343	750	3189	8596	7894	1173	750	373
	C	207	142	161	242	294	686	1928	6103	5313	750	561	95

Table 49.--*Summary of simulated monthly streamflows, control point 41 (Yampa River near Deerlodge Park, Colo.), with 50 percent of agricultural and no transmountain diversions, and with 50 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 47 historic conditions]

OPTION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
						WITHOUT TRANSMOUNTAIN DIVERSIONS							
1	A	741	738	738	750	742	860	1685	5763	5790	2350	1461	972
	B	750	750	750	750	750	750	1558	4708	4870	2176	1459	948
	C	750	750	750	750	750	750	964	3433	3184	1963	1383	905
2	A	740	738	738	750	750	847	1607	6006	6416	2362	1491	980
	B	750	750	750	750	750	750	1388	4749	5485	2194	1491	948
	C	750	750	750	750	750	750	792	3344	3195	1998	1420	919
3	A	740	738	738	738	738	843	1675	5808	5091	2360	1494	980
	B	750	750	750	750	750	750	1410	4875	5157	2194	1491	947
	C	750	750	750	750	750	750	835	3349	3189	1998	1421	918
4	A	415	350	348	362	432	1032	3653	9026	7918	1693	694	380
	B	327	315	343	337	371	750	3321	8590	7998	1307	750	341
	C	211	142	190	281	319	709	2067	6191	5389	750	638	113
						WITH TRANSMOUNTAIN DIVERSIONS							
1	A	741	738	738	738	752	852	1546	5292	5204	2277	1423	971
	B	750	750	750	750	750	750	1471	4399	4343	2125	1459	948
	C	750	750	750	750	750	750	900	3308	3026	1907	1372	905
2	A	740	738	738	738	750	844	1485	5557	5819	2301	1474	980
	B	750	750	750	750	750	750	1283	4492	4802	2130	1485	948
	C	750	750	750	750	750	750	750	3280	3006	1963	1420	919
3	A	740	738	738	738	738	838	1530	5323	5484	2298	1474	980
	B	750	750	750	750	750	750	1318	4362	4459	2130	1485	947
	C	750	750	750	750	750	750	750	3280	2995	1963	1415	918
4	A	401	304	269	306	347	956	3392	8764	7660	1537	677	349
	B	316	244	235	288	327	750	3059	8331	7738	1123	750	318
	C	211	119	104	184	148	562	1807	5931	5129	750	574	108

Table 50.--*Summary of simulated monthly streamflows, control point 41 (Yampa River near Deerlodge Park, Colo.), with 75 percent of agricultural and no transmountain diversions, and with 75 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 47 historic conditions]

OPTION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
						WITHOUT TRANSMOUNTAIN DIVERSIONS							
1	A	743	723	635	661	634	772	1502	4728	4680	2960	1986	1152
	B	750	750	750	750	750	750	1356	4411	4326	2908	2047	1264
	C	750	750	637	750	298	583	974	3412	3226	2668	1978	750
2	A	741	738	733	712	664	799	1316	4774	4914	3012	2100	1260
	B	750	750	750	750	750	750	1168	4261	4373	2945	2099	1299
	C	750	750	750	750	750	750	750	3238	3049	2712	2039	1270
3	A	741	738	729	676	596	722	1306	4625	4725	2990	2109	1284
	B	750	750	750	750	750	750	1168	4141	4345	2944	2099	1301
	C	750	750	750	640	163	398	750	3170	3046	2665	2039	1269
4	A	405	316	310	348	413	1034	3656	8978	7880	1684	698	357
	B	326	244	311	339	368	750	3328	8515	7963	1300	750	299
	C	215	120	111	259	294	713	2071	6159	5356	750	678	112
						WITH TRANSMOUNTAIN DIVERSIONS							
1	A	703	691	571	475	505	725	1404	4504	4350	2844	1768	1061
	B	750	750	750	745	750	750	1260	4315	4166	2807	2030	1251
	C	750	750	169	110	131	371	878	3316	3130	2574	1150	750
2	A	715	711	682	632	608	750	1217	4392	4513	2903	2003	1149
	B	750	750	750	750	750	750	1045	4016	4154	2858	2097	1295
	C	750	750	667	450	243	567	750	3053	2948	2635	2034	750
3	A	705	711	675	594	557	700	1205	4342	4331	2871	1996	1136
	B	750	750	750	750	750	750	1044	3969	4058	2841	2097	1287
	C	750	750	750	171	137	360	750	2995	2945	2529	2034	750
4	A	395	272	223	256	300	871	3238	8584	7492	1471	684	339
	B	319	227	173	243	238	725	2935	8126	7574	1105	750	285
	C	215	119	104	147	133	378	1639	5770	4967	750	611	112

Table 51.--*Summary of simulated monthly streamflows, control point 41 (Yampa River near Deerlodge Park, Colo.), with 100 percent of agricultural and no transmountain diversions, and with 100 percent of both agricultural and transmountain diversions, and including 100 percent of industrial and municipal diversions for all simulations*

[FLOW VALUES: A=MEAN; B=MEDIAN; and C=80-PERCENT EXCEEDANCE. Underscored values are less than corresponding table 47 historic conditions]

OPTION	FLOW VALUES	MONTHLY FLOWS, IN CUBIC FEET PER SECOND											
		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT
		WITHOUT TRANSMOUNTAIN DIVERSIONS											
1	A	642	591	452	492	567	697	1490	4612	4980	3605	1681	989
	B	750	750	515	750	750	750	1367	4482	4856	3709	1759	750
	C	478	141	122	114	224	407	985	3452	3910	3450	750	750
2	A	710	672	563	502	535	746	1268	4434	4923	3703	1990	1080
	B	750	750	750	750	750	750	1083	4185	4643	3803	2648	750
	C	750	750	254	115	127	488	750	3228	3761	3571	317	750
3	A	703	670	553	429	390	610	1237	4369	4811	3718	2068	1094
	B	750	750	750	356	217	495	1066	4130	4596	3802	2651	750
	C	750	750	249	105	124	301	750	3137	3521	3571	784	750
4	A	402	291	275	335	388	1018	3661	8930	7841	1677	701	347
	B	322	239	231	328	365	750	3333	8422	7942	1320	750	284
	C	219	119	105	221	151	674	2075	6103	5348	750	637	130
		WITH TRANSMOUNTAIN DIVERSIONS											
1	A	597	472	362	321	322	627	1377	4458	4794	3218	1419	840
	B	750	683	195	157	197	493	1239	4324	4667	3442	750	750
	C	444	111	104	101	116	301	857	3324	3501	2435	750	750
2	A	674	604	470	419	468	710	1163	4198	4652	3495	1646	959
	B	750	750	518	265	580	750	983	3922	4412	3660	1306	750
	C	750	255	136	102	131	372	750	3059	3169	2852	750	750
3	A	681	617	484	391	339	558	1122	4169	4472	3516	1681	1002
	B	750	750	588	183	182	424	938	3861	4297	3672	1429	750
	C	750	307	134	101	124	299	750	3009	3144	3113	750	750
4	A	391	266	199	228	263	792	3087	8404	7325	1415	690	338
	B	303	199	163	219	184	613	2809	7903	7423	1050	750	263
	C	210	119	104	132	131	340	1501	5584	4829	750	597	130

SUMMARY

A total of 35 major reservoirs has been proposed for construction in the Yampa River basin to provide additional water for increasing industrial, irrigation, and municipal uses. Additionally, two transmountain diversions have been proposed to transport water to the Denver, Colo., and Cheyenne, Wyo., metropolitan areas. A multireservoir-flow computer model was used to simulate the effects on streamflow of five potential options, including one representing historic conditions (no additional reservoir development) and four representing various degrees of reservoir and transmountain-diversion development. Various combinations of 17 larger proposed reservoirs and the 2 transmountain diversions were used in the model analysis.

Simulated monthly streamflows at 47 sites throughout the Yampa River basin were determined for the following conditions:

A. Historic conditions:

1. Historic conditions without any proposed diversions.

2. Historic conditions with 100 percent of proposed transmountain diversions.

B. Reservoir-development options 1-4:

1. Allocation of 25 percent of total active reservoir storage for agricultural use without any transmountain diversions, and including 100 percent of industrial and municipal diversions.

2. Allocation of 25 percent of total active reservoir storage for agricultural use with 25 percent of proposed transmountain diversions, and including 100 percent of industrial and municipal diversions.

3. Allocation of 50 percent of total active reservoir storage for agricultural use without any transmountain diversions, and including 100 percent of industrial and municipal diversions.

4. Allocation of 50 percent of total active reservoir storage for agricultural use with 50 percent of proposed transmountain diversions, and including 100 percent of industrial and municipal diversions.

5. Allocation of 75 percent of total active reservoir storage for agricultural use without any transmountain diversions, and including 100 percent of industrial and municipal diversions.

6. Allocation of 75 percent of total active reservoir storage for agricultural use with 75 percent of proposed transmountain diversions, and including 100 percent of industrial and municipal diversions.

7. Allocation of 100 percent of total active reservoir storage for agricultural use without any transmountain diversions, and including 100 percent of industrial and municipal diversions.

8. Allocation of 100 percent of total active reservoir storage for agricultural use with 100 percent of proposed transmountain diversions, and including 100 percent of industrial and municipal diversions.

Results of this study were designed to demonstrate the application of a computer reservoir-modeling technique in helping to evaluate certain areas of concern for proposed reservoir development in the Yampa River basin. This study, as presented, is an extension of some earlier reservoir-modeling work completed for the Yampa River basin (D. B. Adams, D. P. Bauer, R. H. Dale, and T. D. Steele, written commun., 1980). Results presented in this report are somewhat speculative because of assumptions which had to be made for the model application and also because of the limited possible reservoir-development schemes which were considered for the study. The results, however, do present some possible impacts of the proposed sequential reservoir development in the Yampa River basin.

By varying the percentages of agricultural and transmountain diversions within each proposed reservoir-development option, lesser degrees of development than those currently (1979) proposed were simulated, thus providing results for a greater range of alternatives. The results of these simulations will provide water managers and planners with some insight on how proposed surface-water developments will affect minimum streamflows.

During the partial model verification for the basin, the fit of the mean monthly streamflow statistics to streamflow-gaging-station records, statistics are good to fair (5 to 20 percent). Comparisons between the main-stem Yampa River model results and streamflow-gaging station record statistics show a decrease in model accuracy in the downstream direction from minus 5-percent difference at Steamboat Springs to minus 20-percent difference at the Craig or Maybell streamflow-gaging stations.

Model-simulation results for nine representative control points presented in this report are summarized below. Results for the remaining 38 control points may be obtained from the U.S. Geological Survey for the cost of computer and reproduction time.

For certain tributary locations--namely Elk River near Trull (control point 38) and Trout Creek at mouth (control point 34)--the monthly flow statistics are far less affected by allocation percentages or development option than are those for the Yampa River main stem. The transmountain diversions also have little effect for these two locations. In general, the 50-year monthly flow statistics for any tributary to the Yampa River exhibit regulated flow patterns only if that tributary had one or more reservoirs upstream.

The Yampa River main-stem sites respond in different ways, depending on their location in the proposed reservoir system and other downstream and upstream demands. In general, all locations studied responded to increases in agricultural-diversion water-use allocation percentage and transmountain diversion with reduction in streamflow. In some instances, streamflow in certain reaches could be increased by releases from upstream reservoirs resulting from downstream reservoir demands.

The Vidler and Hog Park transmountain diversions had noticeable effects on most Yampa River main-stem sites. The Vidler transmountain diversion affected all Yampa River locations downstream from Steamboat Springs, Colo., while the Hog Park diversion affected all Little Snake River locations downstream from approximately Dixon, Wyo. Effects of both diversions were recognized at the Yampa River near Deerlodge Park location. The Steamboat Springs location is most highly affected by the Vidler transmountain diversion with lesser impact downstream.

Of the nine sites of interest presented in this report, three of the sites had some periods of projected zero flow for the 50-year monthly-flow simulation. The Steamboat Springs location had periods of zero flow when the Vidler transmountain diversion was included for reservoir-development options 3 and 4 at the proposed 25-percent water-use allocation and for all options at the 100-percent water-use allocation. The Craig location on the Yampa River had some zero-flow periods in reservoir-development option 4 at the 25-percent water-use allocation level, increasing to several instances of zero flow for all options at the 100-percent water-use allocation, both with and without the Vidler transmountain diversion. The Yampa River at Maybell location maintained some flow in all the monthly flow statistics until the irrigation-water allocation reached 75-percent water-use allocation. At this 75-percent water-use allocation, several zero-flow months occurred, especially during the low-flow season of summer and fall.

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